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RESEARCH ARTICLE

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Exploring experiences that foster recognition in engineering across race and gender

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Abstract

Background: Students' recognition beliefs have emerged as one of the most important components of engineering role identity development for early-career undergraduate students. Recognition beliefs are students' perceptions of how meaningful others, such as peers, instructors, and family, see them as engineers. However, little work has investigated the experiences that facilitate recognition beliefs, particularly across the intersections of race, ethnicity, and gender. Investigation of these experiences provides ways to understand how recognition may be supported in engineering environments and how White and masculine norms in engineering can shape marginalized students' experiences.

Purpose: We examined how specific experiences theorized to promote recognition are related to recognition beliefs for students at the intersections of race, ethnicity, and gender. Based on self-reported demographics, we created 10 groups, including Asian, Black, Latino and Hispanic, Indigenous, and White cisgender men and Asian, Black, Latinè/x/a/o and Hispanic, Indigenous, and White ciswomen, trans, and non-binary individuals. This article describes the patterns within each intersectional group rather than drawing comparisons across the groups, which can perpetuate raced and gendered stereotypes.

Methods: The data came from a survey distributed in Fall 2017 ($n = 2316$). Ten multiple regression models were used to understand the recognition experiences that influenced students' recognition beliefs by intersectional group.

Results: There is no one-size-fits-all approach to developing students' recognition beliefs. For example, family members referring to the student as an engineer are positively related to recognition beliefs for Asian, Black, Latino and Hispanic, and White cisgender men. Friends seeing Asian and White marginalized gender students as an engineer is predictive of recognition beliefs. Other recognition experiences, such as receiving compliments from an engineering instructor or peer about their engineering design and contributions to the team, do not influence the recognition beliefs of these early-career engineering students.

Conclusion: This article emphasizes the need to draw on multiple experiences to support the equitable development of early-career engineers across race, ethnicity, and gender, and reveals patterns for recognition that may support future scholarship on effective classroom practices for recognition.

KEYWORDS

engineering identity, ethnicity, gender, race, recognition

1 | INTRODUCTION

Although engineering identity has emerged as a key area of scholarship over the last few decades (Godwin et al., 2020; Morelock, 2017; Rodriguez et al., 2019), many researchers and educators have yet to reckon with the fact that most quantitative identity work has centered the experiences of White and cismen (CM). This reality is due to both participation rates within engineering, often resulting in small sample sizes, and a hegemonic culture of whiteness and masculinity that privileges exclusionary ways of knowing (Godwin et al., 2021; Secules, 2019). Without acknowledging and working toward including the experiences of students at the intersections of marginalized racial, ethnic, and gender identities, research practices (re)produce methods, systems, and logic that privilege White and masculine ways of becoming and identifying as an engineer (Zuberi & Bonilla-Silva, 2008).

A recent systematic review of quantitative methods for broadening the participation of Black students in engineering and computer science emphasized the lack of quantitative research studies that operationalize race as "more than a variable" (Reeping et al., 2023, p. 780). Most often, race, ethnicity, and gender are included as a variable in regression modeling, and this approach most often sets the categories of White and men as the defaults as these are the largest groups in engineering enrollments (Godwin et al., 2021; Reeping et al., 2023). Studies also often aggregate data for multiple racial and ethnic groups into a single minoritized group due to small sample sizes (Ro & Loya, 2015). Quantitative studies with the power to disaggregate by race/ethnicity and gender are rare, and even in those studies, race/ethnicity and gender are often included as "control" variables (refer to Reeping et al., 2023, for a more complete discussion of the statistical assumptions of this approach). This approach accounts for variance that might occur for individuals who identify across demographic categories but also "plays[s] the game of 'what would have happened if the person was [this race]'" (Reeping et al., 2023, p. 777). In many cases, the experiences of Black, Latinè/x/a/o, and Indigenous students are statistically overshadowed by results of White and Asian students in studies of gender, and the experiences of women and non-binary students are statistically overshadowed in studies of race/ethnicity. Additionally, studies of gender most often focus on a gender binary, and the experiences of White ciswomen dominate these results (Haverkamp et al., 2021). As such, there are opportunities to complicate our statistical procedures to provide a more nuanced understanding of the experiences within rather than across groups that are marginalized in engineering. One set of methods that have been offered as an opportunity to do this work is person-centered analyses (Godwin et al., 2021; Reeping et al., 2023). These quantitative methods work to recognize heterogeneity in data, preserve it, and work against hegemonic norms in quantitative research.

Our person-centered approach, builds off prior identity research and begins to interrogate students' recognition at the intersection of race, ethnicity, and gender to explore the ways different populations within engineering experience recognition and incorporate that experience into their identity as an engineer. Recognition by self and others as someone who is or can become an engineer is a key supporting component of the development of their engineering identities (e.g., Cross et al., 2017; Nosek et al., 2002; Ong et al., 2011; Pierrakos et al., 2009; Ross & Godwin, 2016; Rodriguez et al., 2018; Verdín et al., 2019). Instead of using race/ethnicity or gender as variables within our models, we run different regressions for each group (an approach that decenters race/ethnicity and gender as causal variables; Reeping et al., 2023). Through a greater understanding of the processes by which students come to see themselves as engineers, engineering education can more equitably integrate identity-supporting practices into curricular and cocurricular engineering education practices.

1.1 | Engineering role identity

Engineering role identity has emerged as a framework to understand how students see themselves as the kind of person who can do engineering (Huff & Ross, 2023; Morelock, 2017; Rodriguez, Lu, & Bartlett, 2018). Engineering role identity conceptualizes how students make sense of what it means to be a professional within the field of engineering and can reveal information about how students understand who they are in the world, who they can become, and whether they belong (Godwin, 2016; Godwin et al., 2020). The development of a role identity happens through an ongoing, dynamic positioning of an individual within a social context, the structure–agency dialectic. This back-and-forth process between an individual and structures to position oneself (as an engineer) is constrained and enabled by an individual's actions to position themselves as an engineer (i.e., agency) and external social structures—which include norms, values, policies, and practices. This constant positioning creates messages given and received as students make sense of themselves as engineers (Burke & Stets, 2009; Ross et al., 2021). Through the ongoing, temporal, and contextual positioning as an engineer, students develop views of themselves as engineers as they identify with the duties, responsibilities, and knowledge association of that role (Becker & Carper, 1956; Eliot & Turns, 2011; Stets & Burke, 2000).

How students are socially positioned and how they position themselves as engineers are gendered and racialized as students interact with external structures and internal ideations of what and who an engineer is, which is embedded in whiteness and masculinity. How students identify with a role has been linked to numerous educational outcomes, including the choice of engineering as a major (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016), persistence in engineering degree programs (Patrick et al., 2018; Pierrakos et al., 2009; Verdín, 2021a, 2021b; Verdín & Godwin, 2021), motivation (Godwin & Kirn, 2020; Osborne & Jones, 2011), learning (Tatar et al., 2016; Walther et al., 2011), and progression into a community of practice (Lent et al., 2008; Thomas, 2014).

1.2 | Recognition as a part of engineering role identity development

How people believe others see or "recognize [them] as a 'certain kind of person'" (Gee, 2000, p. 99) is a key element in the development of an engineering role identity as the experience of recognition by others both positions someone as part of a professional group and verifies an individual's internal belief of self as an engineer. Recognition can also be considered agentic as individuals make bids for recognition from others to support how they see themselves in the role of an engineer (Burke & Stets, 2009; Stryker & Burke, 2000). Of the factors that inform engineering role identity, recognition beliefs are the most important factor in the development of an engineering identity for early-career students (Godwin, Kirn, et al., 2016; Godwin & Potvin, 2015; Godwin, Potvin, et al., 2016), which establishes the importance of further research to better understand this phenomenon. Prior research has primarily focused on students' self-reported beliefs that others recognize them as the kind of person who can do engineering and the outcomes, but less work has examined the experiences that may influence whether students form these beliefs about themselves as an engineer (Osborne & Jones, 2011; Scalaro et al., 2021).

Additionally, engineering role identities are developed in the context of overlapping group memberships or social identities including gender, race, and ethnicity, among many (Brickhouse & Potter, 2001; Burke & Stets, 2009; Carlone & Johnson, 2007; Ross et al., 2017). Social identity refers to how an individual feels membership with social group(s) based on shared characteristics. These memberships can be chosen or assigned by social norms and ultimately influence how one operates and how others perceive them within society (Stets & Burke, 2000). The gendered and racialized stereotype of who can be an engineer (i.e., a structure that often constrains engineering identities as White and male; Cross, 2020; Pawley, 2017) and the actions that others take to recognize students or not based on that stereotype (another structure that constrains identities) shape how students develop their sense of self in the role of an engineer. As such, recognition is intimately tied to gender, race, and ethnicity.

Previous work illustrated the impact of recognition, or lack thereof, on the development of engineering role identities for Black women (Ross et al., 2017), Latinas (Rodriguez et al., 2019), women from multiple marginalized groups (women of color in the original study; Carlone & Johnson, 2007), and White women (Godwin & Potvin, 2015; Tonso, 1999; Tonso, 2006). Recognition is important for all these students; however, ciswomen, trans, non-binary, Black, Indigenous, and Latinè/x/a/o individuals may not have the same access to recognition that can aid in the development of an engineering identity as their White CM peers (Verdín et al., 2021). Additionally, experiences that support recognition beliefs for some groups may be different than others. To equitably support the development of engineering role identities in educational environments, a better understanding of how recognition is experienced to inform students' beliefs about how others see them as the kind of person that can do engineering (i.e., their recognition beliefs) interpreted alongside gender, race, and ethnicity is needed.

1.3 | Research question and purpose of study

In this work, we answer the research question, "To what extent are specific recognition experiences related to students' recognition beliefs for students at the intersections of race, ethnicity, and gender?" This study uses regression analyses to examine students' experiences of recognition that influence their recognition beliefs for multiple intersectional groups.

2 | RESEARCH TEAM POSITIONALITY

To help the reader understand the construction of this study exploring engineering role identity across race, ethnicity, and gender and the decisions made within this manuscript, we provide a description written by each author of their positionality within the field and in relation to this research. We provide this early in the manuscript as our positionalities as researchers shape the theories we engage with, methods used, and mechanisms of communication. Each author reflected on key questions of how positionality impacted what research we choose to do, how we relate to participants, and the research quality (Secules et al., 2021).

- McIntyre is a postdoctoral research associate in engineering education. Her research has explored how to create inclusive engineering environments that support diverse perspectives and identities. This work is motivated by the need for engineers who can think creatively across disciplinary boundaries, including significant untapped potential from students minoritized in engineering (i.e., women, Black, Latinè/x/a/o, Indigenous learners, and individuals at the intersections of these identities). Her recent work and previous experiences have challenged her to reckon with aspects of social and epistemic privilege and marginalization engrained at the seams of engineering. These experiences also influenced her to critically reflect on her positionality and lean into her identity as a Black woman passionate about community engagement and inclusion to understand how it shapes her identity as an engineering education researcher. She is particularly sensitive to how she interprets and portrays participants' attitudes, beliefs, and experiences and acknowledges the problematic aspects of the history and practices of the research process. Most importantly, it is pertinent to her to recognize how her intersectional identity does not exclude her from unconsciously reproducing knowledge, skills, and practices that center whiteness and heteronormativity without being intentionally reflexive throughout the research process.
- Scalaro is a Woman-identifying, White graduate student in engineering education. Her research explores how recognition of an engineering identity is interpreted as meaningful by undergraduate engineering students and how recognition changes across time. This work is motivated by the need to further explore recognition to develop practices that can purposefully support identity development for a diverse student population. Through increased exposure to engineering education and conversations of diversity, equity, and inclusion, she now sees that recognition is often a conversation of power and privilege in who has access to recognition as well as who gets recognized for what practices. She is aware that the support of her own engineering identity through recognition may have been denied on accounts of her gender but privileged on accounts of her race. She is aware that without consciously checking her biases, she may replicate whiteness and heteronormativity through who she recognizes as an engineer and for what practices.
- Godwin is a White ciswoman chemical and biomolecular engineering faculty member whose research is in engineering education. Her research has focused on how the culture of engineering shapes students' identities, belonging, and career pathways. This work is motivated by her own experiences in engineering education and industry. This author takes a pragmatic and interpretive approach to research using both quantitative and qualitative research methods to understand the specific lived experiences of individuals and the shared impact of engineering culture on systemically minoritized students. She fundamentally believes that the researcher's positionality influences all aspects of the research process, including the types of questions asked, sources of data, data analysis, and interpretation. Throughout the process of conducting this study, she has questioned the default norms of measurement and statistics with the team and has worked to describe the methodological choices and theorizing of identity, race, ethnicity, and gender in this manuscript. She acknowledges that this approach does not answer all the emergent questions related

to equitable recognition, and it is valuable as it begins to describe nuanced differences that provide new opportunities for inquiry.

- Kirn is a gay, White cisman faculty member in engineering education. His experiences with passing and covering in engineering influence his goals to create just, equitable, and inclusive engineering environments. His experiences shape continual critical reflection on his positionality and have led to the centering of equity, inclusion, and cultures of care in his work. Moreover, he recognizes how his identities allow for access to privilege and how he must actively work against defaults that reproduce inequality and exclusion. To work toward his goals, he has explored the ways undergraduate and graduate engineering education served to marginalize students and create homogenized systems of beliefs that reproduce existing systems of education and work. Particularly, his work centers the voices of students to understand the ways ecosystems shape students' actions.
- Verdín is a Latina (Mexican heritage) faculty member in engineering education. Her research focuses on issues of access and persistence of first-generation college students, Latinx students, minoritized students broadly, and those who hold multiple forms of social identities. She uses multiple lenses to understand how persistence can be supported and hindered, including engineering identity, sense of belonging, and funds of knowledge. She believes that issues of access span throughout a student's educational pathway. There are experiences that expose students to engineering-related fields that are not equitably available to all, thus systematically disenfranchising their pursuit of an engineering degree. Her focus on the first-generation college student population in engineering stems from being a first-generation college student herself and the fact that the majority of Latinx students in higher education are the first in their families to attend college. Through her own lived experiences, she is acutely aware of the challenges first-generation college students face, not only in postsecondary education but prior to entering college.

These reflective statements were discussed as a team in shaping the study's design and discussing the implications that this quantitative research can and cannot have in engineering education. Particularly, we wanted to shift this analysis away from comparing across racial, ethnic, and gender identities to avoid replicating results that center whiteness (Godwin, 2020; Holland, 2008; Okun, 2021), perpetuate anti-blackness (Holly, 2020), and uphold a gender binary (Haverkamp et al., 2021). Our approach to studying recognition is counter to traditional studies of demographic variables that intentionally and unintentionally treat race, ethnicity, and gender as causal variables. In taking this approach, we challenge ourselves to question how our methodological decisions can better promote a just and equitable version of engineering education rather than perpetuating the status quo (Mertens, 2012).

3 | THEORETICAL FRAMEWORK

3.1 | Engineering role identity: Recognition

For this study, we operationalize *recognition experiences* in relation to *recognition beliefs* across various, overlapping social identities.

Recognition experiences are opportunities students have to position themselves as engineers in which they may or may not be recognized as an engineer (Melo et al., 2020). Students position themselves as engineers through speaking, acting, dressing, feeling, valuing, and practicing their understanding of what it means to be in that role (Gee, 2000; Holland et al., 1998). Qualitative research demonstrates that specific engineering experiences (e.g., research, teaming) provide opportunities to perform an engineering identity that is recognized by others (Faber & Benson, 2015; Tonso, 1999). These performances may include being passively allowing oneself to be seen a certain way and agentically making bids for recognition (i.e., intentionally engaging in actions to align oneself with the perception of what it means to be an engineer; Gee, 2000).

External power structures ultimately influence how students have access to perform an engineering identity and how these performances are recognized (Tonso, 1999; Tonso, 2006). Students who "fit" the stereotype of an engineer are more often recognized without any intentional bids, while those who may not "fit" the stereotype may make several bids for recognition that are not taken by meaningful others (e.g., peers, mentors, or instructors; Malone & Barabino, 2009). Prior work describes an interplay between external structures that often devalue or constrain the engineering identities of students, including White women (Tonso, 1999) and Black men (Miles et al., 2020). Other work describes how people internally respond to these structures and perform these identities (Burke & Stets, 2009; Giddens, 1984). For example, one study describes the experiences of Latinas who overperformed an engineering identity to fit the White and masculine norms (Verdín, 2021a, 2021b). Another study described how Black women reshaped what it meant to be an engineer in their contexts (Ross et al., 2021). Our work extends these conversations by focusing on recognition experiences—the opportunities to perform engineering identities—to better understand how these are related to recognition beliefs at the intersection of race, ethnicity, and gender.

We define *recognition beliefs* as the extent students feel that important others see them as an engineer or as the type of person who can do engineering (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016; Scalaro et al., 2021). Through recognition experiences in which students have the opportunities to perform their identities, students may develop these internalized recognition beliefs. Recognition experiences are uniquely experienced; not every student has access to the same experiences and even two students with the same experience may interpret and internalize the experience differently. These underlying differences are often influenced by the systemic and structural issues that manifest as institutional and interpersonal messages that are conveyed and internalized by students in curricular and cocurricular environments (Sellers & Villanueva Alarcón, 2023). This study examines the relationship between recognition experience and recognition beliefs to determine whether there are any patterns by social group. While we acknowledge the importance of the internal mechanisms for *how* experiences are interpreted and internalized into recognition beliefs, this process is outside the scope of this research. By exploring the relationship between recognition experiences and the recognition beliefs of students across overlapping social identities, results can provide suggestions that educators can use to design and facilitate explicit recognition experiences that support recognition beliefs for a broader population of students, rather than prioritizing normative experiences that most often benefit White men.

3.2 | Framing race, ethnicity, and gender

We explicitly express our framing of race, ethnicity, and gender to provide a basis for the use of these grouping in our analyses. Race, ethnicity, and gender are socially constructed, and the measurement of these categories is fraught with difficulty, controversy, and even superficiality. Demographic measures are not simple or neat boxes into which individuals are categorized, nor do the social meanings of race, ethnicity, or gender remain constant over time and space (Holland, 2008; Zuberi & Bonilla-Silva, 2008). Instead, they represent complex social histories, hierarchies, and systems of oppression (Marks, 2008). Despite these challenges, race and gender have real meaning and implications for individuals in society and education. Bonilla-Silva (1997) wrote, "After the process of attaching meaning to 'people' is instituted, race [and we argue, ethnicity and gender, as well] becomes a real category of group association and identity" (p. 473). As such, marking a race or ethnicity on a survey has real meaning to a student's identity and their lived experience. This approach is a simplifying assumption guided by social norms of what it means to be a member of a social group (e.g., a White woman) and the methodology. In this work, we consider race and ethnicity similarly as they have similar racializing impacts on individuals within US society. We also acknowledge the separate histories of these concepts in their construction (Bonilla-Silva, 1999).

We recognize that a quantitative approach to these questions provides only descriptive evidence and lacks the contextual understanding necessary to understand causal mechanisms of how recognition experiences inform recognition beliefs. As a result, we can describe trends in how recognition experiences may differently be related to recognition beliefs within social groups. This work does not directly develop or demonstrate generalizable interventions for systemic change, nor does it provide causal evidence for how recognition experiences are internalized into recognition beliefs. Race, ethnicity, and gender are not causal to the phenomena observed. Instead, our examination provides ways to consider how engineering norms and values may shape how students have differential opportunities for recognition and meaning-making of those experiences, which, in turn, shape their beliefs about themselves as engineers.

4 | METHODS

To answer our research question, we gathered data from a survey of 3711 first-year engineering students across 32 ABET-accredited institutions in the United States. ABET-accredited institutions in the United States with common first-semester engineering courses were stratified by overall student enrollment, that is, small (7750 or fewer), medium (7751 to 23,050), and large (23,051 or more), based on data from the Integrated Postsecondary Database System (U.S. Department of Education and Institute of Education Science Nation Center for Education Statistics, n.d.). A stratified random sampling strategy helped to avoid overrepresentation by either a few large, public engineering institutions or numerous small institutions. We recruited institutions with a common first-semester course to get a representative sample of all engineering majors. Paper–pencil surveys were distributed in the Fall of 2017 to students enrolled in introductory engineering courses. The surveys were digitized using an optical character recognition scanner and checked for accuracy by multiple research assistants.

4.1 | Measures

This survey included several scales related to a larger research project; in this study, we focused on recognition experiences and students' recognition beliefs, consistent with our theoretical framing.

4.1.1 | Recognition experiences item development

Recognition is a critical aspect of identity development that engineering educators should cultivate in engineering classrooms, experiences to diversify engineering, and provide inclusive learning environments for all students (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016). There are no quantitative measures of recognition experiences. The existing measures for recognition probe students' self-reported recognition beliefs by others. We used students' descriptions of experiences that made them feel like an engineer from a pilot qualitative study to develop items that could be used to measure sources of recognition. The pilot study consisted of conducting one-on-one interviews with 12 first-year engineering students to understand their attitudes and beliefs about engineering identity, belonging, and recognition in engineering. These students were selected to participate in the pilot qualitative study based on their responses on an attitudinal survey (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016) used to determine non-normative attitudinal profiles (Benson et al., 2017) and to ensure maximum variation among students according to their self-identified race and ethnicity, gender identity, sexual orientation, and disability.

Each student was asked, "Was there a time when you felt recognized as an engineer?" follow-up questions probing deeper insights into the experiences were asked. The experiences of recognition indicated by each student were developed into 18 items centering on students' chosen wording and phrasing to measure potential experiences of recognition. The developed items were then presented to a group of eight undergraduate students and three engineering education graduate students for item-level feedback on applicability to their experience and clarity in wording. These items were designed to be used as single items and had no hypothesized or theoretical factor structure. We used a seven-point anchored numeric scale ranging from 0 (Strongly Disagree) to 6 (Strongly Agree), asking students to indicate how much each of these experiences contributed to feeling like an engineer (DeVellis & Thorpe, 2021).

4.1.2 | Recognition beliefs

We used four items from a previously established engineering role identity measure that capture students' recognition beliefs (i.e., internalized feelings of recognition) on a seven-point anchored numeric scale of agreement ranging from 0 (Strongly Disagree) to 6 (Strongly Agree) (Godwin, 2016). In our prior work, these items had strong validity evidence with the same population used in this study, first-year engineering students (Godwin & Kirn, 2020; Verdín & Godwin, 2021). Additionally, we verified the use of these survey items as a single factor using confirmatory factor analysis. Specifically, the Satorra–Bentler adjusted chi-square was $SB\chi^2 = 10.40$, $df = 2$, $p = .006$. The fit indices were CFI of 0.99, TLI of 0.99, RMSEA of 0.043 with a 90% CI [0.022, 0.066], and SRMR of 0.012, all suggesting a good model fit (Kline, 2015). The four recognition items were averaged to create the outcome variable: students' recognition beliefs. A summary of the close-ended survey questions used in this analysis can be found in a supplemental table provided in the Supporting Information (Supplemental Table 1).

4.2 | Participants

Participants indicated their gender identity from the following multiselect option list—female (woman), male (man), agender, genderqueer, cisgender, and transgender, including an option to write in a gender not listed. In this analysis, the participant grouping for marginalized gender (MG) was defined for students who identified as transgender ($n = 11$), genderqueer ($n = 12$), agender ($n = 11$), women ($n = 596$), and cisgender women ($n = 30$). In contrast, participants who indicated their identity as men or cisgender men were grouped as cisgender men (CM). Written responses were also coded for these two groups.

Similarly, participants indicated their racial and ethnic group identification by selecting one or more options from a list of seven groups—Asian; Black or African American; Latino/a/x or Hispanic; Middle Eastern or North African; Native Hawaiian or Other Pacific Islander; Native American or Alaska Native; and White, including an option to write in a racial/ethnic group not listed. In accordance with the 2010 U.S. Census Bureau classification of race and ethnicity, we defined White based on students who indicated White, Middle Eastern, or North African on the survey (U.S. Census Bureau, 2020). We also defined Indigenous based on students who indicated Native Hawaiian, Native American, or Alaska Native (U.S. Senate, 2012). This decision allowed us to include these responses within the analyses.

One of the challenges of conducting quantitative research with marginalized populations is small sample sizes. The reality of needing power to detect significant results creates practical challenges in conducting this type of research. We made decisions about how to group individuals within our study based on our theoretical approach to gender, race, ethnicity, and pragmatic limitations. Engineering is "culturally dominated by men and hegemonic masculinity" (Haverkamp et al., 2021, p. 56), which negatively affects ciswomen, transgender, and gender nonconforming individuals (Crossley, 2019). This hegemony is experienced universally and yet differentially by these groups, and we acknowledge our inability to make specific claims about each subgroup within the MG group (Cech & Waidzunas, 2021). We decided to include all individuals who may experience marginalization based on their gender identity rather than exclude the experiences of trans and gender nonconforming students, who are historically absent from engineering education studies (Cech & Waidzunas, 2011). The term *MG* comes from calls within the transgender and gender nonconforming community to create a term inclusive of all individuals who experience negative impacts of hegemonic masculinity (Crossley, 2019). Responses of men and CM were analyzed together as they are similar in response patterns within the data, and students may not be aware of the meaning of cisgender (Rohde et al., 2017).

Similarly, the Indigenous group represents varied cultures and geographic locales across the United States. We provided a starting list of race and ethnicity based on current demographic measures common in education, which are not devoid of historical issues of racism (Horton & Sykes, 2008) and monolithic identity groupings that exclude the nuances associated with an ethnic group (Villanueva Alarcón et al., 2022). We recognize that the experiences of these populations are not equivalent (Williams et al., 2022). As with gender, the choices to aggregate were made to balance the needs for group size in statistical testing while also trying to maximize the discussion of specific groups within our sample.

These decisions are imperfect and represent a tension within our work as we tried to balance the goals of representing participants' lived experiences within an engineering space that is White and masculine and having the statistical power to reveal patterns of opportunity for recognition within engineering. The choice for aggregation affects and limits some of the claims that can be made from our work, particularly regarding differential experiences of ciswomen, transgender, and gender nonconforming individuals (Trenshaw, 2018).

We created 10 intersectional groups, as indicated in Table 1, by five racial and ethnic groups and two gender groups, for example, Latinè/x/a/o and Hispanic Marginalized Gender = LHMG or Latino and Hispanic Cisgender Men = LHCM. Participants who selected racial and ethnic identifiers across multiple categories were placed into both groups for analysis with a weighted contribution. For example, someone who identified as White, and Latinè/x/a/o or Hispanic were placed into the White and Latinè/x/a/o or Hispanic groups that aligned with their gender responses with a contribution to both groups. This approach is analogous to the critical quantitative approach of effects coding described by Mayhew and Simonoff (2015) and provides a within-group analysis of which recognition experiences are most important for a particular group in developing strong recognition beliefs. However, our approach does not capture the unique experiences of individuals with multiple racial and ethnic identities. Rather than an overall model to compare between groups that requires a reference group, this technique focuses on how trends within subgroups of race, ethnicity, and gender can be understood and does not position responses of any racial, ethnic, or gender group as normative—the standard against which all other effects are interpreted.

4.3 | Analysis

We used R, an open source software for statistical computing and graphics, to analyze the data (R Core Team, 2020). First, the data were digitized and cleaned by removing indiscriminate responses, reducing the sample from 3855 to 3711 valid responses. Then, we used Mahalanobis distance to detect and remove multivariate outliers (Tabachnick &

TABLE 1 Student-reported racial and ethnic identity and gender identity.

	Gender identity	
Race/ethnicity	Marginalized gender	Cisgender men
Asian	85	216
Black	52	97
Indigenous	21	27
Latinè/x/a/o and Hispanic	68	190
White	441	1265

Note: The number of participants in the table is greater than the number of participants in the study, as participants could select multiple demographic identifiers.

Fidell, 2013). Multivariate outliers can occur when different populations are mixed in the same sample or when other important variables are omitted; it is important to note how there is a risk of producing both false-positive and false-negative results (i.e., mask or unintentionally fabricate outliers; Tabachnick & Fidell, 2013). The alpha value for the Mahalanobis distance was set as $\alpha = .001$. Approximately 151 cases of outliers were detected and removed, resulting in a sample size of 3560. Following the Mahalanobis distance test, we created the gender variables for MG and CM, resulting in a final sample size of 2316.

We used separate multiple linear regressions for each group to examine the specific experiences that promote students' recognition beliefs (i.e., outcome variable). To move away from treating gender and race/ethnicity as separate control variables and to avoid making comparisons across a normative group (i.e., White, CM; Bowleg, 2008), we divided our dataset based on the intersecting groups described in Table 1. Ten separate multiple regression models were run based on the gender and race/ethnicity groups. The internal consistency for the recognition belief measure of each model was calculated, and Cronbach's alpha coefficients were between 0.75 and 0.85, indicating acceptable levels of reliability (Taber, 2018). Collinearity and normality assumptions were examined to ensure that the final models were adequate (Supplemental Table 1). Variable inflation factor (VIF) statistics were within acceptable ranges (VIF <5; Table 2; Bowerman & O'Connell, 1990; Field, 2013; Menard, 1995; Myers, 1990). Additionally, each variable's skewness and kurtosis were within acceptable ranges ($<|2|$ and <7, respectively) to meet normality assumptions, and visual inspection of Q–Q plots indicated the residuals were normally distributed. The maximum likelihood regression approach used is robust to mild non-normality (Schmidt & Finan, 2018; Supplemental Table 2).

5 | RESULTS

To examine the experiences that supported students' recognition beliefs, we ran a multiple linear regression model for each group. We consciously do not discuss the results of the groups compared with White CM to resist dominant norms in methodological approaches and to avoid generalizing what contributes to students' sense of recognition in engineering to the numerical majority in the data and engineering. Our results indicate trends in recognition experiences that are related to recognition beliefs for each group. First, we present the recognition experiences by MG grouping in alphabetical order. Following, we present the results of CM also in alphabetical order. A summary of the results can be found in Table 2. In the subsections that follow, we provide information about the overall model fit (i.e., F-statistic) and the standardized coefficients (Cohen et al., 2003).

5.1 | Asian MG

Asian students with MG identities had positive and statistically significant recognition experiences across three measures. Recognition experiences that were statistically significant were: when engineering instructors knew their name ($\beta = .24$, $p < .05$), when their family called them an engineer ($\beta = .32$, $p < .01$), and when they applied problem-solving skills

TABLE 2 Regression results for multiple models of recognition beliefs regressed on to experiences of recognition.

Item	AMG	BMG	IMG	LHMG	WMG	ACM	BCM	LHCM	ICM	WCM
Q6a: Engineering instructors know my name	0.24* (0.07)									
Q6c: Win an award							−0.22* (0.07)	−0.14* (0.04)		−0.07** (0.02)
Q6d: Family calls me an engineer	0.32** (0.07)		0.66*** (0.12)	0.29* (0.09)		0.21** (0.04)	0.34* (0.11)	0.30*** (0.05)		0.25*** (0.02)
Q6e: Friends call me an engineer					0.28*** (0.04)		0.35* (0.12)			
Q6f: Engineering major		0.34** (0.09)								
Q6g: Apply engineering skills to assignments			0.55*** (0.12)			0.21** (0.08)			0.39* (0.16)	0.15*** (0.03)
Q6i: Peers trust leadership						0.15* (0.06)				0.09** (0.03)
Q6j: Volunteer										
Q6k: Instructor		0.43** (0.09)							−0.40* (0.16)	
Q6l: Apply skills to everyday life	0.21* (0.09)					0.17* (0.07)				0.13*** (0.03)
Q6n: Team members appreciate contributions										0.11** (0.03)
Q6p: Participation in precollege cocurricular activities		0.26* (0.07)			0.12*** (0.03)					
Q6q: Participate in engineering class				−0.34* (0.16)	0.32*** (0.05)				0.50* (0.22)	
Q6r: Engineering skills contribute to society				0.60*** (0.17)				0.37*** (0.06)		

Note: Standard errors (SEs) are included in parentheses. Refer to Supplemental Table 1 for the survey items. All reported values are standardized estimates. Significant results are indicated by asterisks. Experiences of recognition with non-significant values were removed from the analysis and do not appear in this table.

Abbreviations: ACM, Asian cismen; AMG, Asian marginalized gender; BCM, Black cismen; BMG, Black marginalized gender; ICM, Indigenous cismen; IMG, Indigenous marginalized gender; LHCM, Latinè/x/a/o and Hispanic cismen; LHMG, Latinè/x/a/o and Hispanic marginalized gender; WCM, White cismen; WMG, White marginalized gender.

*$p < .05$; **$p < .01$; ***$p < .001$.

into their daily life ($\beta = .21$, $p < .05$). Overall, these three recognition experiences significantly informed AMG's recognition in engineering ($F_{3,81} = 14.13$, $p < .001$) and helped explain 32% of the variance (adjusted R^2 of .32).

5.2 | Black MG

Black students with MG identities had positive and statistically significant recognition experiences across three measures. Recognition experiences that were statistically significant included: when they received acceptance in their desired engineering discipline such as industrial, mechanical, or electrical engineering ($\beta = .34$, $p < .01$), when their instructor emphasized how the course will make them more like an engineer ($\beta = .43$, $p < .001$), and after participating in precollege programs designed to increase students interest and engagement in STEM fields such as Project Lead the Way and FIRST robotics ($\beta = .26$, $p < .05$). Overall, the three recognition experiences significantly informed BMG's recognition in engineering ($F_{3,48} = 14.74$, $p < .001$) and helped explain 45% of the variance with an adjusted R^2 of .45.

5.3 | Indigenous MG

Indigenous students with MG identities had positive and statistically significant experiences across two measures. Recognition experiences that were statistically significant included: when their family called them an engineer ($\beta = .66$, $p < .001$) and when they applied their engineering skills to assignments such as homework and projects ($\beta = .55$, $p < .001$). These two recognition experiences significantly informed IMG's recognition in engineering ($F_{2,18} = 26.5$, $p < .001$). The model produced an adjusted R^2 of .72, indicating that recognition experiences explain 72% of the variance for IMG recognition in engineering.

5.4 | Latinè/x/a/o and Hispanic MG

Latinè/x/a/o and Hispanic students with MG identities had positive and negative statistically significant recognition experiences across three measures. Recognition experiences that were statistically significant and had a positive effect included: when their family called them an engineer ($\beta = .29$, $p < .05$) and when they believed their engineering skills could contribute to society ($\beta = .60$, $p < .001$). Notably, believing their engineering skills can contribute to society was nearly two times more important than their recognition by family. Participation in engineering classes had a negative effect on their recognition in engineering ($\beta = -.34$, $p < .05$). Overall, these three recognition experiences significantly informed LHMG's recognition in engineering ($F_{3,64} = 10.71$, $p < .001$) and helped explain 30% of the variance (adjusted R^2 of .30).

5.5 | White MG

White students with MG identities had positive and statistically significant recognition experiences across three measures: when their friends called them an engineer ($\beta = .28$, $p < .001$), after participating in precollege programs designed to increase students' interest and engagement in STEM fields such as Project Lead the Way and FIRST robotics ($\beta = .12$, $p < .01$), and after participating in engineering classes ($\beta = .32$, $p < .001$). These three recognition experiences significantly informed WMG's recognition in engineering ($F_{3,437} = 64.47$, $p < .001$) and helped explain 30% of the variance (adjusted R^2 of .30).

5.6 | Asian CM

Asian CM had positive and statistically significant recognition experiences across four measures. Statistically significant recognition experiences involved: when their family called them an engineer ($\beta = .21$, $p < .01$), when they applied their engineering skills to assignments such as homework and projects ($\beta = .21$, $p < .01$), when their peers entrusted them with the responsibilities of a leader ($\beta = .15$, $p < .05$), and when they applied problem solving skills to their daily life ($\beta = .17$, $p < .05$). These four recognition experiences significantly informed recognition in engineering ($F_{4,211} = 27.66$, $p < .001$). The model produced an adjusted R^2 of .33, indicating that recognition experiences explain 33% of the variance for WMG recognition in engineering.

5.7 | Black CM

Black CM had positive and negative statistically significant recognition experiences across three measures. Experiences that positively supported their recognition in engineering included: when their friends called them an engineer ($\beta = .35$, $p < .05$), and when their family called them an engineer ($\beta = .34$, $p < .05$). Conversely, winning an award for an engineering project had a negative effect on their recognition in engineering ($\beta = -.22$, $p < .05$). Overall, these three recognition experiences significantly informed BCM's recognition in engineering ($F_{3,93} = 14.55$, $p < .001$) and helped explain 30% of the variance (adjusted R^2 of .30).

5.8 | Indigenous CM

Indigenous CM had positive and negative statistically significant experiences across three measures. Recognition experiences that were statistically significant and had a positive effect were as follows: when they applied their engineering skills to assignments such as homework and projects ($\beta = .39$, $p < .05$), and when they participated in engineering classes ($\beta = .50$, $p < .05$). Conversely, when their instructors stated, "This class will make you more like an engineer," this experience had a negative effect on their engineering recognition ($\beta = -.40$, $p < .05$). These three recognition experiences significantly informed ICM's recognition in engineering ($F_{3,23} = 6.989$, $p < .001$) and explained 41% of the variance (adjusted R^2 of .41).

5.9 | Latino and Hispanic CM

Latino and Hispanic CM had positive and negative statistically significant recognition experiences across three measures. Recognition experiences that were statistically significant and had a positive effect were as follows: (1) when their family called them an engineer ($\beta = .30$, $p < .001$), and (2) when they believed their engineering skills could contribute to society ($\beta = .37$, $p < .001$). Yet, winning an award for an engineering project had a negative effect on their recognition in engineering ($\beta = -0.14$, $p < .05$). Overall, these three recognition experiences significantly informed LHCM's recognition in engineering ($F_{3,186} = 25.67$, $p < .001$) and explained 28% of the variance (adjusted R^2 of .28).

5.10 | White CM

White CM had statistically significant positive and negative recognition experiences across six measures. Recognition experiences that were statistically significant and had a positive effect were as follows: (1) when their family called them an engineer ($\beta = .25$, $p < .001$), (2) when they applied their engineering skills to assignments such as homework and projects ($\beta = .15$, $p < .001$), (3) when their peers entrusted them with the responsibilities of a leader ($\beta = .09$, $p < .01$), (4) when they applied problem-solving skills into their daily life ($\beta = .13$, $p < .001$), and (5) when they felt their team members appreciated their contributions to group projects ($\beta = .11$, <.01). Conversely, winning an award for an engineering project had a negative effect on their recognition in engineering ($\beta = -.07$, $p < .01$). Overall, these six recognition experiences significantly informed WCM's recognition in engineering ($F_{6,1258} = 85.4$, $p < .001$) and explained 29% of the variance (adjusted R^2 of .29).

6 | DISCUSSION

This study used regression analyses to examine students' experiences of recognition that predicted their internalized recognition beliefs at the intersection of race, ethnicity, and gender. In this work, we developed and incorporated an understanding of how particular kinds of recognition experiences are related to students' recognition beliefs and, thus, identities as engineers. The variation in what kinds of experiences are important by race, ethnicity, and gender emphasizes differences in potentially the types of experiences afforded to particular groups and particular ways recognition experiences are perceived and evaluated. A deeper examination of engineering role identity as connected to engineering's racialized and gendered defaults is necessary for inciting "personal and professional consciousness about racial, ethnic, and cultural factors" that influence students' identity development and recognition (Holly, 2020, p. 629). We believe that this study offers two interconnected contributions to the engineering education research community: (1) our results emphasize recognition is not a universal, one-size-fits-all effort, and (2) the racialized and gendered culture of engineering creates different relationships between recognition experiences and recognition beliefs.

For all groups, recognition experiences explain a significant portion of the variance in recognition beliefs. Some models explained a large portion of the variance through recognition; for example, 72% of the variance was explained in recognition beliefs for Indigenous MGs. In contrast, the model for Latino and Hispanic CM explained 28% of the variance in recognition beliefs. While this result is still statistically significant, there may be other important shaping factors not captured in our models for these students. Our results support prior findings about the importance of specific recognition experiences for early-career students broadly (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016). These different results for groups at the intersection of race, ethnicity, and gender indicate that a one-size-fits-all approach does not consistently result in positive or significant relationships between recognition experiences and recognition beliefs. We describe some of these examples but do not discuss every cross-cutting experience. For example, experiences where family members refer to the student as an engineer are particularly important for Asian, Black, Latino and Hispanic, and White CM and Asian, Indigenous, and Latinè/x/a/o and Hispanic MGs. This finding is consistent with prior literature that reports the significance of external recognition, specifically from family, reinforces identity development for Latinas (Rodriguez et al., 2019). Other research emphasizes that as students engage in engineering, the role of *familia* and *fictive kin* in supporting identity development is a key part of their engagement within engineering (Revelo Alonso, 2015; Rodriguez et al., 2019; Simmons & Martin, 2014). Being recognized by important family or family-like figures may be particularly important for some students and not others. Indeed, a study of first-generation college students emphasized community networks as important sources of knowledge support, specifically students' neighborhood friends, college friends, family members, and coworkers (Verdín et al., 2021). This result points to opportunities to engage families or communities in engineering formal classrooms in ways that may foster these kinds of recognition experiences.

Other recognition experiences, such as receiving compliments from an engineering instructor or peer about their engineering design and contributions to the team, were not influential for early-career engineering students, especially students marginalized by gender and race. This result may be due to how individuals perceive these people as less important in their social sphere at the beginning of university or may be a result of fewer students having these kinds of opportunities in large-enrollment introductory STEM courses (Scanlon et al., 2007) or as a result of bias in the classroom (Park et al., 2022). These types of recognition may be more important as students progress in their academic pathways, considering students' prioritization of recognition beliefs and beliefs about their ability to understand and do well in engineering vary over time (Scalaro et al., 2021). It may also be due to the types of compliments or peer interactions. Research emphasizes that teams are a place in engineering that often creates negative and exclusionary experiences for marginalized students (Cross & Paretti, 2020; Dickerson et al., 2021; Tonso, 2006). Additionally, instructors often only recognize particular ways of knowing aligned with White and masculine norms (Verdín et al., 2021; Wilson-Lopez et al., 2016). These documented dominant norms may explain why some recognition experiences were unimportant or negatively influenced marginalized students. These results may be an artifact of how the questions were framed as recognizing students' contributions and skills rather than the role of instructors in going beyond recognition to converting those assets into forms of social and cultural capital (Rios-Aguilar et al., 2011). Particular attention to power and privilege within engineering is essential to understanding these recognition processes more deeply.

We also found that classroom experiences related to recognition beliefs did not have the same importance across groups. For example, Latinè/x/a/o and Hispanic MG students showed a negative relationship between recognition beliefs and participation in engineering classes. In contrast, these experiences were positively related to recognition beliefs for White MG students and Indigenous CM. However, Indigenous CM indicated that being told an engineering class would make them more like an engineer was a negative predictor of recognition beliefs. The norms of engineering culture that are hostile and isolating for marginalized students, particularly in predominantly White institutional contexts (Godfrey & Parker, 2010; Strayhorn et al., 2014), may be related to why participation was linked to negative recognition beliefs. The types of recognition and messaging students receive are linked to how knowledge is constructed and valued in engineering. Expectations of acceptable participation shape how students engage in engineering work and see themselves as engineers. As such, the educational defaults often do not create spaces where Indigenous and Latinè/x/a/o students can leverage their skills (McGee, 2021; Wilson-Lopez et al., 2016).

Additionally, orientations to engineering work and the application of engineering had some positive relationships for particular students. Both Latinè/x/a/o and Hispanic MG students and CM felt recognized as an engineer when they perceived their engineering skills would contribute to society. A study of adolescent Latinè/x/a/o students found that engineering design experiences that were connected to their communities had a positive influence on their belief about their ability to do engineering, changed their perception of the field of engineering, and fostered feelings of belongingness (Mejia et al., 2015). These trends support prior literature on the importance of authentic and community-based engineering work for Black and Latinè/x/a/o students (Samuelson & Litzler, 2016).

Not all recognition experiences were positively related to recognition beliefs. Black, Latino and Hispanic, and White CM were less likely to feel a sense of recognition by winning an award for an engineering project, although the effect sizes of this relationship are small for Latinos and White CM. The recognition experience of winning an award was the only measure consistently producing a negative effect for some student groups. While we cannot draw causal conclusions about the use of awards in introductory engineering courses, the use of awards as a recognition experience may not result in the types of outcomes intended. Instead, regularly validating Black men's contributions in the classroom beyond a one-time award may create more effective recognition experiences for developing students' recognition beliefs (Fries-Britt & White-Lewis, 2020).

While a particular hypothesis did not drive this study, it was surprising that four items were not statistically significant for any of the intersectional groups, especially considering how the items were derived from student responses. The items that were not significant were designed to examine the importance of nonengineering instructors learning students' names, receiving compliments from an instructor for incorporating prior knowledge into an engineering design, team members recognizing their peers' efforts, and participating in engineering clubs or societies in college. The timing of the study may contribute to these findings; students may not have been wholly integrated into the engineering community and primarily drew on their precollege experiences to indicate their most salient experiences and incoming attitudes and beliefs about their engineering identity.

Our study emphasizes the need to examine within-group relationships between recognition experiences and beliefs. For engineering educators, these results indicate that various recognition experiences may provide the best opportunities for students across groups, barring a few examples that were negatively or unrelated to students' recognition beliefs. For engineering education researchers, the findings point to opportunities for future investigation and a need to consider recognition and other identity studies at the intersections of race, ethnicity, and gender without comparison to a dominant group or treating social groups as causal variables.

The relationships between recognition experiences and recognition beliefs do not occur in a vacuum. Engineering as a field and engineering education has a documented history of White supremacy and misogyny (Akpanudo et al., 2017; Cross, 2020; Haverkamp et al., 2019). These systemic factors are embedded in what it means to be an engineer, who participates in engineering, and how individuals are valued or not within the engineering culture. Our results stem from these socially constructed realities that result in recognition experiences nuanced by race, ethnicity, and gender. As a result, focusing only on engineering role identity is not a panacea for engineering professional development and student success; instead, it is a nuanced and complex process of becoming that is situated in the history of engineering as raced and gendered (McGee, 2016; Pawley, 2019; Slaton, 2015). Thus, this work begins to describe general trends in how recognition may be both experienced and important for students at the intersections of students' social identities that overlap and can result in compounding experiences of marginalization.

7 | LIMITATIONS

While this research study provides a deeper understanding of connections between recognition experiences and recognition beliefs with considerations of race, ethnicity, and gender, there are some important limitations to acknowledge, particularly for research where equity and inclusion are the central focus. Our study only examined the experiences of early-career engineering students at one point in time, which constrains our knowledge about the recognition experiences that are most salient as students progress throughout engineering. The strength of this study is that it provides practical insight into how to support students entering engineering education. However, other cocurricular experiences are important to engineering role identities including internships/cooperative education, design experiences, research experiences, and career fairs (Castillo et al., 2022; Ju & Zhu, 2023; Meyers et al., 2010; Vicente et al., 2023). We decided to exclude these items under the assumption that early-career engineering students may not have completely integrated into the engineering community, limiting their awareness of and participation in the resources provided by various identity-based professional organizations or engineering student support centers.

Similarly, the examples provided for the survey item measuring student engagement in pre-collegiate programs may only be accessible for students who reside in geographic locations relatively close to higher education institutions and metropolitan areas. In contrast, students who live in rural communities may have limited access (if any) to programs that encourage early engagement in STEM. We selected examples based on the programs described by the students who participated in the pilot study. While the students who chose to participate in the pilot study were attitudinally and demographically diverse, the participant responses garnered a limited perspective of the types of precollege engineering programs that may be of interest to a nationally representative sample.

While the goal of this approach was to describe patterns of recognition experiences and recognition beliefs by social groups, we faced tensions about how to represent individuals and multifaceted identities within our quantitative study. For example, our decision to include transgender and gender nonconforming students within the MG group, to some extent, reproduced a nontraditional gender binary by splitting our data into two groups and including a MG group dominated by ciswomen. While this approach may have limited our understanding of the recognition beliefs among students within the MG group, it nevertheless provided an avenue to include transgender and gender nonconforming students in the analysis rather than erase their experiences within our study or ignore the growing recognition of the spectrum of gender identities prevalent in engineering. Our study was also limited because of the use of discrete racial and ethnic groups based on demographic measurement norms within the United States. Nevertheless, students often have familiarity with these types of measures and identify with the provided categorizations; a quantitative approach to understand general trends for students and reveal patterns within groups of how recognition experiences are related to recognition beliefs simplifies the complex realities of race, ethnicity, and gender. We believe our results provide a useful starting point to question how recognition may occur in an engineering context that is White and masculine and may require further qualitative explorations that offer more nuanced understandings of students' recognition experiences.

The reality of small sample sizes in quantitative research makes this type of study challenging and reflects the pressing issues of representation and equity within engineering spaces. We want to openly acknowledge the tension in our work. We were concerned about the risk of Type II error in our models with small sample sizes for each group, meaning that we may not have identified relationships between recognition experiences and recognition beliefs that exist for particular groups. However, after examining the magnitude of the effect sizes for our smallest samples, that is, Indigenous MG ($n = 21$) and Indigenous CM ($n = 27$), a post-hoc power analysis yielded a statistical power above 0.80, indicating a high likelihood of detecting the observed effects.

In addition, this approach does not explore the interplay of other identity-supporting constructs, such as performance/competence beliefs and interests, which are known to mediate students' identity development (Godwin, Kirn, et al., 2016; Godwin, Potvin, et al., 2016). Likewise, this analysis does not capture the nuance of how recognition experiences are interpreted and internalized as meaningful (Scalaro et al., 2021). These limitations emphasize how time and culture are critical elements when examining students' internationalization of recognition.

8 | FUTURE DIRECTIONS

This research study provides a more nuanced examination of the relationship between recognition experiences and recognition beliefs and emphasizes areas for additional work. The population of this study was limited to early-career engineering students. Although it provided practical insight into how to support students, future work needs to explore students' recognition experiences and recognition beliefs for the duration of their engineering programs. We share similar sentiments with Rodriguez et al. (2019); future work should investigate access to recognition experiences, how internalized recognition beliefs evolve, and how students value specific recognition experiences at varying times during their engineering journey.

Future directions should ensure that items measuring students' recognition experiences are culturally responsive and capture the nuances of their lived experiences beyond their first semesters in their programs. For example, the survey item measuring students' participation in college clubs and societies was not significant for any intersectional group. However, several studies report the importance of identity-based engineering organizations as playing an important role in the identity development of Latinè/x/a/o, Black, women, and individuals at the intersections of those identities (Revelo Alonso, 2015; Ross et al., 2021). Such organizations include engineering student support centers and engineering ethnic professional organizations, which play a critical role in the recruitment and retention of students minoritized in engineering (Lee & Matusovich, 2016) and serve as reaffirming structures for the identity development of Latinas (Revelo Alonso, 2015) and Black women in engineering (Ross et al., 2021). However, the examples provided in our survey did not include racial and ethnic or gender identity-based engineering organizations such as the Society of Hispanic Professional Engineers (SHPE), the National Society of Black Engineers (NSBE), the Society of Asian Scientists and Engineers (SASE), Out in Science, Technology, Engineering, and Math (oSTEM), the National Organization of Gay and Lesbian Scientist and Technical Professionals (NOGLSTP), or the Society of Women Engineers (SWE).

Future work should include a broader range of pre-collegiate engineering experiences to make the survey more generalizable to students beyond the current population who mostly reside close to higher education institutions and metropolitan areas. Additional programs could include NSBE Summer Engineering Experiences for Kids (SEEK), engineering for us all (e4usa), or junior chapters of NSBE and SHPE. This expansion would provide students with a broader selection of programs that reflect their identity and interests, resulting in a more nuanced understanding of the experiences facilitating the internalization of recognition. Lastly, these results reflect the time and place they were conducted. Additional work should be used to understand how the pandemic may have exacerbated these results.

9 | IMPLICATIONS

The results of this study highlight implications for future research and practitioners. First and foremost, this study highlights that there is no one-size-fits-all approach to fostering recognition beliefs and that there is a need for a multifaceted approach to center equity and inclusion while integrating identity-building interventions for early-career engineers. As students have opportunities to practice their identities and be recognized in ways meaningful to them, it is critical that educators recognize the inequitable ways students have been recognized by race, ethnicity, and gender (Tonso, 1999). This study indicates that White CM may have benefited more from or had more opportunities to be recognized, as indicated by the high number of relationships found between recognition experiences from peers and by applying engineering skills in the classroom and daily life on their recognition beliefs. As such, a curriculum could be developed to facilitate broad access to recognition experiences and equitable recognition from peers and faculty.

Actions that faculty and administrators often defer to when attempting to foster recognition may not be the answer. One such example is giving awards as a mechanism of recognition. The findings of this study highlight that designating award structures may not be the answer to developing recognition beliefs of early-career engineers. Specifically, Black, Latino and Hispanic, and White CM all had significant negative relationships between awards and recognition beliefs and no groups had significant positive relationships. Aligning with previous literature, students at this phase of their engineering career may become more aware of perceived differences in their knowledge and abilities and thus reject these forms of recognition (Scalaro et al., 2021).

Recognition experiences could also be connected to students' engineering trajectories and social networks to influence their recognition beliefs. Specifically, Black and Latinè/x/a/o MG students saw the benefit of connecting engineering skills to their present and future. For Latinè/x/a/o and Hispanic students directly connecting engineering practices to more global considerations of societal improvement may benefit their recognition beliefs, for an example, see Verdin and Quiroga (2022). At the same time, Black MG students may benefit from reflection activities that help them see how their newly acquired skills help them move closer to being an engineer. Open-ended reflective exercises that probe into future goals, personal values, and engineering work can provide flexible ways to provide recognition. Further, Asian, Black, Latino and Hispanic, and White CM and Asian, Latinè/x/a/o and Hispanic, and White MGs all had significant positive findings related to experiences of their family, friends, or peers calling them engineers. Designing educational activities that ask students to discuss engineering with these members of their social networks could serve as a low-cost model for students to be called engineers and develop positive recognition beliefs.

This work provides an example of a quantitative approach that "sits in the tensions" of doing equity research (Godwin, 2020). There are some strengths of discussing quantitative results without treating race, ethnicity, and gender as causal variables through person-centered approaches (Reeping et al., 2023).

10 | CONCLUSION

Research on identity development in engineering education has often stressed the importance of students' internalized recognition beliefs, with a limited understanding of the types of experiences promoting meaningful recognition. We provide results that emphasize the need to draw on multiple recognition experiences to support the development of early-career engineers across race, ethnicity, and gender. Further, our results indicated unique patterns of recognition experiences at the intersection of race, ethnicity, and gender, highlighting how there is no one-size-fits-all approach to promoting recognition. These findings provide implications for educators and practitioners as they consider how they can begin to support the development of recognition beliefs for early-career engineering students through various curricular changes grounded in culturally relevant or responsive pedagogy and recognition-building activities. While our results offer some insight into the effort needed to promote recognition, future work must examine how students' internalized recognition beliefs and supporting recognition experiences evolve and deeply explore the process of facilitating meaningful recognition.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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