Who I am now and who I hope to be: Examining when Latinx students actualize their engineering identity and how that supports their persistence

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Introduction

This **empirical research brief** explores how the different operationalizations of Latinx students' engineering identity affect persistence beliefs when considering the mediation effect of classroom belonging. Prior work has examined the relationship between engineering identity and a sense of belonging on students' persistence beliefs using data collected at one point in time [1]. However, this snapshot view offers a limited understanding of how identity and belongingness influence students' persistence. It is important to consider how students are authoring and sustaining their identities as engineers over time. As students progress through their engineering degree programs, they are in negotiations with their role as students and engineers. While some readily take on the identity of an engineer at present, others hold an aspirational view of one day becoming an engineer [2]. By considering the ways Latinx engineering students are operationalizing their engineering identity, as present-oriented or aspirational, we can better understand how their identity development is impacting their certainty of graduating with an engineering degree. This paper aims to answer the following research question: *In what ways does a present-oriented and aspirational engineering identity distinctly impact Latinx students' classroom belonging and persistence beliefs over the course of a semester?*

To answer our research question, we drew on two interrelated theoretical frameworks: engineering role identity and sense of belonging. Role identity is a dynamic process that can change over time and can be influenced by students' surroundings. Students operate in a feedback loop that is informed by their perceptions of the roles (e.g., expectations and behaviors associated with their role) and the feedback they receive from their environment [3]. They are subject to their own understanding of what it means to be an engineer and the feedback they receive from their environment about engineering. The feedback or messages from students' environments either support or challenge their perceptions of the ways they should navigate their role as engineers. Subsequently, students shape their understanding of who they currently are and who they can become within the context of the role, a future possible self [3]-[4].

A sense of belonging can be influenced by an individual's identity and alignment with a specific group or environment. Who one is and how one behaves affect the perceived fit in a given context, such that identity acts as a "link between the personal realm and the collective understandings embedded in the culture" [5, p.26]. In the context of this paper, a sense of belonging refers to a "sense of affiliation and identification with the university community," specifically within the classroom environment [6, p.228]. Being an engineer requires performing according to the norms and expectations of the role, which continue to favor masculinity and whiteness [7]-[9]. Latinx students may experience more intensely the need to negotiate their social identities to establish a sense of belonging [9]-[10], which can impact their certainty of graduating with their engineering degree.

Engineering identity and sense of belonging function as internalized barometers that can help affirm Latinx students' presence within engineering. Prior work has shown that when engineering identity and sense of belonging are supported, women's persistence beliefs are supported [1]. However, when Latinx students do not perceive a sense of alignment between who they are and who they are expected to be, they may question their choice of major [10]-[11] or choose to redefine what it means to be an engineer [9], [12]. In this paper, we continue to explore the relationship between engineering identity, belongingness, and persistence beliefs, specifically of Latinx undergraduate engineering students over time. We expand the conceptualization of engineering role identity to incorporate future possible selves through the use of aspirational engineering identity, enabling a better understanding of the mechanisms Latinx students draw on to persist.

Methods

Participants. The data were collected during the Spring 2022, Fall 2022, Spring 2023, and Fall 2023 semesters at one Hispanic-serving institution in the U.S. Southwest. The data from each semester was combined to help increase the sample size (n =189). Students were asked to fill out the survey at the beginning and end of the semester. Participants were enrolled in one of three courses: Statics, Strength of Materials, and Embedded Systems. Participants had varying instructors. Our sample predominantly consists of first-generation college students (79%). Among the 189 students in the dataset, 79% identified as Latinx, 15% were Asian, 10% were White, and the other races/ethnicities listed in the survey, together, represented less than 10% of the sample. Since the majority of the students in our data identify as Latinx, we frame our results as representing the experiences of Latinx students.

Survey Measures. The engineering identity survey measures used were: "*I feel like an engineer now*" (present-oriented engineering identity) and "*I will feel like an engineer in the future*" (aspirational engineering identity). One survey measure was used to evaluate students' persistence beliefs, i.e., "*I am certain that I can graduate with an engineering degree*." The measure that captures classroom belonging was created using five survey items, which were validated using data from minoritized students [1]. All items were rated using a 7-point Likert scale with anchors of 0 = "strongly disagree" and 6 = "strongly agree"). The specific survey items can be found in Table 1 in the Appendix section.

Data Analysis. We used two structural equation models to understand the relationship between engineering identity, classroom belonging, and Latinx students' persistence beliefs over time. The two models are differentiated by the conceptual time orientation of the engineering identity items, "*I see myself as an engineer now"* and "*I will feel like an engineer in the future.*" Both models included survey measures collected at the beginning of the semester and the end of the semester. Only the persistence beliefs item collected at the end of the semester was included in the models.

Results

Measurement Model. The measurement model for the latent constructs of classroom belonging at the beginning of the semester (T1) and end of the semester (T2) was evaluated via confirmatory factor analysis. The scaled Satorra-Bentler adjusted chi-square test for goodness of fit was $SB\chi^2 = 40.80$, df = 29, p =0.07, scaling factor = 1.55. The CFI = 0.989, TLI = 0.982, RMSEA of 0.047 90% CI [.012,.072], and the SRMR = 0.042. All fit indices suggest that our measurement model is a good fit [13]-[15]. Additional details can be found in Table 2 in the Appendix.

Structural Model Fit and Estimates. Two models were separately evaluated. We report the results of each model fit and their corresponding estimates below. Our results are framed as representing the experiences and outcomes of Latinx students, as they represent the majority of the students in our sample data (79%). Studies have investigated the relationship between identity and belongingness. While some scholars have found that identity supports belongingness [1], [5] others have found that belongingness reinforces disciplinary identity [16]-[17]. To determine the directional relationship between engineering identity and classroom belonging, two versions were evaluated using the BIC and AIC values, that is:

- version 1: engineering identity (i.e., aspirational or present) → classroom belonging
- version 2: classroom belonging → engineering identity (i.e., aspirational or present)

In both versions of the structural model, the CFI, TLI, and RMSEA were within acceptable ranges. However, the set of models with engineering identity being regressed onto classroom belonging (i.e., version 1: engineering identity → classroom belonging) were determined to be a better fit because they produced lower BIC and AIC values.

Present-oriented Engineering Identity Model (I see myself as an engineer now)

The model focused on present-oriented engineering identity yielded a Satorra-Bentler adjusted chi-square test value of $SB\chi^2(53) = 78.25$, $p = 0.01$, scaling factor = 1.47. The model fit indices were CFI = .98; TLI = .97; RMSEA= .051, 90%CI[.03,.07], and SRMR=.043; collectively, the model indices suggest a good model fit. Only significant paths were retained in the final model. Paths that were removed are represented as dashed lines, see Figure 1.

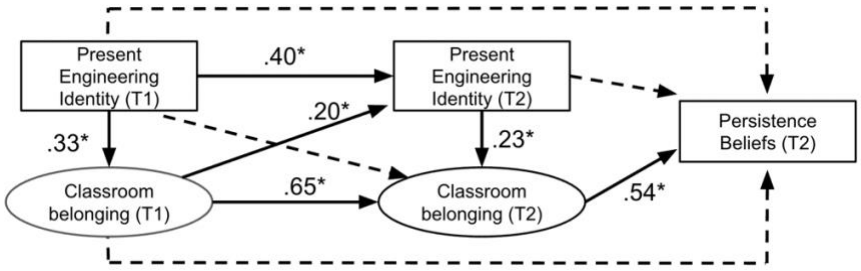

Figure 1. *Structural equation model for present-oriented engineering identity model*
Note. * = p-values less than 0.05; All values reported in standardized form.

Latinx students' present-oriented engineering identity at Time 1 supported their classroom belonging at Time 1 ($\beta = .33$, $p < .001$). A sense of classroom belonging at Time 1 positively

supported students' present-oriented engineering identity at Time 2 (β = .20, p = .002). While a present-oriented engineering identity at Time 1 did not predict classroom belongingness at Time 2, seeing themselves as engineers in the now at the end of the semester did support Latinx students' classroom belonging at Time 2 (β = .23, p < .001). Only classroom belongingness at Time 2 significantly supported Latinx students' persistence beliefs at the end of the semester (β = .54, p < .001), explaining 29% of the variance of their persistence beliefs.

Aspirational Engineering Identity Model

The aspirational engineering identity model contained the variable "*I will feel like an engineer in the future.*" The model had a Satorra-Bentler adjusted chi-square test value of $SB\chi^2(53) = 66.08$, p = 0.11, scaling factor = 1.07. The model fit indices were as follows: CFI = .99; TLI = .99; RMSEA= .036, 90%CI[.00, .06], and SRMR=.041, all within an acceptable range, suggesting a good model fit. The significant pathways for the structural model are illustrated in Figure 2.

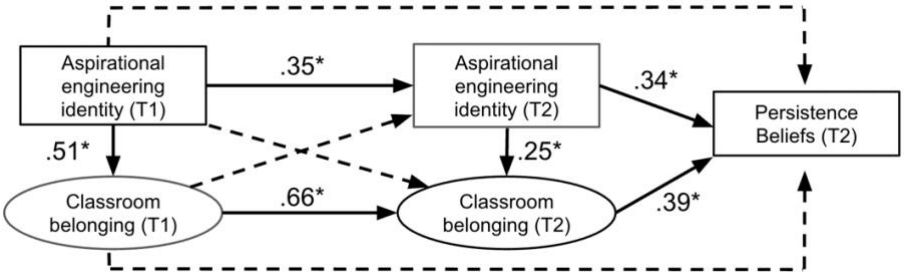

Figure 2. *Full structural equation model for aspirational engineering identity model*
Note. * = p-values less than 0.05; All values reported are standardized.

Latinx students' aspirational engineering identity at Time 1 significantly supported their sense of classroom belonging at Time 1 (β = .51, p < .001). Their aspirational engineering identity at the end of the semester supported their classroom belonging at the end of the semester (β = .25, p < .001). Yet their aspirational identity at Time 1 did not predict their classroom belongingness at Time 2. Most notably, classroom belonging at Time 2 (β = .39, p < .001) and aspirational engineering identity at Time 2 (β = .34, p = .001) significantly supported Latinx students' persistence beliefs, collectively explaining 27% of the variance. Both factors held similar weights, indicating that they are relatively equal in importance in supporting Latinx students' persistence beliefs.

Discussion

In this paper, we evaluated how Latinx students' operationalization of engineering identity, as a present or aspirational authoring, supported their persistence beliefs and how the classroom environment mediated that relationship. As Latinx students are in the process of becoming engineers, some report similar levels of present-oriented and aspirational engineering identity. While others report greater levels in one perspective over the other, that is, lower present identity and higher aspirational identity. The two models highlight the different ways in which Latinx students' engineering identity supported their persistence beliefs. In both models, there was a

significant relationship between Latinx students' sense of belonging in the classroom at the end of the semester (Time 2) and their beliefs about persisting in their degree program. This result signals the importance of sustaining classroom belongingness on Latinx students' persistence, irrespective of where they are in their identity development trajectory. Additionally, a unique attribute in the present-oriented model was the significant effect between classroom belonging at Time 1 and present engineering identity at Time 2; this relationship was not observed in the other model. Still, the most interesting relationship within the aspirational model was between aspirational engineering identity and Latinx students' persistence beliefs at Time 2. We further discuss these three relationships below.

Across both models, Latinx students' classroom experiences influenced their certainty of graduating with an engineering degree. Classroom experiences can help students understand who they are and are expected to be within an engineering context. It is through their direct experiences with engineering content that they can gain confidence in their ability to persist through engineering. In this study, all of the participants were enrolled in challenging engineering courses with high D,F,W rates: Statics, Strength of Materials, and Embedded Systems. These are typically the first "technical" engineering courses students take within their respective majors. Latinx students may be using these courses to gauge their general fit in their major and profession at large. Engineering learning environments reproduce messages about who can and cannot be engineers [10], [18] and are often permeated by messages of exclusivity (i.e., hidden curriculum [19], underrepresentation [20], and other forms of marginalization [21]). In the context of Hispanic-Serving Institutions, reimagining the classroom setting in ways that affirm Latinx students' culture and multiple identities within engineering can help validate their ways of being and knowing in engineering contexts.

Based on previous explorations of engineering identity and belonging [5], [16], [22], we hypothesized that a present-oriented engineering identity at Time 1 would influence classroom belonging at Time 2 and that classroom belonging at Time 1 would affect present-oriented engineering identity at Time 2. However, in our model, we only found that classroom belonging at Time 1 significantly predicted Latinx students' present-oriented engineering identity at Time 2. This relationship suggests that classroom belonging aided Latinx students' ability to see themselves as an engineer in the present across a semester and reinforced their present engineering identity beyond their pre-existing levels. As Latinx students engage with more major-specific courses, they gain an understanding of how to navigate engineering and are able to see themselves be successful in technical engineering spaces, thus supporting their persistence beliefs. Additionally, this relationship underscores the multifaceted effect classroom belongingness has in supporting Latinx students, specifically by helping them see themselves as engineers in the present and supporting their persistence beliefs at the end of the semester.

Our results showed that Latinx students' aspirational engineering identity significantly predicted their persistence beliefs, a relationship not observed in the present-oriented model. This finding suggests that a present engineering identity is not required for Latinx students to persist; rather, it is more important to feel like they will become engineers in the future to support their

persistence. It is not a surprise that an aspirational identity held comparable importance as classroom belonging. In our prior work, Latinx students' ability to feel like engineers was tied to their access to meaningful hands-on engineering experiences. When they were not able to see themselves as engineers in the present moment, Latinx students understood their current position as being aligned with their goal of becoming engineers, thus supporting their aspirational engineering identity [2]. It may be that an aspirational engineering identity is a more tangible form of engineering identity for Latinx students than a present-oriented engineering identity. We need to consider how students' role as academic learners, the effect of rigorous engineering technical courses on their self-concept [23]-[24], and the inaccessibility of hands-on experiences [25]-[26] impact their ability to feel like engineers in the present. In response to systemic biases and messaging about what it takes to be an engineer, Latinx students may be leaning on their aspirational engineering identities because it allows them to assess their alignment to the field according to their perceived trajectory and not their current engineering-related experiences, or lack thereof. By focusing on who they wish to become in the future, Latinx students are able to situate themselves as engineers in progress, a role to be achieved in the future [27]; in turn, this helps them feel more certain about their ability to graduate with an engineering degree.

Implications

Practical ways that professors can create a welcoming classroom environment are through culturally relevant pedagogy, fostering an environment of mutual respect, and providing useful feedback on assignments [28]-[29]. To further support Latinx students' aspirational engineering identity, a curriculum can be developed that allows Latinx students to tap into their aspirational engineering identity through opportunities aligned with their goals as engineers. For example, an engineering curriculum can center Latinx students' altruistic cultural values by incorporating service-learning and community-based design projects. Additionally, the implementation of interdisciplinary classroom examples and projects can foster Latinx students' interests at the intersection of engineering and other disciplines (e.g., business, entrepreneurship, art, health, etc.) By implementing practical strategies, institutions can better serve their students and foster an environment that values Latinx students for who they are by supporting their developing engineering identity.

Conclusion

This work highlights how present-oriented and aspirational engineering identities differentially support Latinx students' persistence beliefs, with classroom belonging serving as a mediating factor. It is evident that engineering identity is operationalized in different ways; however, both present-oriented and aspirational engineering identities remain important for Latinx student success and attunement to the discipline. Greater efforts are needed to help Latinx students feel capable of succeeding in engineering in ways that align specifically with their aspirations as engineers. By supporting Latinx students' aspirational engineering identity, institutions can reinforce their persistence in the field.

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Appendix

TABLE I. Survey Items

1.I feel like an engineer now (T1)
2. I will feel like an engineer in the future (T1)
3. I feel comfortable in my engineering classes (T1)*
4. I feel supported in my engineering classes (T1)*
5. I feel that I am part of my engineering classes (T1)*
6. I feel welcomed by my engineering professors (T1)*
7. I feel welcomed by my classmates in engineering (T1)*
8. I feel like an engineer now (T2)
9. I will feel like an engineer in the future (T2)
10. I feel comfortable in my engineering classes (T2)**
11. I feel supported in my engineering classes (T2)**
12. I feel that I am part of my engineering classes (T2)**
13. I feel welcomed by my engineering professors (T2)**
14. I feel welcomed by my classmates in engineering (T2)**
15. I feel certain I can graduate with an engineering degree (T2)

Note. *Items used for construct of classroom belonging at Time 1, ** Items used for construct of classroom belonging at Time 2

TABLE II. Confirmatory factor analysis factor loadings, standard errors, average variance extracted, and item reliability

	Factor loadings	*SE*	Item reliability
Factor 1: Classroom belonging at the beginning of the semester (α=0.87, AVE = .64)			
I feel comfortable in my engineering classes (T1)	.74*	.08	.55
I feel supported in my engineering classes (T1)	.85*	.08	.72
I feel that I am part of my engineering classes (T1)	.84*	.08	.71
I feel welcomed by my engineering professors (T1)	.84*	.07	.71
I feel welcomed by my classmates in engineering (T1)	.72*	.08	.52
Factor 2: Classroom belonging at the end of the semester (α=0.90, AVE = .65)			
I feel comfortable in my engineering classes (T2)	.76*	.06	.58
I feel supported in my engineering classes (T2)	.89*	.06	.79
I feel that I am part of my engineering classes (T2)	.91*	.07	.83
I feel welcomed by my engineering professors (T2)	.76*	.07	.58
I feel welcomed by my classmates in engineering (T2)	.71*	.08	.50

Note. *= significant p-values ($p < .05$), *SE* = standard error, α = Cronbach's alpha; AVE = average variance extracted; T1 = data collected at the beginning of the semester; T2 = data collected at the end of the semester