

RESEARCH ARTICLE

Belonging in engineering: Exploring the predictive relevance of social interaction and individual factors on undergraduate students' belonging in engineering

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Abstract

Background: Belonging in their academic discipline affects students' participation and retention in engineering. While prior studies have conceptualized belonging as a predictor of outcomes, this study examines belonging as an outcome that depends on interpersonal and intrapersonal variables.

Purpose: This quantitative study tested a conceptual model of academic belonging for undergraduate engineering students that hypothesized how intrapersonal and interpersonal variables predict belonging in engineering. The model proposed that engineering students' satisfaction with and valuing of their academic discipline mediate these predictors' effects on belonging.

Design/Methods: This study sampled undergraduate engineering students ($n = 849$) across six universities and used structural equation modeling to examine the direct and indirect effects of four exogenous variables (achievement striving, grit, peer interaction, faculty interaction) on one endogenous variable (academic belonging). The model included satisfaction with and valuing of their academic discipline as mediator variables.

Results: The direct effects of peer interaction, faculty interaction, as well as passion and perseverance (sub-constructs of grit) on academic belonging were significant. The direct effects of achievement striving on predicting academic belonging were not significant. Satisfaction mediated the effects of the predictors on students' sense of belonging in engineering.

Conclusions: Peer interaction was the most robust contributor to belonging, while faculty interaction and the value that students ascribe to their academic discipline predicted their sense of belonging in engineering. This work provides a novel model of belonging in engineering and its interpersonal and intrapersonal antecedents with educational, policy, and research implications to improve engineering students' belonging within their academic discipline.

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KEY WORDS

belonging, engagement, structural equation modeling

1 | INTRODUCTION

The engineering workforce drives scientific and technological innovation and is essential in addressing complex sociotechnical challenges (National Academies of Sciences, Engineering, and Medicine, 2018; Wilson et al., 2015). A sustainable engineering workforce depends on the availability of trained professionals with the essential skills to address emerging and future engineering challenges. However, such a sustainable workforce is possible only when we can adequately recruit, train, and retain students in engineering programs, including those from groups that have been traditionally underrepresented in engineering education (National Academy of Engineering, 2011; National Center for Science and Engineering Statistics, 2023). While students may enroll in engineering programs for a variety of reasons (Matusovich et al., 2010; Painter et al., 2017; Watson et al., 2015), having a sense of belonging in the engineering program is crucial to their retention in engineering careers (Danielak et al., 2014; Judson et al., 2015; Mooney & Becker, 2020). Having a sense of belonging in engineering is especially important for students who may feel isolated in their fields of study because of the lack of peers, faculty members, and mentors of similar backgrounds (Litzler & Samuelson, 2013).

Belonging has been viewed as a fundamental human need. In Maslow's five-tier hierarchy of needs, belonging is presented as the third tier after meeting physiological and safety needs (Maslow, 1943). Building on Maslow's work, Baumeister and Leary (1995) found the need to belong influences behavior, emotion, and motivation. Although belonging has been theorized and studied for decades, it has become a growing part of national conversations, given sociocultural trends such as isolation resulting from the COVID-19 pandemic (Lim et al., 2021) and high rates of loneliness among Gen Z adults (Cigna, 2018).

The need to belong is universal, but there is a particular expediency to understanding sense of belonging in undergraduate engineering education. Belonging has implications for students' mental health, which is an ongoing challenge within the engineering stress culture (Jensen & Cross, 2021) and undergirds students' emotional and psychological well-being within their academic community (Anderman, 2002). During the COVID-19 pandemic and shift to remote teaching, (lack of) belonging among undergraduate engineering students came into sharp focus with its effect on persistence and performance (Buckley et al., 2023; Misra et al., 2023). Amid ongoing calls to better support students from backgrounds that have been traditionally underrepresented in engineering (National Center for Science and Engineering Statistics, 2023), sense of belonging has been shown to be important for students with minoritized or marginalized identities to develop an engineering identity and persist in their studies (Fletcher et al., 2023; Ong et al., 2020; Patrick et al., 2023).

Belonging has been studied from various disciplinary and theoretical perspectives, giving rise to multiple definitions and measurements (Allen et al., 2021). Within the academic setting, a student's sense of belonging has been variously conceptualized as their inclusion in the campus community (Hurtado & Carter, 1997), the extent to which they feel accepted and respected at their school (Fong Lam et al., 2015), their social and emotional connection to the school (Neel & Fuligni, 2013), psychological sense of academic and social integration (Hurtado et al., 2007), and psychological sense of identification and affiliation (Hausmann et al., 2009). Belonging for students has been found to be context-specific and operate at different scales, including at the classroom, educational program, and institution levels (Wilson et al., 2015). Given these various definitions and context-specificity of belonging, the present study defined belonging as a student's perception of acceptance, fit, and inclusion in their academic discipline of engineering (Simmons, Hunsu, & Adesope, 2019). Relative to research on classroom- or institutional-level belonging, that on belonging in the university department or discipline has received less attention (Knekta et al., 2020).

Prior studies have conceptualized and examined belonging as an antecedent or a predictor of other educational outcomes in empirical research studies. For example, belonging has been discussed in relation to satisfaction (Hurtado et al., 2007), persistence (Davis et al., 2019; Hausmann et al., 2007; Marra et al., 2012), academic motivation (Neel & Fuligni, 2013), academic engagement (Wilson et al., 2015), university environment (Johnson et al., 2007; Meeuwisse et al., 2010), grit (Verdín et al., 2018), and academic performance (Davis et al., 2019; Fong Lam et al., 2015). However, we argue that belonging is also the consequence of interpersonal and intrapersonal factors within the context of students' educational experiences. Based on a narrative literature review of belonging, Allen et al. (2021) proposed an

integrative framework for belonging that includes competencies, opportunities, motivations, and perceptions. This framework speaks to personal, relational, and contextual factors that affect students' sense of belonging. Building on this work, we suggest there is theoretical and practical expediency to conceptualizing and investigating belonging as an outcome variable, not just as a predictor or mediator of other educational outcomes.

As noted earlier, prior studies have examined how belonging predicts other educational outcomes. However, such studies do not highlight the contribution of both social and individual variables that predict belonging within engineering. Investigating the predictors of engineering belonging in the context of a student's social environment could improve understanding of which social engagement and interpersonal factors promote their belonging. The present study was designed to examine belonging as it relates to students' engagement in undergraduate engineering education and investigated the effects of students' individual factors and social interactions on belonging as an educational outcome. The study used structural equation modeling (SEM) to examine the validity of a framework that hypothesizes the predictive and mediating role of social and individual components of engagement on academic belonging. The study was guided by the following research questions:

Research Question 1a: To what extent do the individual variables of achievement striving and grit affect engineering students' sense of belonging in their discipline?

Research Question 1b: To what extent do the social engagement variables of peer and faculty interaction affect engineering students' sense of belonging in their discipline?

Research Question 2: How comparable are the effects of these individual and social engagement variables on engineering students' sense of belonging in their discipline?

Research Question 3: Are the effects of the individual and social engagement variables on sense of belonging in the discipline mediated by major satisfaction and major valuing?

2 | REVIEW OF LITERATURE

Studies that examine student belonging in higher education often draw upon Tinto's (1990) and Astin's (1984, 1999) models of persistence in college (Hausmann et al., 2009). Tinto's model emphasized the role of students' social and academic integration in belonging, while Astin's model highlighted students' involvement in understanding persistence. Studies using these models have conceptualized belonging as integration (Davis et al., 2019; Wilson et al., 2015) and involvement (Kahu et al., 2022; Knekta et al., 2020; Procentese et al., 2020). However, there are important distinctions between belonging and integration, especially for groups of students who have traditionally been underrepresented in engineering. Tinto's model has been criticized for implying that it is a student's responsibility to adapt to the institution rather than the institution's responsibility (Johnson et al., 2007). In addition, the relevance of Tinto's model to students of diverse backgrounds has been questioned. Critiques have argued that the model overemphasizes students' need to integrate or assimilate into the majority's norms (Soria & Stebleton, 2013). Calling for a more nuanced focus on belonging, Hausmann et al. (2007) argued there is a need for a "more systematic study of one variable [belonging] that has received sparse attention in existing studies of student persistence" (p. 804).

While belonging has been studied as a predictor of educational outcomes in the empirical literature (Gutiérrez et al., 2022; Korpershoek et al., 2020; Salles et al., 2019; Won et al., 2018), theoretical or conceptual frameworks of the mechanisms that lead to belonging are scarce. A conceptual framework of academic belonging for undergraduate engineering students that incorporates interpersonal and intrapersonal correlates of social engagement and student experience could be valuable in identifying and testing a mechanism of academic belonging. In the following sections, we briefly highlight important correlates that contribute to students' sense of belonging in their academic discipline. The following correlates are discussed in order to build upon both foundational research (Baumeister & Leary, 1995) and recent research (Misra et al., 2023) that highlighted the importance of social interaction for sense of belonging. Specifically, this previous work has shown peer and faculty interaction to be important for fostering sense of belonging in academic contexts. There is also evidence from qualitative research that belonging is shaped by personal factors, such as interest in/passion for the academic discipline and resilience (Buckley et al., 2023) and that belonging is context-specific (Wilson et al., 2015). Given the personal and contextual factors that can affect belonging, our review also highlights students' perception of the value of their academic discipline, their satisfaction with it, determination to succeed, and passion and persistence (coupled as grit). In the following review, we synthesize literature across different fields that investigated various populations. We present this relevant, contextual information to highlight the

importance of understanding such relationships within the context of undergraduate engineering education. This combination of interpersonal factors coupled with social interaction can provide a more holistic understanding of belonging. (See Table 1 for the variable list, symbols, and definition.)

2.1 | Peer interaction

Peer interaction refers to student–student engagements, with positive peer interactions facilitating connectedness, collaboration, and knowledge sharing (Simmons et al., 2017). The theoretical thread between peer interaction and belonging began with the pioneering work of Baumeister and Leary (1995), which articulated the fundamental human motivation for belonging based on frequent and positive interpersonal relationships. By interacting with peers in their academic discipline, students can develop a sense of belonging within engineering. The link between positive interaction among students and educational outcomes is well documented. For example, Moran and Gonyea (2003) found that peer interaction was a stronger predictor of student outcomes than faculty interaction, student involvement, and student effort among undergraduate students at a university in the United States. Peer involvement deepens students' connection to their academic environment, while peer support is a crucial aspect of belonging among first-year university students (Morrow & Ackermann, 2012). Additionally, peer relationships contribute to undergraduate students' engineering identity (Davis et al., 2023). Taken together, the literature has shown that interpersonal relationships among peers can contribute to various academic and intrapersonal outcomes, which motivated the inclusion of peer interaction in our model of engineering students' belonging in the discipline.

2.2 | Positive faculty interaction

Positive faculty interaction is defined as students' perceptions of, treatment by, and satisfaction with faculty (Simmons et al., 2017). Like peer interaction, this component of social engagement connects to the hypothesis that belonging is

TABLE 1 Constructs, definitions, abbreviations, and variable groups.

Latent factor name	Name abbreviation	Definition	Variable group
Peer interaction	PEINT	Peer interaction refers to student–student engagements, with positive peer interactions facilitating connectedness, collaboration, and knowledge sharing (Simmons et al., 2017)	Social interaction
Positive faculty relations	FCREL	Positive faculty interaction is defined as students' perceptions of, treatment by, and satisfaction with faculty (Simmons et al., 2017)	Social interaction
Achievement striving	ACSTR	Achievement striving is defined as students' determination to succeed that leads them to behave in ways that promote academic performance (Simmons et al., 2017)	Individual factor
Grit	GRIT	Grit is defined as an individual's trait expressed as passion and persistence in achieving long-term goals (Duckworth et al., 2007)	Individual factor
Major satisfaction	MJSAT	Major satisfaction is defined as student satisfaction with, and emotional connection to, their intended major (Simmons et al., 2017)	Individual factor
Major valuing	MJVAL	Major valuing describes the importance that students assign to their academic major (Simmons, Hunsu, & Adesope, 2019)	Individual factor
Perseverance	PERSE	Perseverance is the quality of persisting in a task or goal despite facing challenges, obstacles, or setbacks	Individual factor
Passion	PASSI	Passion is a strong and intense emotion or enthusiasm toward something. It is a driving force that motivates and inspires individuals to pursue their interests and goals	Individual factor
Academic belonging	ACBEL	Student's perception of acceptance, fit, and inclusion in their academic discipline (Simmons, Hunsu, & Adesope, 2019)	Outcome

predicated on positive and frequent interpersonal relationships (Baumeister & Leary, 1995). In the academic context, faculty members play a crucial role in university students' cognitive development and affective socialization (Micari & Pazos, 2012; Pascarella & Terenzini, 1991; Trolian et al., 2016). Kim and Lundberg (2016) found that student–faculty interaction directly affected classroom engagement and that sense of belonging partially mediated the relationship between student–faculty interaction and classroom engagement among final-year university students. Other work, such as Brooms' (2020) study on Black males and Freeman et al.'s (2007) survey of first-year students, also linked positive faculty–student interaction with university students' sense of belonging. Faculty interaction was included in the present study to build upon the theoretical and empirical links between engagement with faculty and students' sense of belonging in their discipline.

2.3 | Major valuing

Major valuing describes the importance that undergraduate students assign to their academic major (their discipline) (Simmons, Hunsu, & Adesope, 2019). This construct is rooted in the expectancy-value theory, which proposes that a sense of values influences persistence, performance, and choice (Eccles & Wigfield, 2002; Wigfield & Cambria, 2010). According to the expectancy-value theory, subjective task value is composed of interest value (enjoyment), attainment value (importance of doing well), utility value (relation to goals), and relative cost (negative aspects of task engagement). The theory also suggests that students' sense of value feeds directly into their choices and performance related to achievement. The value that students assign to their academic tasks and disciplines affects their attachment to learning activities and environments via motivation. Regarding the link between belonging and valuing, a study of high school students in Germany found that a more heightened sense of belonging positively affected students' expectations for success within the expectancy-value framework (Ladewig et al., 2022). A study of middle school students found significant correlations between belonging and value (Goodenow, 1993). Given the context-dependence of belonging, our work sought to build on this connection between valuing and belonging among undergraduate engineering students.

2.4 | Major satisfaction

Major satisfaction is defined as student satisfaction with and emotional connection to their intended academic major or discipline (Simmons et al., 2017). It is conceptualized as the extent to which students are happy with their major, are enthusiastic about it, intend to stay in their major, and express interest in pursuing a career. Like valuing, satisfaction is an affective consideration that plays a key role in students' persistence and retention in higher education. Student satisfaction can operate on multiple scales: an individual course, the degree program, the university, and undergraduate life in general (Elliott & Shin, 2002; Wiers-Jenssen et al., 2002). Peer and faculty interaction can facilitate students' satisfaction with their academic major, as found by Soria and Stebleton (2013) in their study of self-identified working class university students, while a sense of community also contributed to student satisfaction among online learners (Croxton, 2014) and doctoral students (Tompkins et al., 2016). Studies examining the direction of the relationship between student satisfaction and belonging have produced mixed findings. Nonetheless, sense of belonging has been found to be an important predictor of satisfaction with university students' campus experience (Fan et al., 2020), satisfaction with the academic program (Gibson, 2010) and satisfaction with life in general (Civitci, 2015). Given these potential empirical links, our study included undergraduate students' satisfaction with their discipline to understand how it might contribute to their sense of belonging in engineering.

2.5 | Achievement striving

Achievement striving is defined as students' determination to succeed, which leads them to behave in ways that promote academic performance (Simmons et al., 2017). The construct is rooted in proactive behaviors that foster engagement despite situational constraints that may otherwise discourage engagement (Bateman & Crant, 1993). This disposition toward commitment despite obstacles can support students' engagement in school, thereby fostering the sense that they belong there. Students with the determination to succeed show greater satisfaction with and valuation

of their academic discipline (Reeve, 2012), which motivated the consideration of achievement striving in the present study as an intrapersonal variable that can relate to both engagement and belonging.

2.6 | Grit

Grit is defined as an individual's trait expressed as passion and persistence in achieving long-term goals (Duckworth et al., 2007). Like achievement striving, grit is purported to be a stable individual trait that captures sustained interest and effort (Duckworth & Quinn, 2009). In their pioneering work on grit, Duckworth and colleagues developed scales for measuring grit and found that it accounted for higher educational attainment (i.e., GPA) among undergraduates and retention among military academy cadets (Duckworth et al., 2007). In the years since, researchers have examined the relationships between grit and several noncognitive variables in educational contexts (Credé et al., 2017).

Critics have argued that characterizing grit as an individual trait does not account for the environmental factors that may affect a person's achievement (Credé, 2018). This criticism has implications for diversity and inclusion because grit does not consider the effects of systemic inequalities and unjust policies that can affect an individual's academic outcomes. Grit has also been criticized for its practical relevance as a one-dimensional trait (Direito et al., 2021). As a result, it is recommended that grit be deconstructed into its two dimensions: passion and perseverance. A meta-analysis of grit (Credé et al., 2017) indicated that perseverance is a better predictor than passion or grit overall, and thus treating them as distinct variables maximizes their utility value. Bowman et al. (2015) reported that perseverance predicted satisfaction and a sense of belonging among university students, while passion was not significantly associated with satisfaction or belonging. Deconstructing grit, Verdín et al. (2018) found that engineering identity and belonging have a direct effect on perseverance but not on interest (passion). They also reported that belonging mediated identity and perseverance. Given the theoretical and empirical complexity of grit in terms of its effect on academic and intrapersonal outcomes, the present study sought to understand whether students' passion and perseverance in school contribute to their sense of belonging in engineering.

3 | CONCEPTUAL FRAMEWORK

As previously discussed, belonging is linked to academic outcomes that support students' persistence, and on a broader scale, psychological outcomes that contribute to their wellbeing. However, belonging itself is a complex construct, which in disparate research has been shown to be influenced by contextual, interpersonal, and intrapersonal factors. The intrapersonal factors that shape students' experiences may include traits that they bring to, or acquire in, the academic community, although we acknowledge that some traits are the consequences of privilege and are not fixed. Conversely, students may also pick up cues that shape their subjective experiences and sense of academic belonging from their interactions with consequential people within their academic community. Hence, a conceptual framework of belonging must account for the interrelationships between cogent interpersonal factors of students' social interaction and relevant intrapersonal factors. We identified and hypothesized directional relationships between the intrapersonal and interpersonal variables suggested by theoretical and empirical literature as correlates of undergraduate engineering students' belonging. We propose a conceptual model of academic belonging (Figure 1) based on our synthesis of relevant literature.

Since students are social beings, peer interaction and positive faculty interaction, two constructs of social engagement described in the previous section, may shape their sense of belonging in their academic discipline. Therefore, we hypothesized that both variables have a direct, positive relationship with students' satisfaction with their discipline (major satisfaction) and the sense of value or importance they ascribe to their discipline (major valuing). Additionally, we hypothesized that major satisfaction and major valuing would mediate the effects of these two variables of social engagement on belonging. We anticipated that when students have positive experiences with faculty and peers in their discipline, they will feel a greater sense of value and satisfaction about their discipline and, thus, a greater sense of belonging in engineering.

Students are also individuals with purpose and volition. Hence, achievement striving and grit, which are individualistic constructs, also influence students' sense of belonging in their academic community. Therefore, we hypothesized that achievement striving, passion, and perseverance will have significant relationships with major satisfaction and major valuing; we theorized that the effects of both variables on belonging are mediated by how satisfied

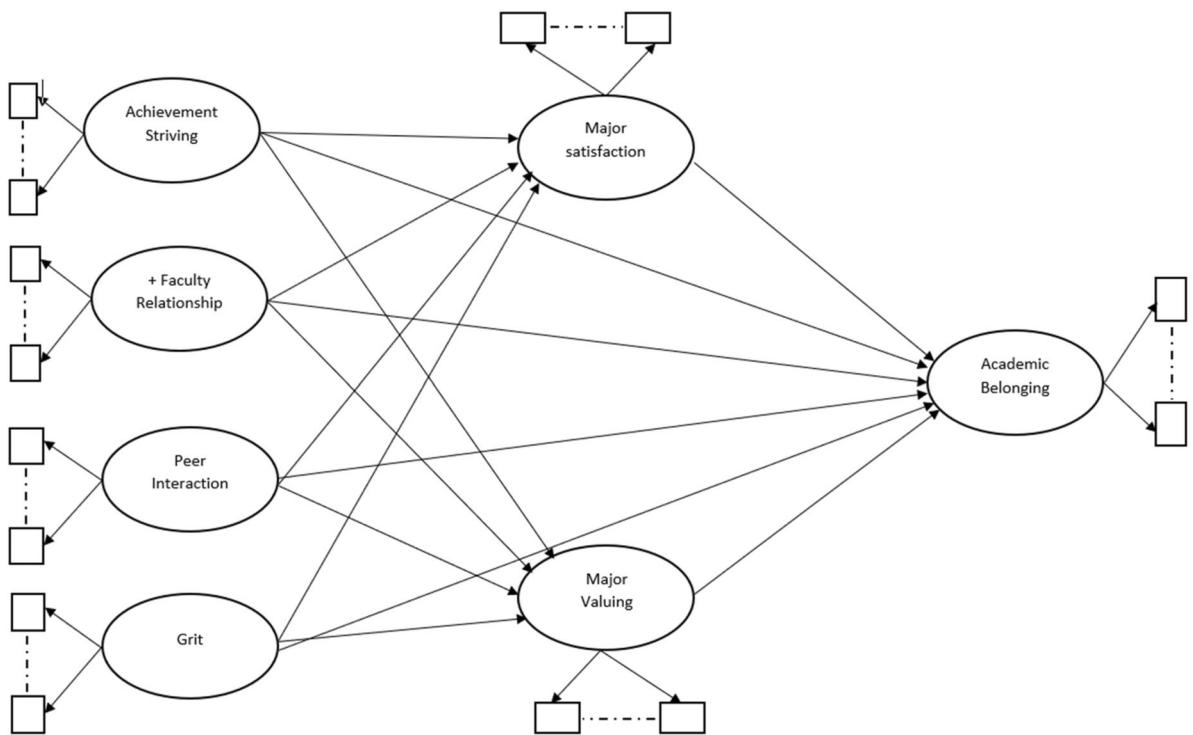


FIGURE 1 Conceptual model of undergraduate engineering students' belonging.

(major satisfaction) students are about their experience in their discipline and the sense of value or importance they ascribe to their discipline (major valuing). We anticipated that students with higher levels of grit or achievement striving may feel a greater sense of value and satisfaction about their discipline and, thus, feel a greater sense of belonging in engineering than those who do not. We recognize that the environmental/institutional variables also account for students' sense of belonging. For conciseness, however, we limited our focus to the interpersonal and intrapersonal variables identified in this study.

3.1 | Purpose of the study

The purpose of this quantitative study was to develop and test a conceptual model for the social engagement and individual factors that affect students' sense of belonging. Figure 1 illustrates a hypothesized conceptual model of academic belonging based on the above-mentioned theoretical propositions. The model hypothesizes the direction of the interrelationships and the effects of individual constructs (i.e., achievement striving, passion, and perseverance) and social engagement (i.e., peer interaction and positive faculty interaction) on belonging in the engineering discipline. The model anticipates the extent to which individual and social factors predict students' sense of belonging in engineering and whether student perceptions of satisfaction and valuing within their academic discipline mediated their effect on belonging. The arrows in the figure are unidirectional (the direction of the arrow indicates the expected path of the relations between the variables under consideration). The rectangular shapes represent the observed variables, which are measured directly as sub-scale items on the survey, and the oval shapes indicate latent factors, which are those not directly measured but understood indirectly as constructs based on the observed variables in the sub-scale survey items (discussed further in the methods). The signs indicate whether the hypothesized correlations are expected to be positive or negative.

3.2 | Contribution of the study

This research contributes to the ongoing conversation about how to support undergraduate students and foster their sense of belonging in engineering given its important link to wellbeing and academic outcomes. The unique

contribution of this work is treating belonging as the outcome rather than a predictor of other variables, as belonging is often treated in the literature, as described above. This work also integrated both social interaction and personal factors to build on disparate work and provide a more holistic understanding of belonging through an empirically tested model that can serve as a foundation for future research, policies, and interventions to facilitate belonging among undergraduate engineering students.

4 | RESEARCHER POSITIONALITY

Our research team represents different topical and methodological expertise as well as personal identities that informed our approach to this work. Four of the authors conduct their research in engineering education and one works in education psychology. Three of the authors specialize in quantitative methodologies while two work primarily in qualitative and mixed-methods research. These methodological approaches and their underpinning ontology influenced our aim of identifying the latent constructs related to belonging and using the model to inform further qualitative research and change that can support undergraduate students, rather than changing the students who do not feel a sense of belonging. As individuals with identities that have been, and continue to be, marginalized in engineering, we are also motivated to support engineering students' belonging in their academic discipline.

5 | METHOD

5.1 | Participants, data collection, and study design

This quantitative study was based on participants' responses to items on the Postsecondary Student Engagement (PosSE) survey: information on the survey development has been published (Simmons et al., 2015, 2017). The PosSE survey measures college students' engagement in out-of-class activities. Participants for this study included 849 undergraduate engineering students (308 women) surveyed across six public research universities in southern and mid-Atlantic states in the United States. The institutions included comprised four with very high research activity (one of which is a Hispanic Serving Institution, HSI) and two with high research activity (one being a Historically Black College and University, HBCU, and the other an HSI). Although participants for this study were recruited from multiple universities, their lived experiences may not fully capture the spectrum of undergraduate student experience across the United States. The survey was administered to the population of all undergraduate engineering students in the participating institutions, who then anonymously responded on Qualtrics. The institutions selected for sampling were ones where a significant number of engineering degrees are awarded to women and underrepresented racial and ethnic groups, which ensured our sample included underrepresented groups in engineering (American Society for Engineering Education, 2023). The participants' mean age was 21.31 years ($SD = 3.44$; range, 18–51 years) and included students enrolled at all levels of the undergraduate program from first year to senior year, and a few were in the fifth year or beyond. Table 2 shows the participants' demographic distribution. The study was approved by the Institutional Review Board at the lead university and conducted in cooperation with the universities where the survey was distributed for data collection. Participation in the study was voluntary, and students could opt out of the survey at any time.

This study used SEM to examine the direct and indirect effects of four exogenous variables (achievement striving, grit, peer interaction, faculty interaction) on one endogenous variable (academic belonging). We used major satisfaction and major valuing as mediator variables. Our analytical strategy included measurement model analysis and structural model analysis. First, measurement model analysis was conducted to examine the relationship between the latent variables and their measures. Next, a structural model analysis was conducted to explore the hypothetical dependencies of the variables included in the model in Figure 1 (Hoyle, 2011; Kline, 2010).

5.2 | Measurement

Items of the PosSE survey were used to measure the constructs of interest to this study. The survey used six sub-scales that measure engineering student engagement and sense of belonging in their academic disciplines relative to their interaction with other students and faculty (Simmons, Hunsu, & Adesope, 2019). The constructs were major

TABLE 2 Demographic data of study participants.

	Number of students	Percent
Gender		
Man	532	62.7
Woman	308	36.3
Other	7	<1
Not reported	2	<1
Race		
Asian	62	7.3
Black/African American	103	12.1
Hispanic/Latino(a)	232	27.3
Others	38	4.5
White	414	48.8
Enrollment status		
First year	216	25.4
Sophomore year	153	18
Junior year	202	23.8
Senior year	218	25.7
Fifth year and beyond	60	7.1
Age		
<20	280	33
20–24	492	58
25–29	50	5.90
30–45	26	3.10
>45	1	<1

satisfaction, major valuing, achievement striving, peer interaction, positive faculty relationship (interaction), and academic discipline belonging, as identified in previous work that used exploratory and confirmatory factor analysis (CFA) to conclude the best fit factor model (Simmons, Hunsu, & Adesope, 2019). The sub-scales were assessed on a 5-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree).

The *major satisfaction* sub-scale included five items that capture students' perceptions about their overall satisfaction with (and felt emotional connection to) their majors. Sample items included the following: "I don't intend to change my major from my current major to another," and "I think I will be very happy to spend the rest of my career in my current major." The *academic discipline belonging* sub-scale included three items that measure perceptions of acceptance or sense of felt inclusiveness within one's academic department or unit. The following items were included: "I do not feel a strong sense of 'belonging' to my academic discipline," "I do not feel like 'part of the family' in my academic discipline." The *achievement striving* sub-scale used five items to assess participants' perceptions of their actions being unconstrained by situational (Bateman & Crant, 1993) factors in schools. Items included "I am constantly on the lookout for new ways to improve my life" and "If I believe in an idea, no obstacle will prevent me from making it happen."

Items on the *peer interaction* sub-scale used four items to capture participants' perceptions about their involvement and interactions with peers, such as "I discuss academic issues with peers" and "I discuss social issues with peers." *Faculty interaction* included three items to capture participants' views about how satisfied they felt with how they were treated by faculty or instructors in their program. Sample items included "The instructors in my program respect me" and "I am satisfied with the faculty in my major." The *major valuing* sub-scale included five items to capture participants' perceptions about their sense of identification with their chosen major and included "It matters to me how well I do in my major at school" and "Being good at my major is an important part of who I am." The survey also included eight items from the grit scale (Duckworth & Quinn, 2009). Recent research has demonstrated that grit's utility is maximized when deconstructed into passion and perseverance (e.g., Bowman et al., 2015; Credé et al., 2017; Verdín et al., 2018); the same approach was taken in this study.

6 | RESULTS

6.1 | Preliminary analysis

Mean scores and standard deviations (SD) of students' responses to the survey questions ($n = 849$) are reported in Table 3. The internal consistency reliability coefficient for the factors on the scale ranged between .74 and .90 Cronbach alpha (α). The data were examined for normality using the criterion ± 2 value proposed by Gravetter and Wallnau (2014). Skewness and kurtosis statistics showed no deviations from the normality for all the variables. Small to high Pearson's correlation coefficients among the variables were observed (see Table 4). Significant correlations were observed between academic belonging and other variables. The correlation between passion and peer interaction was small, negative, and significant.

6.2 | Measurement model analysis

A CFA was conducted using the lavaan package in R programming software (R version 4.0.3) to examine the fits of the measurement model of the variables used in this study (R Core Team, 2021; Rosseel, 2012). Two competing measurement models were compared with the base or null model as seen in Table 5. The first model comprised eight latent variables: major satisfaction (MJSAT), major valuing (MJVAL), achievement striving (ACSTR), peer interaction (PEINT), positive faculty relation (FCREL), passion (PASSI), perseverance (PERSE), academic belonging (ACBEL), and 31 observed variables. Model fit adequacy was evaluated against the recommended threshold of fit indices: comparative fit index (CFI) ≥ 0.95 , Tucker-Lewis index (TLI) ≥ 0.95 , root mean squared error of approximation (RMSEA) ≤ 0.06 , and standardized root mean squared residual (SRMR) ≤ 0.08 (Browne & Cudeck, 1993; Hu & Bentler, 1999; Marsh et al., 2004; McDonald & Ho, 2002). The CFA result indicated that the measurement model had a good statistical fit: Chi-square result, $\chi^2(401) = 1305.86$, $p < .001$, RMSEA = 0.052, SRMR = 0.050, CFI = 0.938, TLI = 0.928, indicating good factor structure and construct validity. Standardized loading coefficients for the measurement model ranged between 0.497 and 0.938 as shown in Table 6. The second model, comprising seven latent variables (major satisfaction [MJSAT], major valuing [MJVAL], achievement striving [ACSTR], peer interaction [PEINT], positive faculty relation [FCREL], grit, academic belonging [ACBEL], and 31 observed variables) had worse model fit indices from the CFA result compared to the first model: Chi-square result, $\chi^2(408) = 2233$, $p < .001$, RMSEA = 0.073, SRMR = 0.076, CFI = 0.874, TLI = 0.857.

6.3 | Structural model analysis

An SEM analysis was conducted using the R programming software to examine the structural validity of the hypothesized model. Achievement striving (ACSTR), peer interaction (PEINT), positive faculty relation (FCREL), and grit (GRIT) were specified as exogenous variables; major satisfaction (MJSAT) and major value (MJVAL) were specified as mediators; and academic belonging (ACBEL) was specified as the outcome variable. The SEM analysis was based on maximum likelihood estimation because the factors were normally distributed (Kline, 2010). Model fit for the hypothesized model in Figure 2 was marginal: Chi-square result, $\chi^2(408) = 2319.825$, $p < .001$, CFI = 0.867, TLI = 0.849, RMSEA = 0.074, SRMR = 0.082. A post hoc SEM analysis in which the components of grit (passion and perseverance) were specified as separate constructs yielded a good fit model: Chi-square result, $\chi^2(401) = 1394.05$, $p < .001$, RMSEA = 0.054, SRMR = 0.056, CFI = 0.932, TLI = 0.921. Hence, the ad hoc model informs the discussions of the analysis in the next section.

6.3.1 | Direct effects

The standardized coefficients for the final model in Figure 3 show that the direct effects of peer interaction ($\beta = .096$, $p = .050$), positive faculty relation ($\beta = .109$, $p = .041$), passion ($\beta = .255$, $p < .001$), and perseverance ($\beta = -.253$, $p < .001$) on academic belonging were significant. On the contrary, the direct effect of achievement striving on predicting academic belonging was not significant ($\beta = .191$, $p = .226$).

TABLE 3 Descriptive statistics of variables in the study.

Variables	Mean	SD	Skewness	Kurtosis	Cronbach's α
MJSAT	3.39	0.52			.85
Q69_32	3.38	0.60	-0.50	-0.08	
Q69_2	3.47	0.66	-1.26	2.00	
Q69_21	3.33	0.66	-0.64	0.11	
Q69_22	3.24	0.75	-0.81	0.43	
Q69_20	3.54	0.58	-0.94	0.50	
MJVAL	3.43	0.57			.88
Q69_26	3.46	0.60	-0.73	0.09	
Q69_24	3.49	0.58	-0.71	0.14	
Q69_25	3.33	0.70	-0.81	0.35	
ACSTR	3.18	0.53			.83
Q69_30	3.04	0.72	-0.20	-0.66	
Q69_16	3.29	0.61	-0.39	0.02	
Q69_29	3.04	0.73	-0.19	-0.78	
Q69_31	3.13	0.72	-0.36	-0.43	
Q69_23	3.40	0.62	-0.63	-0.10	
PEINT	3.19	0.62			.88
Q69_49	3.24	0.69	-0.59	0.14	
Q69_48	3.31	0.64	-0.56	0.12	
Q69_50	3.19	0.75	-0.75	0.41	
Q69_51	3.01	0.81	-0.54	-0.16	
FCREL	3.18	0.59			.86
Q69_3	3.23	0.63	-0.57	1.00	
Q69_18	3.12	0.72	-0.72	0.81	
Q69_15	3.20	0.66	-0.75	1.40	
PASSI	2.59	0.62			.80
Q69_52	2.83	0.75	-0.16	-0.39	
Q69_54	2.59	0.76	0.06	-0.42	
Q69_56	2.52	0.76	0.14	-0.37	
Q69_57	2.43	0.84	0.13	-0.55	
PERSE	3.18	0.49			.74
Q69_58	3.10	0.69	-0.33	-0.27	
Q69_59	3.31	0.59	-0.31	-0.05	
Q69_53	2.83	0.75	-0.07	-0.53	
Q69_55	3.50	0.58	-0.77	0.22	
ACBEL	1.97	0.77			.90
Q69_1	2.00	0.84	0.47	-0.48	
Q69_17	1.99	0.85	0.47	-0.51	
Q69_27	1.93	0.84	0.64	-0.18	

6.3.2 | Indirect effects

A bootstrap procedure was executed to examine the indirect effects of the exogenous variables via the mediation paths. An indirect effect is significant if the 95% CI of its estimate does not include zero (Shrout & Bolger, 2002). Table 7

TABLE 4 Pearson correlations among variables of MJSAT, MJVAL, ACSTR, PEINT, FCREL, PASSI, PERSE, and ACBEL ($n = 849$).

Variables	1	2	3	4	5	6	7	8
1. MJSAT	1							
2. ACBEL	.525**	1						
3. MJVAL	.569**	.324**	1					
4. ACSTR	.424**	.239**	.474**	1				
5. PEINT	.310**	.188**	.279**	.449**	1			
6. FCREL	.457**	.328**	.351**	.342**	.248**	1		
7. PERSEV	.442**	.199**	.428**	.586**	.375**	.368**	1	
8. PASSI	.152**	.269**	0.054	-0.030	-.131**	0.019	.103**	1

** $p < .01$.

TABLE 5 Measurement model comparison.

Model	χ^2	df	CFI	TLI	SRMR	RMSEA	BIC	AIC
Null	1496	465						
Model 1 (perseverance and passion)	1309	401	0.938	0.928	0.050	0.052	42,646	42,246
Model 2 (grit)	2233	408	0.874	0.857	0.076	0.073	43,526	42,961

shows the results of the estimated effects with their corresponding 95% confidence intervals. The results showed that the indirect paths through major satisfaction were significant and that major satisfaction partially mediated the effects of peer interaction ($\beta = .0869$, $p < .001$), faculty relationship ($\beta = .144$, $p < .001$), and passion ($\beta = .096$, $p = .007$) on academic belonging. Major satisfaction also completely mediated the effect of perseverance on academic belonging. Major valuing, however, did not mediate the effects of any of the predictor variables examined on academic belonging.

7 | DISCUSSION

A sense of belonging to an academic community has significant implications for students' experiences and outcomes (Thomas, 2012). In addition, belonging affects students' motivation to learn and commitment to school (Osterman, 2000). Previous studies have examined academic belonging as an antecedent (or predictor) of many other educational outcomes among university students. Across the literature, outcomes such as retention (Davis et al., 2019), intention to persist (Hausmann et al., 2007), motivation (Freeman et al., 2007), and grit (Verdín et al., 2018) have been shown to predict belonging, across different student populations and contexts to which they feel belonging.

The current study proposed that social engagement factors (peer and faculty interaction) and intrapersonal factors (achievement striving and grit) would predict academic belonging. Grit was later deconstructed as passion and perseverance, as extant literature (Credé et al., 2017; Direito et al., 2021) and our model analysis suggested. Furthermore, we proposed that students' valuing of and satisfaction with their academic discipline would mediate the effects of these variables on their sense of belonging in engineering. A conceptual model of academic belonging derived from the literature was evaluated using the SEM technique to address the research questions underlying this study.

Related to the intrapersonal factor of achievement striving, past research has stemmed from proactive personality in the workplace. A meta-analytic review of these studies indicated that proactive personality is associated with career success and career satisfaction and is positively related to empowerment (Fuller & Marler, 2009). Similarly, a longitudinal study of employees' behaviors showed that proactive personality positively correlates with career satisfaction (Seibert et al., 2001). The analysis of our conceptual model suggested that achievement striving had no significant direct effect on academic belonging. However, the mediation analysis of the conceptual model showed that it had a significant indirect effect on belonging via major satisfaction. This result indicates that major satisfaction completely mediated the effect of achievement striving on belonging in the sample examined. It suggests that proactive students may experience

TABLE 6 Results for the measurement model ($n = 849$).

Latent construct	Observed variables	λ	SE	Residual variance (δ)
MJSAT	Q69_32	0.778***	0.017	0.394
	Q69_2	0.534***	0.028	0.715
	Q69_21	0.794***	0.017	0.370
	Q69_22	0.740***	0.020	0.452
	Q69_20	0.796***	0.016	0.366
MJVAL	Q69_24	0.893***	0.010	0.202
	Q69_25	0.743***	0.017	0.448
	Q69_26	0.938***	0.008	0.121
ACSTR	Q69_30	0.724***	0.020	0.475
	Q69_16	0.755***	0.019	0.430
	Q69_29	0.710***	0.021	0.497
	Q69_31	0.644***	0.023	0.585
	Q69_23	0.693***	0.022	0.520
PEINT	Q69_49	0.915***	0.025	0.163
	Q69_48	0.887***	0.027	0.213
	Q69_50	0.766***	0.024	0.413
	Q69_51	0.606***	0.029	0.633
FCREL	Q69_3	0.937***	0.011	0.122
	Q69_18	0.695***	0.02	0.517
	Q69_15	0.849***	0.014	0.280
PASSI	Q69_52	0.493***	0.031	0.757
	Q69_54	0.644***	0.025	0.585
	Q69_56	0.808***	0.020	0.348
	Q69_57	0.811***	0.020	0.342
PERSE	Q69_58	0.688***	0.023	0.527
	Q69_59	0.744***	0.021	0.446
	Q69_53	0.521***	0.030	0.729
	Q69_55	0.680***	0.023	0.537
ACBEL	Q69_1	0.848***	0.012	0.282
	Q69_17	0.872***	0.011	0.239
	Q69_27	0.889***	0.011	0.210

Note: Chi-square result, $\chi^2(401) = 1305.86$, $p < .001$, RMSEA = 0.052, SRMR = 0.050, CFI = 0.938, TLI = 0.928.

*** $p < .001$.

a greater sense of belonging if they find the educational experience that they get in their discipline to be satisfying. Consequently, personal achievement striving alone may be insufficient to foster belonging.

Related to the intrapersonal factor of grit, the sample data better supported (validated) the ad hoc model of belonging (Figure 3) than the hypothesized model (Figure 2). Hence, our study provided empirical evidence supporting deconstructing grit as passion and perseverance. Perseverance did not have a significant direct and positive effect on academic belonging as anticipated. However, it had a significant indirect effect on academic belonging—via major satisfaction. As with achievement striving, the evidence suggests that students who persevere in their discipline and find their discipline satisfying are more likely to have a higher sense of belonging in engineering. Unlike perseverance, however, the direct effect of passion on academic belonging was significant. Our results also indicate that the effect of passion on belonging was partially mediated by major satisfaction. This observation aligns with some of the fundamental propositions of Duckworth and colleagues in their pioneering work on grit (Duckworth et al., 2007; Duckworth & Quinn, 2009).

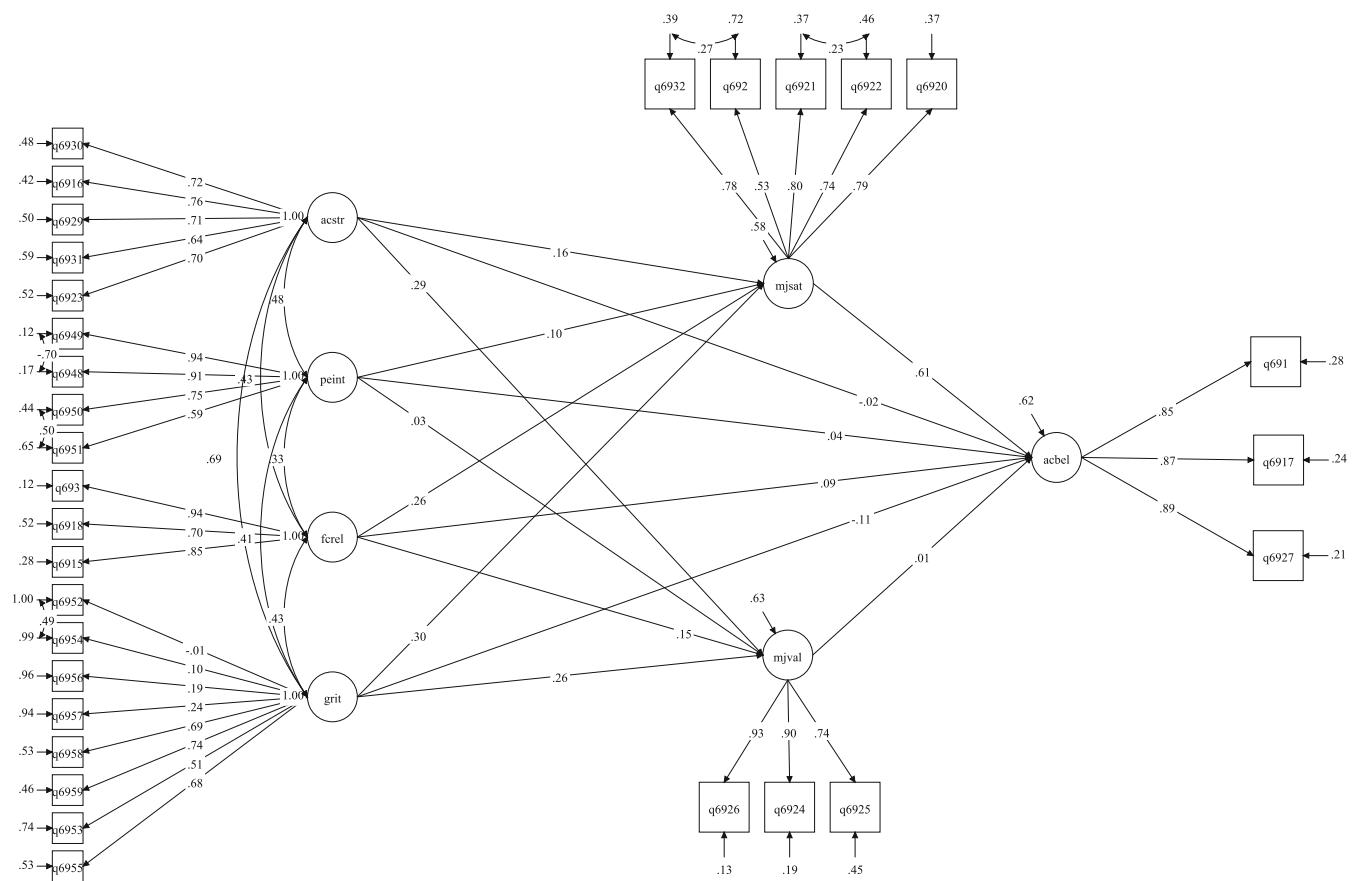


FIGURE 2 Hypothesized model of undergraduate engineering students' belonging.

Related to the interpersonal factors, the results show that the direct effect of positive faculty relationships on academic belonging was significant. However, it was observed that satisfaction partially mediated that relationship. Lastly, the results show that peer interaction had a significant, direct effect on academic belonging. Although satisfaction partially or fully mediated the effects of the previous variables on belonging, neither satisfaction nor valuing was a significant mediator of peer interaction's effect on academic belonging. This observation indicates that the effect of peer interaction on academic belonging did not depend on major satisfaction or major valuing. We further observed that major valuing was not a significant predictor of belonging.

7.1 | Relevance of findings to prior research

Relative to the other variables examined in this study, peer interaction was the most robust contributor to belonging; its effect on belonging was not dependent on major satisfaction or major valuing. Concerning the magnitude of these effects, we observed that both variables of social engagement (peer interaction and positive faculty relationships) were better predictors of belonging than the individualistic variables of achievement striving, passion, and perseverance. This finding is supported by different theoretical models of student persistence, retention, and integration in college—especially those championed by Tinto (1990) and Astin (1984)—that convey the importance of peer and faculty interactions as critical factors in forging belonging and promoting student retention. Similarly, the contributions of both peer and faculty relationships to belonging have been tested and supported in past empirical research (Hoffman et al., 2002; Zumbrunn et al., 2014) and supported by Baumeister and Leary's (1995) belonging hypothesis that centers frequent and positive interactions with the same people.

In addition to identifying the importance of these social engagement factors, our model highlights a nuance about the relationships we investigated between satisfaction and belonging. Some studies (Civitci, 2015; Fan et al., 2020; Gibson, 2010)

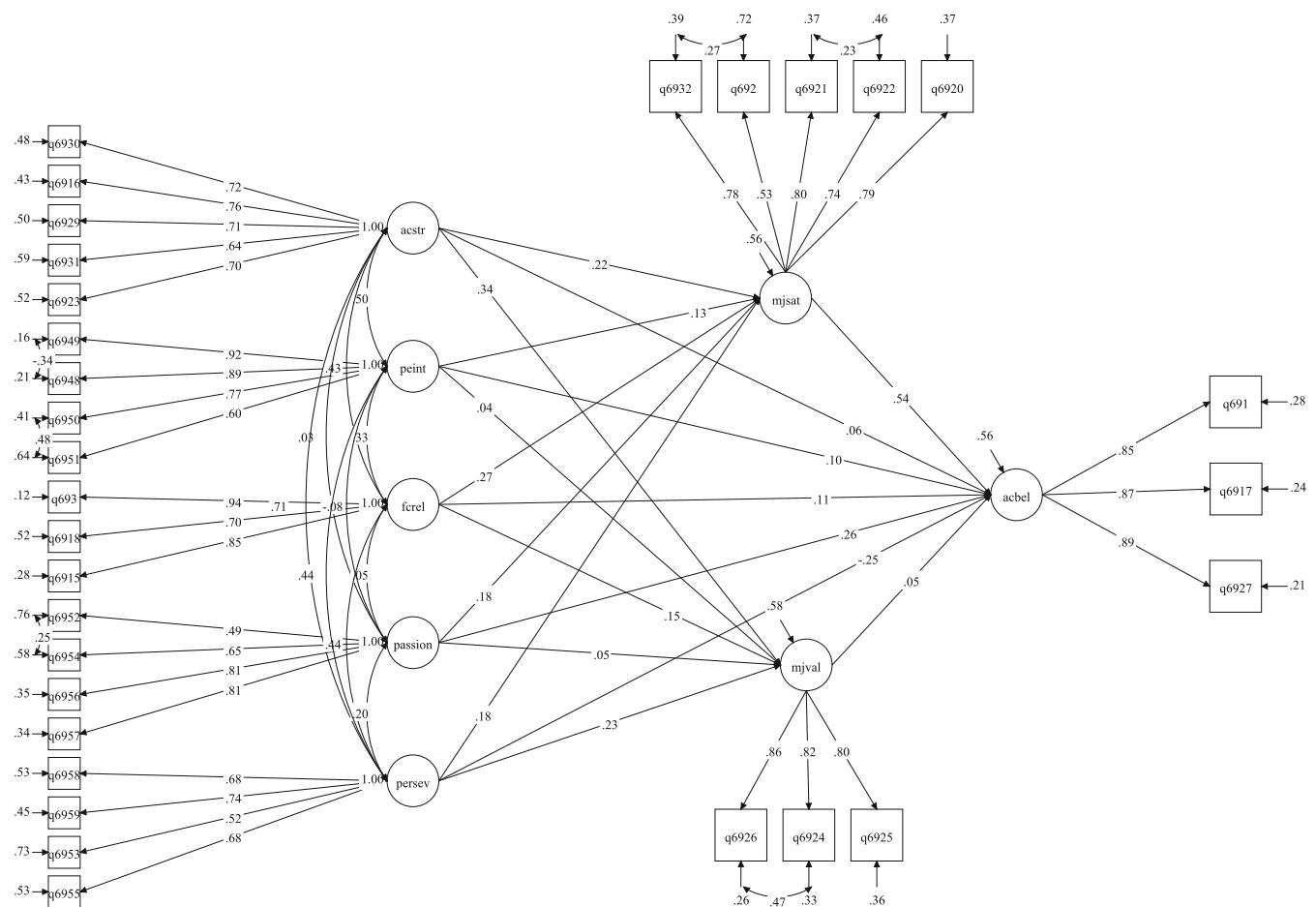


FIGURE 3 Ad hoc model after modification.

TABLE 7 Path coefficients of the model.

Path	Estimated effect	SE	95% CI	p
PEINT → MJVAL → ACBEL	0.002	0.001	[0.000, 0.005]	.065
FCREL → MJVAL → ACBEL	0.008	0.010	[-0.005, 0.022]	.446
ACSTR → MJVAL → ACBEL	0.017	0.023	[-0.012, 0.048]	.450
PASSION → MJVAL → ACBEL	0.003	0.004	[-0.003, 0.008]	.515
PERSEV → MJVAL → ACBEL	0.011	0.009	[-0.004, 0.002]	.213
PEINT → MJSAT → ACBEL	0.069	0.015	[0.029, 0.067]	.000
FCREL → MJSAT → ACBEL	0.144	0.038	[0.123, 0.206]	.000
ACSTR → MJSAT → ACBEL	0.118	0.049	[0.102, 0.222]	.016
PASSION → MJSAT → ACBEL	0.096	0.036	[0.061, 0.138]	.007
PERSEV → MJSAT → ACBEL	0.099	0.051	[0.027, 0.161]	.050

have reported that belonging predicts satisfaction among university students. In each instance of these studies, satisfaction was constructed as an outcome variable and belonging as its predictor. However, our study indicates that the relationship between satisfaction and belonging can be bidirectional—meaning that having a sense of satisfaction can influence belonging, and vice versa. Our study further highlights that major satisfaction partially or fully mediates between individual and social constructs of engagement in academic belonging.

7.2 | Implications for research and practice

Given how students' sense of belonging factors into their university experience, wellbeing, and progression, there is a growing focus on fostering university students' belonging (Thomas, 2012). We argue that interventions, research projects, and policies should then consider the factors that predict belonging, rather than treating belonging solely as an antecedent. Given the contextuality of belonging, it is also important to center a specific population and context. Our model builds on previous work that has primarily looked at belonging among pre-university students or not specific to the engineering discipline. The present study extended the ongoing discourse about belonging in engineering by exploring its relationships with individual and social engagement factors among undergraduate engineering students across multiple institutions. Although we focused on a set of interpersonal and intrapersonal factors, future engineering education research may further explore the complex relationships between academic belonging and broader sociocultural variables. More robust theoretical and conceptual models of belonging in engineering may continue to evolve, as more engineering education research reconsiders belonging as an important outcome variable and not only as a predictor of educational outcomes.

Belonging as a fundamental human need has important implications for how students feel, develop, and perform in engineering programs. Hence, gaining a better understanding of the factors that influence how students develop a sense of belonging can elucidate what institutional structures inhibit belonging and what interventions can be leveraged to nurture students' sense of belonging in engineering. Although individual agency plays a role in developing and maintaining belonging, this study suggests that social interactions may have more salient effects on belonging. For instance, the study pointed out that social interactions between student peers and faculty were more consequential predictors of belonging than individual grit and achievement-striving factors. The observation also suggests that students tend to have a greater sense of satisfaction within their discipline when there is a positive social climate between them and their peers and faculty members. Thus, institutional variables and interventions that foster satisfaction could promote a greater sense of belonging in students. In addition, students' satisfaction with their academic major and overall university experience has gained increased attention over the last few decades, especially as higher education has been recognized as a service industry with students being customers (Ammigan & Jones, 2018; Douglas et al., 2008).

Our proposed and validated model provides novel insights into undergraduate engineering students' belonging that contribute to the ongoing conversation in engineering education around fostering students' sense of belonging. In light of isolation and remote teaching necessitated by the COVID-19 pandemic, students' sense of belonging has become a greater focus (see, e.g., Buckley et al., 2023; Fletcher et al., 2023; Misra et al., 2023), and we aim to provide theoretical and empirical implications that advance ongoing work to better support engineering students by highlighting the role of peer and faculty interaction and the mediating role of students' satisfaction with and valuation of their discipline.

7.3 | Limitations of this study

The internal reliabilities of the sub-scales used in this study were mostly very high (above $\alpha > .8$). However, the study was based on students' self-report about the factors examined in our study. Additionally, this correlational study cannot ascertain causality between the variables. Hence, we acknowledge the need for caution in interpreting our data. This study drew on student samples from multiple institutions that may have unique college experiences that influence their students' belonging in their engineering majors. Unfortunately, we could not examine potential institutional differences in perceived belonging in academic majors because our dataset did not have a proportionate participant distribution across the institutions sampled. Similarly, we were unable to explore differences in belonging across gender, ethnicity, and age groups. Future studies may extend this study by drawing on a broader and larger sample from the undergraduate engineering student population.

8 | CONCLUSION

The current study evaluated the validity of a model that proposed undergraduate students' belonging in engineering as an outcome variable. The study sampled engineering students across six universities to examine the comparative effects

of intrapersonal and interpersonal variables on participants' sense of academic belonging in their discipline. The study further explored whether students' satisfaction and valuing of their academic discipline mediated this effect.

Achievement striving did not affect academic belonging directly, but it had a small indirect effect on sense of belonging if students found their experiences in their academic discipline satisfying. In the same vein, perseverance alone was insufficient to have a statistically significant effect on belonging. Hence, personal striving behaviors alone may not foster a sense of belonging if other factors (especially institutional factors) fail to cultivate feelings of satisfaction in students. Of the individualistic variables, only passion had a significant direct effect on participants' sense of academic belonging. Social interaction and engagement indicators had a more consequential effect on participants' feelings of belonging in engineering than individual factors. The study highlights the significance of students' satisfaction in their educational experiences on academic belonging. Lastly, the sense of value students ascribed to their majors did not predict academic belonging. This work highlighted treating academic belonging as an outcome variable that is supported through peer and faculty interaction and cultivated via students' satisfaction in their engineering major.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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