Building Commitment in First-Year Engineering Students: Socio-Cognitive Factors and Parallel Mediation Pathways

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Abstract

This Complete Research Paper details a study on the socio-psychological factors that sustain academic commitment—and, by extension, persistence—in first-year engineering students. The first-year transition is a period of heightened uncertainty during which cognitive and emotional resources significantly influence day-to-day engagement. Building on Social Cognitive Theory, Self-Determination Theory, Expectancy-Value Theory, and models of academic and social integration, we investigate how three personal factors—self-efficacy, self-regulation, and intrinsic motivation—translate into academic commitment through two direct mechanisms: sense of belonging to the significant and perceived value of coursework.

We conducted a cross-sectional study in a required first-semester engineering course ($N = 554$) at a large engineering school in Chile. Students completed a validated Likert-scale instrument measuring self-efficacy, self-regulation, intrinsic motivation, sense of belonging to the major, perceived value of coursework, and academic commitment (behavioral/cognitive engagement). We estimated multiple-mediator path models using observed variables, employing robust standard errors and confidence intervals. Three theoretically motivated specifications were compared: parallel mediation via belonging and value (Model 1); single mediator belonging (Model 2); and single mediator value (Model 3). Model adequacy was evaluated with robust CFI/TLI, SRMR, and information criteria (AIC/BIC). We report explained variance (R^2) and standardized effects.

The two-mediator model (Model 1) provided the best fit (robust CFI ≈ .96; SRMR ≈ .03; lowest AIC/BIC) and explained 41% of the variance in academic commitment ($R^2 = .409$). Both mediators were well explained by the predictors (R^2belonging = .306; R^2value = .291) and exhibited significant residual covariance, consistent with their conceptual proximity. In Model 1, self-efficacy showed partial mediation, combining a significant direct effect on commitment ($\beta \approx .275$, $p < .001$) with a total indirect effect ($\beta \approx .190$, $p < .001$) through belonging and value. In contrast, intrinsic motivation ($\beta\_indirect \approx .126$, $p < .001$) and self-regulation ($\beta\_indirect \approx .145$, $p < .001$) operated primarily through the mediators; their direct paths to commitment were not statistically significant once mediators were included. Among the mediators, sense of belonging exerted the stronger direct effect on commitment ($\beta \approx .313$, $p < .001$) relative to perceived value ($\beta \approx .169$, $p < .001$). Sensitivity analyses showed that models with only one mediator performed less effectively. Removing value (Model 2) decreased the model's fit and simplicity, while excluding belonging (Model 3) caused the greatest decline, reducing R^2 for commitment to .355. Collectively, the evidence supports complementary pathways through which personal resources translate into day-to-day engagement: identity/connection (belonging) and purpose/relevance (value).

The findings suggest efforts to improve persistence should target immediate mechanisms. First, fostering belonging—helping students see themselves as part of the engineering community and connected to peers and faculty—can significantly improve commitment during the first year when "belonging uncertainty" is high. Second, course and program designs that highlight and reinforce the value by explaining why concepts and tasks matter for students' careers and societal impact add explanatory power beyond belonging alone.

Third, because self-efficacy links directly to commitment, programs should offer experiences that help students recognize progress and build confidence early and consistently. Fourth, self-regulation is an enabling skill that boosts belonging and value; supporting goal setting, planning, and monitoring helps sustain engagement. Addressing these factors during the first year is vital, as identities are shaped, expectations set, and habits developed. Tackling belonging, value, self-efficacy, and self-regulation together creates a framework to align instructional practices, supports, and advising with the psychological factors most influential based on current evidence commitment.
This study explains how core socio-psychological factors—belonging and perceived value—drive academic commitment, with self-efficacy providing additional support. The model guides the alignment of first-year practices and supports to enhance commitment and retention. Limitations include its cross-sectional design and reliance on observed scores, which may compromise the results. Future research will test longitudinal models and subgroup variations. Overall, findings guide first-year engineering efforts to boost engagement, persistence, and success.

Keywords: First-Year Engineering, Academic Commitment, Student Persistence, Sense of Belonging, Perceived Value, Self-Efficacy, Self-Regulation, Intrinsic Motivation, Path Analysis, Mediation Analysis, Socio-Cognitive Factors

Introduction

Engineering programs persistently face the challenge of supporting their students during the transition to the first year, a period in which academic demands increase, peer and faculty relationships are reconfigured, and expectations about what it means to "be an engineer" begin to solidify. In this critical stage, academic engagement serves as a particularly relevant lens for understanding the trajectory's continuity: beyond overall satisfaction, it captures the sustained psychological investment and the student's willingness to persevere in earning their degree. Evidence in higher education indicates that academic engagement can be conceptualized and measured as a distinct construct from satisfaction and is positively associated with performance and progression in engineering and educational programs.[1]–[3] From an applied perspective, positioning engagement as an immediate outcome is relevant for engineering schools that require actionable indicators capable of guiding timely pedagogical decisions and early supports before disengagement translates into delays or dropout.
The literature also shows that academic engagement is closely related to the personal resources students mobilize in response to university demands, particularly motivational factors and self-regulation. In this regard, large quantitative syntheses have found that variables such as self-efficacy, along with other motivational and self-regulatory factors, are among the strongest psychological predictors of performance and retention outcomes in higher education. This evidence indicates that difficulties in persisting through the first year are not only due to contextual variables or academic background but also largely depend on beliefs about one's own ability and the skill to maintain effort and learning strategies in highly demanding environments.

At the same time, several recent studies have highlighted the fragility of early engagement in changing higher education environments. For example, post-pandemic evidence in basic math courses indicates declines in perceptions of preparedness and commitment, which are associated with lower performance and higher dropout rates, reinforcing the need to monitor engagement processes from the initial stages of the curriculum. Additionally, research on pedagogical interventions, such as educational escape room activities, flipped classroom designs, and gamified approaches, indicates that when course experiences increase participation and enjoyment, there are often concomitant improvements in academic engagement and performance. Taken together, these findings justify further exploration of the mechanisms through which personal resources translate into sustained commitment during the first year.

However, the first-year experience is not uniform. In engineering, distinct student profiles have been identified based on levels of motivation, self-regulation, and commitment, associated with different patterns of participation, satisfaction, and academic outcomes.[9], [10] Likewise, emerging evidence in Latin American contexts suggests that socio-cognitive factors are relevant for understanding early trajectories in STEM, which reinforces the need to examine explanatory models in institutional and cultural environments that are less represented in the dominant literature.[11] This is particularly relevant for institutions seeking evidence-based strategies that are also sensitive to the local context and the characteristics of their student body.

This study aims to investigate the relationship between key personal resources, such as self-efficacy, self-regulation, and intrinsic motivation, and academic commitment among first-year engineering students. Specifically, it seeks to determine whether these relationships are mediated by two central direct evaluations crucial for early involvement: a sense of belonging to the field and the perceived value of STEM studies. By testing and comparing alternative mediation models, the research intends to enhance understanding of how academic engagement develops during the initial transition to engineering education. Furthermore, it aims to provide valuable evidence to inform teaching practices and targeted institutional support systems that foster early persistence.

Literature Review

This section reviews research on academic commitment and related socio-cognitive factors that are central to this study, including self-efficacy, self-regulation, intrinsic motivation, sense of belonging, and perceived value in STEM. It uses this body of work to provide context and justify the proposed model for first-year engineering students.

Academic commitment and persistence in higher education

Academic commitment is commonly conceptualized as students' decision and sustained psychological investment in completing their studies, beyond momentary satisfaction or general well-being. Research in South African higher education has shown that academic commitment can be reliably measured and distinguished from satisfaction, and that it is positively associated with achievement and progression in education and engineering programs [1]-[3]. Large-scale syntheses further indicate that motivational and self-regulatory variables such as self-efficacy, effort regulation and achievement goals are among the strongest psychological correlates of academic performance and retention [4]. Research on pre-calculus in post-pandemic contexts shows that decreases in engagement and perceived preparedness are accompanied by declines in performance and increased course repetition, underscoring the fragility of early commitment [5]. Intervention studies in higher education—such as educational escape rooms for programming, flipped classroom implementations and gamified course designs—report that when instructional practices increase students' involvement and enjoyment, academic commitment and course performance tend to improve [6]-[8].

Studies in engineering programs have identified profiles of students differentiated by their levels of motivation, academic commitment, and self-regulation, and have shown that these profiles are associated with different patterns of engagement, satisfaction, and academic outcomes [9]-[10]. In Latin American contexts, emerging work has begun to examine socio-cognitive factors and academic commitment among engineering cohorts, underscoring their relevance for understanding early STEM trajectories [11]. Taken together, this body of research supports treating academic commitment as a direct outcome that is closely tied to persistence in first-year engineering. Building on this evidence, the present study operationalizes academic commitment as the focal outcome, examining how it is shaped by socio-cognitive resources and near-term appraisals during the first semester of engineering studies.

Socio-cognitive frameworks for understanding commitment

The socio-cognitive model tested in this study is grounded in three complementary perspectives, namely Social Cognitive Theory, Self-Determination Theory, and Expectancy-Value Theory [12]-[16]. Social Cognitive Theory emphasizes reciprocal interactions between personal factors, behaviors, and the environment, and positions self-efficacy as a central determinant of effort, persistence, and resilience in academic tasks [12]. Self-Determination Theory highlights the importance of autonomy, competence, and relatedness for high-quality motivation and sustained engagement in learning [13], [17]. Expectancy-Value Theory explains how students' expectations for success and their perceived value of academic tasks jointly shape achievement, engagement, and educational choices, including participation in STEM fields [14]-[16]. Empirical work with STEM and underrepresented student populations shows that higher academic and domain-specific self-efficacy predicts stronger persistence intentions and lower attrition, partly through its relationship with commitment and identity processes [2], [3], [18]-[19].

Self-Determination Theory adds that students are more likely to exhibit sustained commitment when their needs for autonomy, competence, and relatedness are met. Multiple studies indicate that intrinsically motivated students, who find their learning interesting and personally meaningful, tend to use more effective learning strategies, demonstrate greater engagement, and have lower intentions to drop out of science and engineering courses [20]-[22].

Expectancy-Value Theory (EVT) provides a more fine-grained account of how beliefs about competence and value shape achievement, course-taking, and career choices. Foundational and recent EVT work shows that students' expectations for success and their task values (interest, utility, importance, and cost) together predict STEM achievement, persistence, and career aspirations, often with gendered patterns [16], [23]-[26]. Longitudinal and network-analytic studies around the transition to higher education reveal that changes in expectancies, values, and perceived costs are closely linked to changes in behavioral engagement and dropout intentions in early-college engineering [27]-[30].

Sense of belonging and perceived value as direct (proximal) mechanisms

Several studies examine sense of belonging and related constructs, such as sense of purpose, identity, and social integration, as key predictors of persistence in STEM and higher education. Belonging is typically defined as students' perception of being accepted, valued, and fitting in their academic community. Longitudinal work in STEM research experiences, place-based programs, and first-year seminars shows that gains in belonging and purpose are associated with greater engagement, stronger identification with the field, and higher intentions to remain in STEM pathways [31]-[33]. Studies of engineering undergraduates similarly demonstrate that sense of belonging in engineering predicts GPA, satisfaction, and persistence over and above demographic and preparation variables [34], [35].

Recent work highlights that institutions can actively shape students' belonging through learning communities, cohort models, co-curricular engagement, and mentoring structures [36]-[38]. Studies in European and South African universities further document that changes in belonging across the first year are closely tied to academic adjustment and intentions to persist, reinforcing the idea that belonging is particularly fragile during transition periods [39], [40].

In parallel, the EVT-based literature underscores the role of the perceived value of STEM subjects and programs. The Value-Expectancy STEM Assessment scale, which the present study adapts, was developed to measure interest and perceived usefulness of STEM coursework and careers, and its scores have been linked to a STEM career choice and persistence intentions [41]. Other EVT studies show that students' task values in mathematics and science predict both achievement and longer-term engagement, with distinct profiles of expectancy–value–cost linked to different patterns of satisfaction and course selection [24], [25]. Studies conducted in different contexts show that how students perceive the value and the costs of STEM subjects helps explain gender differences in STEM participation and motivation [42]-[44].

Several contributions explicitly compare the relative predictive power of competence beliefs and value beliefs. For instance, some studies find that while expectancy components are stronger predictors of immediate performance, value components uniquely predict course-taking intentions, STEM aspirations, and persistence decisions [16], [26], [45]. Others examine whether interaction terms between expectancy and value add explanatory power beyond models that include only their additive effects, with mixed but generally supportive evidence [46]. Despite this vast evidence, most studies model belonging and value separately rather than as concurrent mechanisms, leaving open questions about their relative and joint contributions to academic commitment in first-year engineering. The present study addresses this gap by specifying belonging and value as parallel direct mediators within the same model, allowing a direct comparison of their relative contributions to first-year commitment.

Personal resources: self-efficacy, self-regulation, and intrinsic motivation

In this paper, the term socio-cognitive factors refers to students' personal beliefs and motivational resources as they develop in interaction with their academic and social environments, such as self-efficacy, self-regulation, and intrinsic motivation. The reviewed literature also supports treating self-efficacy, self-regulation, and intrinsic motivation as foundational personal resources for commitment. Meta-analytic studies indicate that academic self-efficacy is among the strongest predictors of university success, remaining significant even when considering students' past academic records and other background variables [4]. In STEM domains, computer and research self-efficacy have been linked to persistence intentions, particularly for women and students from underrepresented backgrounds [19], [18], [47]. Engineering-specific studies similarly report that students with higher engineering self-efficacy display stronger expectations of success, more positive value beliefs, and better retention during transitions from diploma to degree programs [10], [48].

Self-regulated learning and motivational self-regulation are key factors linked to academic success and commitment. Research on university students' motivational self-regulation strategies indicates that students who actively control their motivation, by setting goals, seeking relevance, and regulating emotions, tend to experience more positive classroom environments, greater engagement, and a reduced risk of dropout [49], [50]. Research on pro-social skills and EVT in STEM indicates that self-regulated and cooperative learners are more likely to hold positive expectancy-value beliefs and to persist in their studies [45]. Cluster analyses of engineering students' noncognitive profiles also identify groups characterized by high self-regulation, high motivation, and high commitment, which tend to show better academic outcomes than low-self-regulation profiles [9], [51].
Intrinsic motivation and interest emerge as additional levers of commitment. Longitudinal studies show that students' intrinsic value and enjoyment change over time as classroom conditions change, for example, in response to teaching practices and assessment, and that these changes are closely related to both their immediate engagement and their later intentions to persist in the course or field [21], [30]. Across these strands, self-efficacy, self-regulation, and intrinsic motivation are positively interrelated, correlate with commitment and persistence, and are likely to exert both direct and indirect effects via belonging and value. Accordingly, the present study models these three resources as exogenous predictors in a unified path model, testing whether their effects on academic commitment operate directly, indirectly through belonging and value, or both.

Gap and contribution

Synthesizing the existing literature on academic commitment and STEM persistence, three key points emerge. First, academic commitment, understood as the decision and effort to complete one's degree, is a crucial immediate predictor of persistence and performance in higher education, especially in engineering programs [1]-[4], [11]. Second, socio-cognitive frameworks consistently emphasize the importance of personal resources like self-efficacy, self-regulation, and intrinsic motivation, along with direct assessments such as belonging, perceived value, and perceived cost, in shaping engagement and persistence [16], [23], [45], [49], [50]. Third, research on sense of belonging and value beliefs in STEM provides strong evidence that both are significant predictors of persistence, yet they have rarely been studied as simultaneous mediators within a unified framework, particularly for first-year engineering students and in Latin-American contexts [31], [34], [35], [39], [41].

The present study addresses this gap by testing a parallel-mediation model in which three personal resources, namely self-efficacy, self-regulation, and intrinsic motivation, predict academic commitment through two correlated direct (i.e., proximal, in expectancy–value and social-cognitive terminology [14], [16]) appraisals, namely sense of belonging to the engineering major and perceived value of STEM coursework. Using survey data from first-semester engineering students in Chile, the study directly compares models with a single mediator to those with two mediators. It estimates the relative contributions of belonging and value. In this way, it integrates and extends the socio-cognitive, expectancy-value, and belonging literature summarized above into a single explanatory model of how first-year engineering students build academic commitment.

Methodology

The sample consisted of 554 first-year engineering students enrolled in a required introductory course at a large private Chilean university. Participants' average age was 19.0 years (SD = 1.34), with ages ranging from 18 to 25 years. The sample was predominantly male: 82.7% identified as men (n = 458) and 17.3% as women (n = 96), a distribution that is broadly representative of the gender composition of the engineering school in which the study took place. Regarding financial support, 46.4% of students reported receiving a scholarship (n = 257), while 53.6% did not (n = 297). Overall, the sample reflects a traditional first-year engineering cohort transitioning directly from secondary education into university studies.

A structured survey instrument was administered, comprising scales for self-efficacy, self-regulation, intrinsic motivation, sense of belonging, perceived value of STEM fields, and academic commitment. All items were answered on a 5-point Likert-type scale (1 = strongly disagree, 5 = strongly agree). The questionnaire also included a brief section to collect sociodemographic information (e.g., gender, age, scholarship status).

Self-efficacy (Seff) was measured using the five-item scale proposed in [52] (e.g., "I am confident that I will do well in my courses"). Self-regulation (SReg) was assessed using a five-item scale based on the work [48] (e.g., "I work on additional exercises or answer end-of-chapter questions, even if I don't have to", "Even when study materials are dull and uninteresting, I keep working until I finish"). Intrinsic motivation (IntMot) was measured with four items from the Intrinsic Goal Orientation subscale of the MSLQ [52], using the STEM-focused wording adapted in [53] (e.g., "I prefer course material that really challenges me so I can learn new things"). Sense of belonging to the engineering major (SB) was measured with a five-item scale adapted from [54](e.g., "I am happy that I chose this major" and "I feel that I fit in this major"). Perceived value of STEM fields (Val_STEM) was measured with an eight-item scale adapted from [41] (e.g., "I find STEM-related jobs very interesting" and "I would take a course in STEM even if it were not required"). Academic commitment (AC) was assessed using the five-item scale developed in [1](e.g., "I have decided to complete my studies successfully"). The reliability of all scales was examined using McDonald's omega (ω) and Cronbach's alpha (α), with coefficients reported in Table 1.

The questionnaire was administered by faculty members during class time, ensuring that students had dedicated time to complete it. Data collection began with an informed consent process, including assurances of confidentiality and the provision of contact details for any questions about the study. The survey was created and delivered using Qualtrics, and all responses were anonymized and stored in secure, backed-up repositories.

Table 1. Scale reliability statistics (McDonald's ω and Cronbach's α).

	N° items	Coefficient ω	Coefficient α
Academic Commitment (AC)		0.811	0.809
Self-efficacy (SEff)		0.906	0.904
Self-regulation (SReg)		0.759	0.773
Percieved Value (Val_STEM)		0.898	0.924
Intrinsic Motivation (IntMot)		0.731	0.687
Sense of belonging (SB)		0.872	0.873

In line with the theoretical framework, our focal model (Model 1) specified self-efficacy, self-regulation, and intrinsic motivation as exogenous predictors of academic commitment and of two correlated mediators: sense of belonging to the major and perceived value of STEM fields. Belonging and value were specified as direct predictors of commitment.
To assess the robustness of this parallel-mediation structure and to reflect prior work that has emphasized a single dominant mechanism, we estimated two reduced models: Model 2 (belonging-only), which retained belonging as the sole mediator, and Model 3 (value-only), which retained perceived value as the sole mediator. These models were treated as sensitivity checks, allowing us to examine how model fit and explained variance changed when one of the mediators was removed. All models were estimated using robust maximum likelihood and compared using CFI, SRMR, and information criteria (AIC/BIC), alongside R^2 for academic commitment and the mediators.

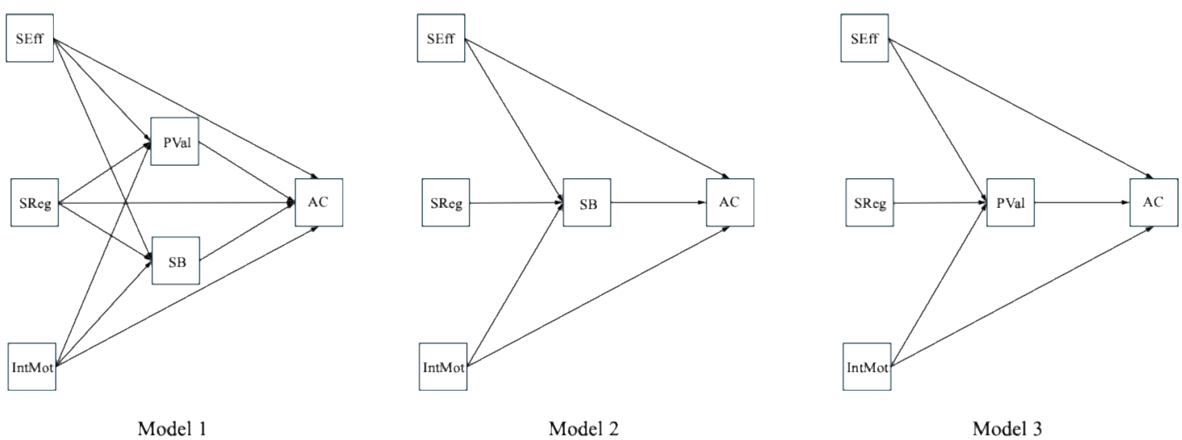

Figure 1. Theoretical Models Tested.

Results

Descriptive statistics for all study variables are presented in Table 1. On the 1–5 Likert scale, students reported moderately high levels of the three personal resources: self-efficacy (M = 3.89, SD = 0.73), intrinsic motivation (M = 3.94, SD = 0.61), and self-regulation (M

= 3.80, SD = 0.67). Direct socio-psychological appraisals were also relatively high, with sense of belonging to the engineering major averaging 4.14 (SD = 0.74) and perceived value of STEM fields averaging 3.90 (SD = 0.68). Academic commitment showed the highest mean score (M = 4.51, SD = 0.58), indicating generally strong behavioral and cognitive engagement among first-semester students.

All variables exhibited negative skewness (from −0.26 to −1.53), reflecting a tendency toward higher scores, which is expected given that the constructs represent desirable academic characteristics. Kurtosis values ranged from 0.37 to 4.08, with academic commitment showing the most pronounced leptokurtic distribution. Overall, departures from normality were modest to moderate; therefore, we relied on robust standard errors and fit indices in the path models to account for these distributional characteristics.

Table 2. Descriptive statistics, skewness, and kurtosis of the study variables.

Dimension	Mean	Std. Deviation	Skewness	Kurtosis
Academic Commitment (AC)	4.512	0.575	-1.528	4.080
Self-efficacy (SEff)	3.893	0.726	-0.714	1.374
Self-regulation (SReg)	3.800	0.666	-0.709	1.595
Percieved Value (Val_STEM)	3.896	0.678	-0.257	0.370
Intrinsic Motivation (IntMot)	3.942	0.605	-0.452	1.623
Sense of belonging (SB)	4.144	0.742	-1.009	1.787

Bivariate Pearson correlations among all variables were conducted (Table 3). As expected, the three personal resources, namely self-efficacy, intrinsic motivation, and self-regulation, were positively and moderately associated with one another (rs = .548–.561, $p < .001$). All three showed significant positive correlations with academic commitment: r = .514 for self-efficacy, r = .437 for intrinsic motivation, and r = .435 for self-regulation ($p < .001$), indicating that students who feel more capable, more intrinsically motivated, and better able to regulate their learning also report higher day-to-day engagement.

Table 3. Pearson correlation matrix of the study constructs.

Variable	SEff	IntMot	AC	SReg	SB	PVal
SEff	—					
Int_Mot	0.548***	—				
AC	0.514***	0.437***	—			
SReg	0.554***	0.561***	0.435***	—		
SB	0.513***	0.412***	0.554***	0.438***	—	
Pval	0.430***	0.458***	0.465***	0.466***	0.455***	—

Consistent with the proposed mediation model, the personal resources were significantly related to both mediators. Self-efficacy correlated .513 with sense of belonging and .430

with perceived value of STEM fields; intrinsic motivation correlated .412 with belonging and .458 with value; and self-regulation correlated .438 with belonging and .466 with perceived value (all $p < .001$). Academic commitment also showed substantial correlations with the mediators ($r = .554$ with belonging and $r = .465$ with perceived value, $p < .001$), suggesting that students who feel they belong in their engineering major and perceive their STEM fields as valuable tend to exhibit higher behavioral and cognitive engagement. Finally, sense of belonging and perceived value were moderately correlated ($r = .455$, $p < .001$), reflecting their conceptual proximity as appraisals of fit and relevance in the academic context, while remaining empirically distinguishable. None of the correlations exceeded .70, suggesting that multicollinearity is unlikely to compromise the subsequent path analyses.

We compared three theoretically derived path models using observed composite scores (Table 4). Because the models had very few degrees of freedom, we focused on CFI, SRMR, and information criteria (AIC/BIC) rather than RMSEA-based thresholds. The parallel-mediation model (Model 1), which included both sense of belonging and perceived value as parallel mediators, provided the best representation of the data. It showed good incremental fit (CFI = .956) and a low SRMR (.034), together with the lowest AIC (2679.55) and BIC (2752.94) among the three models. In contrast, the belonging-only model (Model 2) and the value-only model (Model 3) displayed poor incremental fit (CFI = .670 and .597, respectively) and substantially higher SRMR (.196 and .205) and information criteria (AIC = 2880.14 / 2932.02; BIC = 2936.26 / 2988.15). A chi-square difference test confirmed that constraining the model to a single mediator significantly worsened fit ($\Delta\chi^2(4) = 208.59$, $p < .001$ for Model 2 vs. Model 1).

In terms of explained variance, Model 1 accounted for 41.9% of the variance in academic commitment ($R^2 = .409$), whereas the belonging-only model explained 40.0% ($R^2 = .400$) and the value-only model only 35.5% ($R^2 = .355$). Model 1 also explained 30.6% of the variance in belonging and 29.1% in perceived value. These patterns support Model 1 as the preferred model and indicate that belonging and value operate as correlated but distinct mechanisms linking personal resources to commitment.

Table 4. Fit indices and explained variance for competing mediation models.

Model	χ^2 (df)	CFI	SRMR	AIC	BIC	R^2 Academic commitment
Model 1 – Parallel mediation	32.38 (1)	.956	.034	2679.55	2752.94	.419
Model 2 – Belonging-only mediator	240.97 (5)	.670	.196	2880.14	2936.26	.400
Model 3 – Value-only mediator	292.85 (5)	.597	.205	2932.02	2988.15	.355

Table 5 summarizes the standardized path coefficients for the preferred model with parallel mediation. Together, the predictors and mediators explained 41.9% of the variance in

academic commitment ($R^2 = .419$), 30.6% of the variance in sense of belonging to the major, and 29.1% of the variance in perceived value of STEM fields.
Regarding direct predictors, both mediators were positively and significantly associated with academic commitment. Sense of belonging exerted the stronger direct effect (β = .313, SE = .041, z = 7.70, p < .001, 95% CI [0.233, 0.392]) compared to perceived value (β = .169, SE = .043, z = 3.98, p < .001, 95% CI [0.086, 0.253]). The residual covariance between belonging and value was also significant (β = .167, SE = .032, z = 5.23, p < .001, 95% CI [0.104, 0.229]), consistent with their conceptual proximity as appraisals of fit and relevance in the academic context.

As expected, the three personal resources were positively related to both mediators. Self-efficacy showed the strongest associations with belonging (β = .480, SE = .069, z = 6.99, p < .001, 95% CI [0.345, 0.614]) and value (β = .234, SE = .073, z = 3.19, p = .001, 95% CI [0.090, 0.378]). Self-regulation also predicted higher belonging (β = .266, SE = .083, z = 3.22, p = .001, 95% CI [0.104, 0.427]) and value (β = .367, SE = .074, z = 4.93, p < .001, 95% CI [0.221, 0.513]). Intrinsic motivation was more strongly related to perceived value (β = .376, SE = .086, z = 4.36, p < .001, 95% CI [0.207, 0.545]) than to belonging (β = .201, SE = .079, z = 2.56, p = .010, 95% CI [0.047, 0.355]), suggesting that more motivated students especially tend to see STEM fields as meaningful and relevant.

Table 5. Standardized direct, indirect, and total effects for the preferred parallel mediation model.

	Effect	Estimate	Std. Error	z-value	p	95% Confidence Interval	
						Lower	Upper
SEff→AC	direct	0.275	0.063	4.334	< .001	0.150	0.399
SEff→SB→AC	indirect	0.150	0.030	5.041	< .001	0.092	0.208
SEff→PVal→AC	indirect	0.040	0.016	2.526	.012	0.009	0.070
SEff→AC	total indirect	0.190	0.035	5.397	< .001	0.121	0.258
SEff→AC	total	0.464	0.065	7.094	< .001	0.336	0.593
IntMot→AC	direct	0.145	0.078	1.859	.063	-0.008	0.298
IntMot→SB→AC	indirect	0.063	0.026	2.432	.015	0.012	0.114
IntMot→PVal→AC	indirect	0.064	0.022	2.955	.003	0.021	0.106
IntMot→AC	total indirect	0.126	0.036	3.542	< .001	0.056	0.196
IntMot→AC	total	0.272	0.086	3.151	.002	0.103	0.441
SReg→AC	direct	0.090	0.062	1.436	.151	-0.033	0.212
SReg→SB→AC	indirect	0.083	0.028	2.965	.003	0.028	0.138
SReg→PVal→AC	indirect	0.062	0.020	3.127	.002	0.023	0.101
SReg→AC	total indirect	0.145	0.036	4.018	< .001	0.074	0.216
SReg→AC	total	0.235	0.069	3.415	< .001	0.100	0.370

For academic commitment, self-efficacy retained a significant direct effect after accounting for the mediators ($\beta = .275$, SE = .063, z = 4.33, $p < .001$, 95% CI [0.150, 0.399]), whereas the direct paths from intrinsic motivation ($\beta = .145$, SE = .078, z = 1.86, p = .063) and self-regulation ($\beta = .090$, SE = .062, z = 1.44, p = .151) were not statistically significant. This pattern indicates partial mediation for self-efficacy and full mediation for intrinsic motivation and self-regulation.

The decomposition of indirect and total effects further clarifies these patterns. Self-efficacy displayed a substantial total indirect effect on academic commitment ($\beta_{indirect} = .190$, SE = .035, z = 5.40, $p < .001$, 95% CI [0.121, 0.258]), driven primarily by the pathway through belonging ($\beta = .150$, SE = .030, z = 5.04, $p < .001$, 95% CI [0.092, 0.208]) and, to a lesser extent, the pathway through value ($\beta = .040$, SE = .016, z = 2.53, p = .012, 95% CI [0.009, 0.070]). Combining direct and indirect components, the total effect of self-efficacy on commitment was strong and significant ($\beta_{total} = .464$, SE = .065, z = 7.09, $p < .001$, 95% CI [0.336, 0.593]).

Intrinsic motivation and self-regulation influenced commitment primarily through the mediators. For intrinsic motivation, the total indirect effect was significant ($\beta_{indirect} = .126$, SE = .036, z = 3.54, $p < .001$, 95% CI [0.056, 0.196]), with comparable contributions from the belonging pathway ($\beta = .063$, SE = .026, z = 2.43, p = .015, 95% CI [0.012, 0.114]) and the value pathway ($\beta = .064$, SE = .022, z = 2.96, p = .003, 95% CI [0.021, 0.106]). The resulting total effect of intrinsic motivation on commitment was positive and significant ($\beta_{total} = .272$, SE = .086, z = 3.15, p = .002, 95% CI [0.103, 0.441]), despite the non-significant direct path in the full model.

Similarly, self-regulation exhibited a significant total indirect effect on commitment ($\beta_{indirect} = .145$, SE = .036, z = 4.02, $p < .001$, 95% CI [0.074, 0.216]), again through both belonging ($\beta = .082$, SE = .028, z = 2.97, p = .003, 95% CI [0.028, 0.138]) and value ($\beta = .063$, SE = .020, z = 3.13, p = .002, 95% CI [0.023, 0.101]). The total effect of self-regulation on commitment was significant ($\beta_{total} = .235$, SE = .069, z = 3.42, $p < .001$, 95% CI [0.100, 0.370]), even though its direct effect became non-significant after including the mediators.

Overall, these results support a socio-cognitive model in which academic commitment in first-year engineering students is driven by both direct self-efficacy effects and indirect pathways through sense of belonging and perceived value. Belonging emerges as the stronger direct predictor of commitment, while perceived value provides complementary explanatory power. Intrinsic motivation and self-regulation primarily strengthen these immediate socio-psychological appraisals rather than exert independent, direct effects on commitment.

Discussion

This study examined how key personal resources relate to academic commitment among first-year engineering students by testing alternative mediation models involving sense of belonging and perceived value. Overall, the results consistently supported a parallel-mediation model in which belonging and value function as correlated yet distinct direct mechanisms linking self-efficacy, intrinsic motivation, and self-regulation to academic commitment. Among the personal resources examined, self-efficacy exhibited both a direct association with academic commitment and indirect effects through the proposed mediators, whereas intrinsic motivation and self-regulation were primarily related to commitment via their indirect pathways. This pattern is consistent with prior research highlighting the significant role of self-efficacy in sustaining effort, persistence, and commitment in higher education contexts [1-3]. Together, the predictors and mediators explained a substantial proportion of variance in academic commitment, underscoring the relevance of integrating socio-cognitive resources with students' perceptions of belonging and task value when modeling early engagement in engineering education.

Belonging and value as complementary direct mechanisms

The findings further highlight the importance of distinguishing between sense of belonging and perceived value as complementary, yet non-redundant, direct mechanisms underlying academic commitment, as suggested by prior research emphasizing the distinct roles of identity-related and value-related appraisals in students' engagement [14], [16], [35]. Although both constructs were moderately correlated, the parallel-mediation model consistently outperformed single-mediator alternatives, suggesting that belonging and value capture distinct processes in the early university experience. Sense of belonging reflects students' perceptions of social and academic integration within the engineering context [33], [34], whereas perceived value captures evaluative judgments regarding the relevance and usefulness of academic tasks and goals [15], [39]. The joint inclusion of both mediators indicates that early commitment is shaped by feeling accepted and connected, and by perceiving coursework as meaningful and worthwhile during the transition to university.

Differential roles of personal resources

The results also reveal differentiated roles for the examined personal resources, suggesting that not all contribute to academic commitment through the same pathways. Self-efficacy emerged as a particularly salient resource maintaining a direct association with academic commitment, as also reported in [4], alongside its indirect effects through sense of belonging and perceived value. This pattern indicates that confidence in one's academic capabilities may translate more immediately into day-to-day engagement, while also shaping students' perceptions of fit and relevance. In contrast, intrinsic motivation and self-regulation were primarily linked to commitment through their indirect pathways, reinforcing the view that these resources operate at a more distal level by shaping how students interpret and experience their academic context. Prior research suggests that motivational and self-regulatory processes influence engagement by fostering meaningful appraisals of learning activities rather than directly driving behavioral commitment, a pattern consistent with the indirect effects observed in [30] and [21]. Together, these findings suggest a layered process in which different personal resources operate at distinct points along the pathway to early academic commitment.

It is also worth noting that the present model describes average associations between personal resources and commitment, but these relationships may be moderated by students' responses to adverse academic events. The motivation self-regulation literature suggests that highly self-regulated or intrinsically motivated students may interpret setbacks—such as a low grade on a first exam—as informational feedback that mobilizes additional effort, whereas less-resourced students may interpret the same event as a threat to self-worth and disengage [49], [50]. Although the cross-sectional design of the present study does not allow us to test this directly, the fact that self-efficacy retained a direct effect on commitment while motivation and self-regulation operated indirectly is consistent with the idea that confidence beliefs play a particularly important role in sustaining engagement when early performance is negative. Testing this moderation explicitly is an important avenue for future research, as outlined below.

Implications for first-year engineering practice

From a practical standpoint, these findings underscore the importance of designing first-year engineering experiences that intentionally support both students' sense of belonging and their perceptions of academic value. Consistent with prior research emphasizing the role of social and academic integration during the transition to university [41], [35], the present results show that belonging operates as a key immediate mechanism through which personal resources are translated into academic commitment. Likewise, the mediating role of perceived value aligns with expectancy–value perspectives, highlighting the importance of making the relevance and usefulness of academic tasks explicit to students [14], [15], [39]. Importantly, the direct and indirect effects of self-efficacy observed in this study further suggest that practices fostering confidence through structured feedback and achievable challenges may be particularly salient for strengthening early engagement, as also reported in prior work on academic commitment [1-3]. Together, these implications indicate that supporting early engagement in engineering requires coordinated attention to both personal resources and the immediate experiences of belonging and value through which they are enacted.

Conclusions

This study aimed to examine how key personal resources are associated with academic commitment among first-year engineering students by testing and comparing alternative mediation models in which sense of belonging and perceived value operate as direct mechanisms. Using path analysis, the study evaluated the relative contributions of these correlated mediators in linking self-efficacy, intrinsic motivation, and self-regulation to early academic commitment. The results indicate that personal resources are most effectively translated into academic commitment through students' direct experiences of belonging and perceived value, with the parallel-mediation model providing the best overall fit. Self-efficacy emerged as a particularly salient resource, exerting both direct and indirect effects on commitment, whereas intrinsic motivation and self-regulation primarily influenced commitment through their indirect pathways. Taken together, these findings suggest that early engagement in engineering is shaped by a layered interplay of individual resources and contextual appraisals, underscoring the importance of first-year learning environments that support students' skills and foster their sense of connection and purpose.
This study has several limitations. First, its cross-sectional design, based on self-reported data, does not allow for causal inference. Second, the sample was drawn from first-year engineering students at a single private university in Chile, which may limit the generalizability of the findings. Third, although gender data were collected, the sample was substantially imbalanced (82.7% men, 17.3% women), reflecting the demographic composition of the engineering school, and gender was not examined as a grouping variable in the present analyses. Given that the expectancy–value and belonging literatures document meaningful gender-related differences in STEM motivation and persistence [16],

[25], [42]–[44], this represents an important omission that future work should explicitly address with adequately powered subgroup or multigroup analyses. Finally, the model focused on selected personal resources and direct mechanisms, and other relevant contextual factors influencing academic commitment were not examined.

Future studies should use longitudinal designs to examine changes in academic commitment over time, test the model across diverse institutional contexts, and explore interventions to strengthen belonging, perceived value, and self-efficacy in engineering education. Several specific directions are particularly promising. First, longitudinal studies should map trajectories of belonging and commitment across the undergraduate program and extend measurement beyond graduation to capture persistence in the engineering profession (e.g., first post-graduation employment, field retention at one and three years). Second, research should examine gender and other demographic characteristics as grouping variables, testing whether the relative weight of belonging and value pathways differs across subgroups and identifying mechanisms that may explain women's underrepresentation in engineering. Third, future work should investigate moderators of how students translate adverse academic events—such as a low grade or an unsuccessful first exam—into either strengthened or weakened commitment; initial evidence on mindset, attributions, and motivation self-regulation [49], [50] suggests that highly self-regulated or mastery-oriented students may respond to negative feedback with increased effort, while less-resourced students may disengage. Fourth, studies should refine the commitment construct by linking self-report measures to behavioral indicators (course completion, credit accumulation, help-seeking) to strengthen ecological validity. Collectively, these directions would deepen understanding of belonging and commitment as mechanisms of first-year persistence and inform the design of targeted supports in engineering education.

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