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Toward an Understanding of the Relationship Between Race/Ethnicity, Gender, First-generation Student Status, and Engineering Identity at Hispanic-serving Institutions

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Abstract

Understanding how students of different demographic backgrounds differ in their early engineering identities can help inform educators' efforts to facilitate engineering identity development. This work contributes to this understanding with a quantitative exploration of the ways that race/ethnicity, gender, and first-generation status work together to impact engineering identity among 656 early-career engineering students at a public Hispanic-Serving Institution (HSIs) in the Southwestern United States. Our analyses show no significant differences between non-white and white students, nor between men and women in terms of their engineering identity. Interactions between race/ethnicity and gender were tested and also yielded no significant differences. Students who reported that they will be the first in their family to get a college degree, however, had significantly lower engineering identity scores (=-.205; p<.001). These results lead us to conclude that first generation status at HSIs may be more important than gender and race/ethnicity in the development of engineering identity for early career students at HSIs.

Introduction and Review of Literature

Measures of engineering identity are increasingly used in models of engineering education to evaluate how identity contributes to success and persistence of engineering students [1] - [5]. Engineering identity is generally assumed to contribute to educational success, with stronger engineering identity leading to persistence [1] - [4]. At the same time, data clearly shows that persistence of engineering students varies by race/ethnicity and gender [6] - [9]. Given these previous findings, we expect that engineering identity varies by race/ethnicity, gender, and first-generation status [8], [10], [11]. Yet, relatively little work has quantitatively compared how engineering identity differs across racial/ethnic groups, gender and first-generation status. Understanding how students of different demographic backgrounds differ in their early engineering identities can help inform educators' efforts to facilitate engineering identity development. This work contributes to this understanding by exploring how engineering identity varies in relation to race/ethnicity, gender, and first-generation status among early-career engineering students at a public Hispanic-Serving Institution (HSI) in the Southwestern United States. We analyze survey data from 656 early-career engineering students; approximately two-thirds identify as Latinx, 28.2% identify as women, and 35.2% are first-generation college students. We find that first-generation early-career engineering students have a lower engineering identity than their non-first-generation peers, but engineering identity does not vary significantly by race/ethnicity, by gender, or by family socioeconomic status. These findings suggest that first-generation status may be particularly important for the engineering identity of early-career engineering students at HSIs.

Engineering Identity and Persistence

STEM identity is a measure of how connected a student feels to their STEM discipline [6]. A significant amount of research assumes that developing a STEM identity is very important to succeeding in STEM fields, suggesting that students that develop a STEM identity are less likely to leave their STEM major [1] - [6], [12] - [15]. Studies in engineering identity developed out of the need to highlight the fundamental differences in identity across STEM disciplines [16]. Engineering is unique for several reasons. Engineering programs, historically dominated by non-first-generation, white, male, and middle- and upper-class students, are less diverse, and tend to maintain a particularly exclusive culture, limiting underrepresented students' entry and persistence in the field [16]. Other science, technology, and math fields have made more extensive efforts to recruit and welcome students from a variety of backgrounds [6], [16]. In other words, these fields have sought to reduce systemic impacts that have historically discouraged persistence for students who are members of minoritized groups. Engineering programs, on the other hand, have become notorious for the 'leaky pipeline'—the process whereby students drop out or switch majors before graduation [16].

The lack of diversity and persistence in undergraduate engineering programs has led to a breadth of research on the factors predicting student retention and success—especially that of underrepresented and minoritized groups [2], [3], [5], [12], [14], [15]. In this research, engineering identity –measured in a variety of ways—has become a significant variable contributing to educational success, with stronger engineering identity leading to persistence [7], [10], [17] - [28]. That is, the more students feel like they belong in engineering, feel supported academically, personally, and socially, are recognized as engineers by their peers, faculty, and friends and family, feel competent as an engineering student and identify themselves as an engineer, and see a future for themselves as an engineer, the more likely they will be to remain in engineering [11], [29]. Identity gives purpose, and purpose drives action.

Other important factors that have been explored in the literature of student's persistence in engineering include race/ethnicity, gender, socioeconomic status, and first-generation status. More specifically, studies show that being non-white [10], [17] - [20], identifying with a gender other than male [7], [9], [23], [25] - [27], as well as being the first in your family to attend college [30], [31], are all linked to lower levels of persistence and success in engineering. Many of these studies have also examined various combinations of demographic factors and their interactions with engineering identity and their influence on persistence and success [32] - [36].

While a majority of the literature on engineering identity to date utilizes engineering identity and key demographic factors (race/ethnicity, gender, socioeconomic status, and first-generation status) to predict persistence/success in STEM and engineering, very few studies have examined how these same demographic factors are related to engineering identity itself [8], [17], [29], [37], [38], and even fewer are quantitative [20], [29], [33], [38]. Importantly, these studies do not

specifically test how engineering identity varies across diverse groups based on race/ethnicity, gender, socioeconomic status, and first-generation status. Instead, they focus on the development of an engineering identity for particular student subgroups (i.e., the development of an engineering identity for Latina engineers, or first-generation racially or ethnically minoritized engineers). We turn our attention to those studies in the next section.

The Relationship between Gender, Race/Ethnicity, First-Generation Status, and Engineering Identity

Few articles have examined variation in engineering identity across gender [37], [38]. It is more common to find studies that focus on women and their experiences within the discipline [32] - [36]. Studies that do look at the variation in engineering identity by gender tend to focus on the differences in the motivations that the students have for pursuing engineering, as well as their understanding of what engineering is. Men for example, tend to be motivated by job security, and the hands-on building and design aspects of engineering. Women, on the other hand, value the challenge of the discipline, along with the math and thinking processes aspects of it.[38]. Research has also examined the identity work that engineering students of either gender do to match their identity to the dominant norms and expectations present in their engineering programs. Students, for example, described their efforts to act more masculine while in an engineering-centered environment—meaning that they felt pressure to express an interest in more 'boyish' pastimes, such as cars or technology or videogames, to participate in certain markers of being 'one of the boys' like alcohol consumption and sexist jokes, and to assert dominance over others by intellect, strength, or humor [37]. Since women are pressured to accept and enact this sort of masculine identity, men generally have an easier time belonging to the culture and so perceive engineering as a more natural pursuit; women must carry out considerably more identity work in order to fit in and to choose engineering to begin with [37]. Among these influences on engineering identity are positive role-models and interactions within the department, the fostering the belief in one's competence in engineering and self-liking, and being welcomed and supported by faculty [32], [35].

Revelo [39] - [41] has published extensively on the development of an engineering identity among Latinx students. He identifies commitment to community, the development of oneself as a leader, and having role models as important forms of social capital that help foster an engineering identity in Latinx students. He has also examined the within-group differences in Latinx students' engineering identity development, and finds that variation in Latinx engineering students' engineering identity development is largely explained by the degree of professional and leadership development of the students, the wellbeing of the community of engineering students and faculty in the department, role modeling from mentors, and the existence of an 'engineering family' in the department—especially consisting of others who are also Latinx [39]. The significance of much of this research points to the importance of counter spaces in Engineering departments wherein engineering students of color can find support and safety [39] - [41].

There are also several studies that combine either gender and race/ethnicity, or race/ethnicity and first-generation status and their relationships to engineering identity. For example, Latinx students enrolled in Hispanic-Serving Institutions (HSIs) tend to have a higher engineering identity than Latinx students at a Primarily White Institutions (PWIs)—that is, they are more interested in engineering, intend to work in engineering after they graduate, and are more likely to participate in undergraduate engineering student organizations [29]. Research has also found that HSIs tend to close the gap between Latinx and white students in terms of engineering identity [29], [42]. Espinoza [42] suggests that this can be, in part, due to the differences in the parental education achievements of students in these different institutions. While Latinx students tend to have a lower level of parental education at PWIs, Latinx students have no significant difference in this characteristic compared to white students at HSIs. Family, in addition to supportive professors and an engineering community, has been shown to be an instrumental support for Latinx engineering students, serving as an emotional support and motivation to continue [42].

By far the most commonly researched intersecting factors influencing engineering identity are race/ethnicity and gender—specifically, women of color in engineering [7] - [11], [17] - [29], [43], and most of these studies are qualitative in nature. The research examining the experiences of women of color in engineering explores the double bind of being both a woman and a person of color in a white- and male-dominated field such as engineering, and describe the experiences of these women as they navigate their programs and develop an engineering identity [7], [10], [17] - [23], [25] - [27]. In quantitative studies, engineering identity is often used as a mediating variable between race/ethnicity and gender, and persistence in the program, offering an explanation as to why women of color students continue in the field despite the barriers they face; however, engineering identity is not typically used as the dependent variable [8] - [10], [17] - [21], [23], [25] - [27].

Other studies [21], [22], [43] examine the specific processes by which women from minoritized groups form and strengthen their engineering identity —through supportive relationships with professors, peers, and family, academic and social programs for engineering students of color, and professional development in the form of hands-on engineering experiences. This research also highlights the struggles faced by women of color in engineering, including feeling isolated or ostracized by their difference, having difficulties fitting in, experiencing discrimination from faculty or peers, and lacking support and encouragement from faculty, peers, or programs/clubs [7] - [10], [17] - [20], [23], [25] - [27].

When focusing on first-generation status, Dika [30] and Verdín [44] - [46] suggest that Latinx students are more likely to be first-generation, which creates more barriers to constructing a strong engineering identity, in addition to giving them different reasons than non-first-generation students for choosing and continuing to pursue their engineering degree [30], [44] - [46]. Specifically, Verdín [44] - [46] found that first-generation Latinx students were often encouraged to pursue engineering because of the status associated with the job, job security, or good pay;

however, these same students also reported having less family support. There is also evidence that, despite receiving less support from family, on average, first-generation students have a stronger interest in pursuing careers related to math and engineering and generally had a greater interest in those fields than their non-first-generation counterparts. It is important to note, however, that first-generation students had less of an interest in science—perhaps indicating that first-generation students tend to prefer the hands-on and concrete nature of engineering with its solid and secure job prospects [44] - [46]. Notably, there has yet to be a quantitative study examining the variation in engineering identity by race/ethnicity, gender, and first-generation status at an HSI.

Although the primary focus of studies thus far has been qualitative explorations of the *processes* that lead to the development of engineering identity [7], [9], [10], [17] - [20], [23], [25] - [27], there are some quantitative studies that have explored variations in engineering identity by race/ethnicity, gender, and first-generation [8], [11], [43], [47]. For example, there have been a few studies looking at the effect of race/ethnicity, gender, and parent's education level—a proxy for first-generation status— on engineering identity. Most significantly, Choe et al. [47] and Kendall et al. [11] use race and ethnicity, gender, and first-generation status as predictor variables for engineering identity. In a key study, Kendall et al. [11] assesses the role of institutions in the engineering identity development of Latinx students using a mixed-methods approach (i.e., surveys and interviews). Their findings are revealing: HSI Latinx students were found to have a stronger engineering identity than Latinx students at a PWI; however, this study did not compare white and Latinx students at the same institution, so we still do not know if there is variation in engineering identity by race and ethnicity at HSIs.

While qualitative studies that examine the process of engineering identification among specific intersections of race, ethnicity, gender and class shed light and give voice to marginalized experiences, it is also important to identify the larger, general trends across these underrepresented groups. In order to better understand the role engineering identity can play in fostering success among underrepresented groups, it is important to statistically investigate whether and how these groups differ in their identification with the field. Quantitative studies can help inform our knowledge of the patterns that exist and establish whether students with certain identities or backgrounds differ in levels of engineering identity compared to their more advantaged peers. This is frequently assumed but less often empirically verified. The larger number of study respondents also provides more opportunities for comparisons across various demographic factors.

In sum, few studies have conducted large-n, quantitative analyses of the impact of race/ethnicity, gender, and first-generation status on engineering identity. Most importantly, the studies that have been conducted including all of these variables do not *specifically* focus on testing that hypothesis as their central issue. Finally, there has yet to be a quantitative study examining the variation in engineering identity by race/ethnicity, gender, and first-generation status at an HSI. This work seeks to address this gap in the literature with a quantitative exploration of the ways in which engineering identity varies according to race/ethnicity, gender, and first-generation status among early-career engineering students at a public Hispanic-Serving Institution.

Methods

This analysis is part of a larger mixed-methods, longitudinal project examining how college experiences more generally and STEM support experiences in particular impact social psychological factors over time and subsequently influence educational and occupational outcomes. This paper focuses on how the engineering identity of undergraduate engineering students varies by race/ethnicity, gender, and first-generation student status using surveys from students enrolled in introductory engineering courses at a four-year public Hispanic-Serving Institution (HSI) in the Southwest United States.

New Mexico STEM Experience Survey

The New Mexico STEM Experience Survey was first distributed to early-career undergraduate STEM majors during the Spring 2019 semester and has been administered each semester since. Surveyed students attend one of four HSI colleges and universities in New Mexico – two four-year universities and two community colleges. Respondents are recruited both in classrooms and through emails, with a response rate for those recruited in classrooms at approximately 95% and a response rate for those students contacted by email at a much lower rate around 10%.

To date, more than 1500 students have completed valid baseline surveys and consented to participate in the study. As a result of our sampling and recruitment strategy, and access to introductory engineering classrooms, a total of 656 of our baseline respondents are engineering students from a single four-year university. These students entered the study while enrolled in Engineering 100, an Introduction to Engineering course that is the first required course taken by engineering majors, during the Fall and Spring semesters of 2019 and 2020. The paper takes advantage of this particularly rich source of data to focus on how the engineering identity varies by race/ethnicity, gender, and first-generation student status among students at one of our four-year HSIs.

Measures

The main outcome variable in the analyses presented is *engineering identity*, which is operationalized on the New Mexico STEM Experience Survey by asking student participants how much they agree with a series of statements (previously developed and validated in the work of Carlone and Johnson [18] and Godwin [48]), which we then used to develop an engineering identity index. The engineering identity measure encompasses four scientific concepts—interest, recognition by self and others, and perceptions of competence and performance in engineering—and was calculated by taking the mean score across student responses to the following eleven statements on a seven-point scale (strongly disagree to strongly agree):

My parents see me as an engineer
My instructors see me as an engineer

My peers see me as an engineer
I am interested in learning about engineering
I enjoy learning engineering
I am confident that I can understand engineering in class
I am confident that I can understand engineering outside of class
I can do well on exams in engineering
I understand concepts I have studied in engineering
Others ask me for help in this subject
I have come to think of myself as an engineer

The reliability of this scale is quite high, with a Cronbach's alpha of .916 indicating a high level of internal consistency for the eleven statements that comprise our *engineering identity* scale.

Other key variables in the analyses include students' self-reported measures of their *gender* and students' self-reported measure of their *race/ethnicity.* While completing the survey, respondents were not limited to identifying as a member of a single racial or ethnic group, nor were they limited to a gender binary. Unfortunately, the extremely small number of gender non-binary students (n=4) and multiracial students (n=2) in our current data does not allow us to make assertions about students that identify as non-binary or multiracial in this work.

In addition, a measure of students' *first-generation* status was calculated based on student reports of their parent(s)' or guardian(s)' highest level of educational attainment – and was coded such that first-generation students are those who reported that all of their parent(s) and/ or guardian(s) have less than a college degree. Finally, we include a *free lunch* variable (based on students' self-report of whether or not they were eligible for free or reduced-price lunches while they were growing up) as a proxy control variable for each students' childhood socioeconomic status.

Women included in these analyses had a mean engineering identity score of 5.58, compared to a mean of 5.78 for men. Latinx participants reported a mean engineering identity score of 5.72; Black participants reported a mean score of 5.38; American Indian participants reported a mean score of 5.58; Asian participants reported a mean score of 5.47; and White participants reported a mean score of 5.78. First-generation participants reported a mean engineering identity score of 5.58, compared to 5.80 for participants who are not first-generation college students.

Given the association between race/ethnicity, low income and first-generation status we conduct a series of three ordinary least squares (OLS) regression models. Model 1 includes the gender and free or reduced lunch dummy variables. Model 2 adds the race and ethnicity dummy variables and finally, Model 3 adds the first-generation college student dummy variable. We compare the coefficients across Models 2 and 3 to examine whether there is any evidence that first-generation college student status accounts for any racial/ethnic group differences in engineering identity.

Results

As would be expected given national disparities in gender and the institution's Hispanic-Serving Institution (HSI) designation, men and Latinx students constitute a majority of the sample. Men comprise just over 70% (n=463) of the sample. Latinx students comprise 62% (n=406) of the sample, and White students represent an additional 24.5% (n=161) of the sample. American Indian (n=38), Asian (n=23), and Black (n=18) students make up 5.8%, 3.5%, and 2.7% of the sample, respectively. Approximately one-third of respondents are first-generation college students (n=230) and approximately one-third received free or reduced-price lunches when they were growing up (n=240). The mean value for engineering identity was 5.72 on a 1 to 7 scale. Table 1 presents the results of the ordinary least squares (OLS) regression models predicting engineering identity of early-career students. Model 1 tests whether there is a statistically significant difference between the engineering identity of men and women. Interestingly, the analysis reveals no significant differences between men and women. Model 1 also includes a variable controlling for *free lunch*, which we use as a proxy for a student's family's financial status during childhood. Model 2 adds variables on the racial/ethnic identity of the respondents to the ascertain whether the engineering identity of students varies by racial and/ or ethnic background. Once again, the analyses demonstrate that there are no statistically significant differences between students' engineering identity in relation to race/ethnicity. Model 3 indicates that first-generation student status is a negative, significant predictor of engineering identity (b= -.205; $p < .05$). On average, students who are first-generation have a lower engineering identity than their peers who have at least one parent that graduated from college. Since no significant racial/ethnic differences in engineering identity were found, an analysis of the role of first-generation status as a mediator was not performed. Overall, the analysis finds that first-generation student status is the only significant predictor of early-career engineering identity.

Interactions between variables on race/ethnicity and gender were also tested but failed to reveal significant differences between women from racial or ethnic minoritized groups and White men in terms of their engineering identity, and were therefore not presented here.

Discussion and Future Work

While our expectation was that engineering identity would vary by race/ethnicity and gender, these analyses unexpectedly reveal no significant differences in the engineering identity of students of different racially/ethnically minoritized groups in comparison to their White, non-Hispanic peers; no significant differences in the engineering identity of men and women; and no significant differences based on the intersectional identities of race/ethnicity and gender (our race/ethnicity and gender interaction term).

Table 1: OLS Regression Models Predicting Engineering Identity of Early Career Students

	Model 1	Model 2	Model 3
First Generation	--	--	-.205** (.082)
Latinx	--	-.065 (.088)	-.023 (.090)
Black	--	-.358 (.242)	-.330 (.241)
American Indian	--	-.194 (.172)	-.164 (.172)
Asian	--	-.342 (.211)	-.313 (.210)
Women	.000 (.007)	-.001 (.007)	.000 (.007)
Free Lunch	-.093 (.077)	-.084 (.079)	-.033 (.081)
Intercept	5.823***	5.825***	5.842***

Note: Numbers in parentheses are standard errors *** $p < .001$ ** $p < .01$ * $p < .05$

In fact, the only significant predictor of engineering identity in our analyses is first-generation student status, with students who reported that they will be the first in their family to get a college degree having significantly lower engineering identity scores (b=-.205; p<.01). These results lead us to conclude that first-generation status may be a more important determinant of engineering identity than gender and race/ethnicity for early-career engineering students at HSIs. This is an important finding: first-generation early-career engineering students have a lower engineering identity than their non-first-generation college student peers, even when controlling for race, gender, and family socioeconomic status.

Given our knowledge that women are more likely to leave their engineering major than men and our understanding of how engineering identity contributes to engineering success, we expected to see a significant difference in the engineering identity of men and women. Our finding that there *isn't* significant variation in engineering identity by gender is quite interesting. Indeed, our non-significant coefficient is very close to 0, with an extremely small standard deviation (.007) in all three of our models on Table 1. This suggests that students enrolled in early engineering coursework have similar overall levels of interest, recognition by self and others, and perceptions of competence and performance in engineering (concepts encompassed by our measure of

engineering identity) across gender. It may also be that there are no gender differences in engineering identity because our early-career students are just at the beginning of Herschbach's [16] 'leaky pipeline.' In other words, we expect that systemic impacts may work to lower engineering identity and decrease persistence for students from minoritized groups – not because of individual students' abilities – but as a result of negative institutional impacts due to their minoritized status. Perhaps it is only later, as these students progress through their postsecondary careers, that we might begin to see some variations in engineering identity develop for women-identifying (and also non-White) students. As students are impacted differently by the institution

This can also be due to a possible selection effect in our data. After all, these are the students who were confident enough in themselves as potential young engineers to become engineering majors and/ or enroll in the Engineering 100 course. In other words, there might be a selection effect where the students we are capturing in our data are students that a) are early in their college career to have experienced some of the factors that might lead to disappointment with their major choice, and/ or b) have self-selected into an Engineering 100 course because they are confident enough in their choice of major.

Similarly, we also expected to see significant variation in engineering identity by race/ethnicity. Though not significant, our data show that within our sample *all* non-White students have lower engineering identity than their White peers. Specifically, Latinx students have a slightly lower engineering identity than their White, non-Hispanic peers. American Indian students have even lower engineering identity than White and Latinx students, and Asian and Black students have the lowest engineering identity of all. It is important to note that the relatively small number of students in each of the other non-White racial/ethnic groups* means we should be cautious about making strong assumptions based on these results.

The small number of students in each of the non-White racial/ethnic groups can be the cause for lack of *statistically significant* differences in engineering identity by race/ethnicity. Also, this could be due to an institutional effect of HSIs, in which Latinx and other minoritized students feel more *at home* in these types of institutions and feel less of the effects of being minoritized, as suggested by Kendall and colleagues [11]. Finally, even with our high response rates, it might be that we are simply not capturing *at-risk* students of color in our data. Or, as mentioned above in regard to a lack of significant gender effects, maybe we are seeing no significant variation in engineering identity because these students are just entering Herschbach's [16] 'leaky pipeline.'

Our current data does not allow us to make inferences about what might be the possible causes of this lack of variation. In future work, we will continue to examine the relationship between engineering identity and race/ethnicity, gender, and first-generation status both for early-career engineers (as we increase our sample), and to examine the relationship between these variables over time (as we follow up with study participants longitudinally). That should allow us to more precisely determine if this lack of significant variation is due to institutional effects of HSIs, a

lack of at-risk student representation in our data, or an early-career effect, among other possibilities.

Additionally, since we have a reasonably large cohort of Latinx women in this data (n=121), we can be fairly confident in the lack of a statistically significant interaction effect for Latinx women and engineering identity. For other women of color, we don't have enough cross-sectional data yet to be able to make definitive inferences about how race/ethnicity interacts with gender in influencing engineering identity. Our sample contains a relatively small number of American Indian women (n=16), Asian women (n=4), and Black women (n=3) which prevents us from drawing conclusions about these groups. As we continue to collect cross-sectional data on engineering students in our longitudinal project, however, we expect these numbers to grow enough for us to see how women of color compare in terms of engineering identity, and with time, how their engineering identity changes over time.

Conclusion

Previous work has not quantitatively examined variation in engineering identity by simultaneously modelling race/ethnicity, gender, and first-generation status at an HSI; our data allows us to test quantitative models of how all of these factors are related to engineering identity for early-career engineering students. Our main finding – that first-generation status is the largest determinant of engineering identity, even when controlling for race, gender, and family socioeconomic status – is important. Equally noteworthy is the lack of significant variation in engineering identity by race/ethnicity and gender for these early-career engineers at an HSI. Our results are consistent with prior research suggesting that first generation status may have particular relevance for Latinx students and that HSIs appear to reduce gaps between Latinx and White students. In HSIs and other minority serving institutions, racial/ethnic and gender identification may be less predictive of engineering identity. Instead, family educational background and the associated social and cultural capital may be more important. In our future work, we look forward to examining how these students' engineering identity varies and changes (or not) in relation to their race/ethnicity, gender, and first-generation college student status as they move through their degree programs.

* Reminder: we have a total of 38 American Indian, 23 Asian, and 18 Black students in our sample.

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