Within-Group Differences of Engineering Identity for Latinx Engineering Students

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***Abstract*— The purpose of this Work in Progress paper is to investigate on within-group differences in the way that Latinx students identified as engineers for students who were, at the time of the study, members of the Society of Hispanic Professional Engineers (SHPE). Researchers have shown that there is a link between identification with engineering for college students and persistence in the field. As such, the study of engineering identity is timely and critical. Previous work in this area has shown that there are dimensions of engineering identity development that are key to Latinx students' success. These dimensions include: professional and leadership, community wellbeing, engineering *familia*, and role modeling. Using a culturally-situated survey of engineering identity, we surveyed undergraduate students who identify as Latinx. The results show the ways in which the Latinx undergraduate population surveyed is non-monolithic and the statistically significant within-group differences that exist within this student population.**

Keywords—engineering identity, latina/o, latinx

I. INTRODUCTION

Research in the field of engineering education on engineering identity has shown potential for uncovering new understandings about students' persistence and retention. In this work-in-progress research paper, we seek to understand engineering identity development for Latinx students (Latinx is a gender-neutral term to use in place of the gender-binary term of Latina/o) across different personal and institutional demographics. While research on Latinx students pursuing degrees in Science, Technology, Engineering, and Mathematics is abundant, research focused on Latinxs specifically in the field of engineering is sparse. Perhaps more important, the research on Latinx engineering students has not yet provided nuanced understanding of the diversity that exists within this population across personal and institutional demographics. As the population of Latinxs in the United States increases and is expected to become a minority-majority, the need to understand the varied within-group experiences rises. In other fields, such as medicine, sociology, and education, these within-group differences have been explored and reports provide insight to better understand and serve this population.

This work aims to also further the scholarship of engineering identity by focusing on understanding engineering identity development from a culturally-situated perspective. To achieve this, the instrument utilized was grounded and developed via qualitative methodologies with Latinx engineering students. Such process led to the following four survey constructs, which we present here as four engineering identity dimensions: professional and leadership, community wellbeing, role modeling, and engineering *familia*. The last three identity dimensions pose a new way of understanding identity by incorporating community and collectivistic aspects of how students identify and are identified as engineers.

This work also shows the potential of using culturally-situated instruments to better understand the ways in which Latinx and other minoritized groups of students identify with the field of engineering. The results from this work have implications for engineering identity research as well as for practice in engineering education. Specifically, this work highlights ways in which culturally-situated and nuanced understanding of engineering identity for minoritized groups can help to better structure engineering education programs and practices.

II. REVIEW OF LITERATURE

Engineering identity is a growing concept in the engineering education literature. In Tonso's review of engineering identity[1], the author discusses the various ways (i.e. sociological, psychological, educational) of understanding this growing concept. In this work, we focus on the sociological understanding of engineering identity; namely, how people identify themselves as engineers and how they are identified by others in the field as such. In Gee's[2] seminal work on identity, he posited that one and one's environment are contributors to how we as people develop identity. In a parallel way, engineering identity has also been understood from a development perspective – that is, not just the current state of being or having an engineering identity, but also the process of developing an engineering identity. In this work, we focus on the former in that we are interested in how Latinx students conceptualized being engineers. Two questions serve to guide the differences between these ways of understanding the work in this area of research. How do people develop their engineering identity? How do people identify as engineers?

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Much of current scholarship about engineering identity in the engineering education literature is derived from the scholarship on science identity. Notably, researchers have used and expanded on Carlone and Johnson's[3] theoretical framework of how women of color develop their science identity. In their model, the authors posit that science identity has three main tenets: recognition, competence, and performance. Recognition refers to how students recognize themselves as scientists and how others recognize them as scientists, competence refers to the students' ability and competencies in the field, and performance refers to the process of performing their competencies in front of other people. This framework has been widely used to understand engineer identity because of the parallels between science and engineering. Researchers have found that, in fact, these tenets of science identity translate fair well to engineering[4,5]. A gap in the literature of science identity is the lack of work on understanding the connections between science/engineering identity and other ways of identifying.

With the growth of intersectionality and understanding of people's pluralism, there has also been growth in understanding engineering identity alongside other social and professional ways of identifying. Tate and Lin's[6] work on understanding multiple dimensions of identity focused on academic, social and intellectual dimensions. Later work by others focused on integration of more intersectional ways of understanding identity including those of women of color in engineering using Abes, Jones, and McEwen's[7] model of multiple dimensions of identity. This model was particularly applicable to the experiences of women of color as it was developed with this population at the forefront of the study. Revelo's[8] work on using this model to understand women of color in engineering showed that while women of color view their engineering identity (professional identity in the MDMI model) as having varied saliency, all of the women identified their gender and professional identity as interlinked (e.g., Latina engineer, Black engineer).

Given the growing literature on engineering identity, this work intends to provide a better understanding of ways of identifying with the field of engineering other than professional and leadership.

III. Methodology

To answer the research question, an online survey of engineering identity[9], previously validated and developed for use with this population was administered to a U.S. national email list of college student members of SHPE. The survey was administered using Qualtrics and was sent via email to all undergraduate students in the SHPE National Database.

A. Survey

The culturally situated survey of engineering identity was developed for use with Latinx students who are members of the Society of Hispanic Professional Engineers. The survey instrument, constructed from qualitative data and validated with a pilot dissemination, seeks to measure engineering identity along four dimensions: professional and leadership, community wellbeing, engineering *familia*, and role modeling.

While professional and leadership development have been explored in other studies of engineering identity, the other three dimensions are new to the literature. In the instrument, the construct of ***community wellbeing*** aims to measure how students connect being engineers to their impact on their surrounding community. ***Engineering familia*** aims to measure how students center the familial cultural aspect of being an engineer to their engineering identity. While immediate family can be part of this *familia*, this dimension also includes family-like connections that students made with others. ***Role modeling*** aims to measure how students have and become role models as part being engineers.

An identity score for each identity dimension was computed by summing the value for each respondent on each item belonging to the construct. The sum was then normalized leaving a final identity score out of 100. An overall engineering identity score was calculated by computing the sum of each identity score and normalizing it also out of 100.

B. Data Screening

Prior to data screening, surveys that were not completed were removed as part of the data cleaning process. Standard data screening procedures[10] were followed to find univariate and multivariate outliers. From this procedure, six univariate outliers and 31 unique multivariate outliers were found. These outliers were removed from the dataset. Skewness and kurtosis were also assessed by checking for items that had absolute values of skewness greater than 2 and kurtosis greater than 7[11]. All of the survey items passed the normality test with none having excess skewness nor kurtosis. Finally, singularity and multicollinearity in the data was also checked using Pearson's correlation with no correlation found over the threshold of 0.9. After data screening and data cleaning, there were 708 usable responses remaining in the dataset.

C. Participants

The data for this study came from a survey instrument that was electronically administered to a U.S. national email list of undergraduate student members of SHPE. After data cleaning, there were 708 valid responses, with the missing data on average not exceeding <5% of the sample.

The final sample included 41% female, 23% transfer students, 91% traditional college age students (24 years or younger), and 40% first-generation college students (used parents highest level of education as a proxy). Out of the 708 valid responses, 608 respondents identified as Latina/o, Chicana/o or Hispanic, 69 did not identify as such, 17 sometimes identified, and 4 were not sure. The biggest ethnic groups for all students in the sample were Mexican (43%), Multi Ethnic (11%), and Puerto Rican (10%). At the time of the survey, 4% of the students were at a community college, 27% at Hispanic Serving Institutions (HSIs), and 17% at private institutions. Table I summarizes the participant

descriptive statistics separated by those identified as Latina/o, Chicana/o or Hispanic and those who did not.

Table I – Participant Descriptive Statistics

	Latina/o, Chicana/o, or Hispanic Students (n = 608)	Other Students (n = 100)
Gender		
Female	42%	35%
Male	58%	53%
Ethnicity		
Mexican	49%	7%
Puerto Rican	10%	8%
Multi Ethnic	10%	10%
Other	30%	75%
Age		
18-24 yrs. old	91%	78%
25 yrs. or older	9%	12%
Transfer status		
Native student	78%	63%
Transfer student	22%	27%
First-generation college status		
First generation	44%	14%
Not first generation	55%	76%
Institution type		
Public	83%	16%
Private	17%	74%
Community college status		
Community college	3%	5%
Not community college	96%	85%
HSI status		
HSI	27%	22%
Not HSI	72%	68%

Note: percentages may not add to 100% due to missing values in the data

D. Data Analysis

To answer the research question, we used the software R to conduct one-way analysis of Variance (ANOVA) for the overall engineering identity score and the score for each dimension of engineering identity (i.e., professional and leadership, community wellbeing, engineering *familia*, and role modeling) against student demographics and institutional factors for all students who identified as Latina/o, Chicana/o, or Hispanic. The data passed tests for normality and homogeneity. Student demographics included gender, ethnicity, year in college, generation in college, transfer status, and age. Institutional factors included HSI status, public vs. private, and 4-year vs. 2-year.

Tukey HSD tests were run post-hoc where significant differences in the engineering identity dimensions were found. The analysis was conducted using the R statistical software program with an alpha value of 0.05

IV. Preliminary Results

Preliminary results are reported by category of analysis including student demographics (i.e., gender, ethnicity, parents' highest level of education, transfer status, years in college) and institutional factors (i.e., HSI status, private vs. public).

A. Gender

A one-way ANOVA was conducted to compare the effect of the respondent's gender on each dimension of engineering identity as well as the total score of engineering identity. There were no significant differences found among the groups. Please note that this question in the survey was not asked in binary form; however, only 9 responses were ignored due to missingness.

B. Ethnicity

A one-way ANOVA was conducted to compare the effect of the respondents' ethnicities on each dimension of engineering identity. The largest three populations have been identified as Mexican, Puerto Rican, and Multi-Ethnic respondents, and the other ethnicities were grouped into one group as "Other Ethnicities" for the following comparisons. The only statistical significant difference ($p = 0.01$) was found for the Community dimension between those who identified as Mexican and those in the Other Ethnicities categories. With those who identified as Mexican having the highest average for the Community score and those in the Other Ethnicities category having the lowest average for the Community score.

C. Parent's Highest Education Level

A one-way ANOVA was conducted to compare the effect of the parent's highest education level on each dimension of engineering identity. The ANOVA resulted in statistically significance found across the groups with $F(2, 541) = 13.82$, $p < 0.001$.

A post-hoc Tukey HSD test revealed that students with parents who had received some graduate education had lower engineering identity scores ($M = 77.5$, $SD = 13.58$) compared to those whose parents' highest level of education was high school ($M = 84.71$, $SD = 10.45$). Another statistical difference, though at the $p < 0.01$ level, was found between students with parents who had received some graduate education compared to those whose parents' highest level of education was college ($M = 81.77$, $SD = 12.29$). The same patterns emerged for each of the individual identity dimensions. The means and standard deviations for these are summarized in Table II below.

Table II – Parent's Highest Education Level Differences Across Identity Dimensions

	High School		College		Graduate School	
	Mean	SD	Mean	SD	Mean	SD
Total Engineering Identity	84.71	10.45	81.77	12.29	77.50	13.58
Community	90.11	9.53	86.91	11.63	86.21	10.62
Professional	79.61	16.15	76.31	18.16	69.73	19.90
Role Model	87.26	12.28	85.75	13.05	81.62	15.32
Familia	87.51	12.15	84.68	14.66	80.78	16.10

D. Students' College-Related Demographics

Students self-reported whether or not they were transfer students. Using this data, a one-way ANOVA was conducted

and resulted in statistical differences along the Professional identity dimension between transfer and non-transfer students. The Professional identity score for transfer students was lower compared to the non-transfer students.

A one-way ANOVA was conducted to compare the number of years the students reported being in college across all engineering identity dimensions. This test revealed statistically significant differences across the overall Engineering Identity score between the various groups [$F(3, 535) = 5.15$, $p = 0.0016$]. As a result, a post-hoc Tukey HSD test was conducted to find that only one pair differed significantly; namely, students who had been at their institution for 1-2 years had a lower overall Engineering Identity score ($M = 79.78$, $SD = 12.93$) compared to those who had been at the institution for 5-6 years ($M = 85.61$, $SD = 10.83$). Tukey HSD tests for Professional identity also revealed that students who had been at their institution for 1-2 years had a lower Professional identity score ($M = 71.58$, $SD = 19.23$) compared to those who had been at the institution for 5-6 years ($M = 81.73$, $SD = 16.05$).

Table III – Transfer Student Status Differences Across Identity Dimensions

	Transfer		Non-Transfer		Significance
	Mean	SD	Mean	SD	
Total Engineering Identity	81.21	13.09	82.53	11.75	
Community	88.33	10.96	88.11	10.61	
Professional	73.63	20.40	77.31	17.18	*
Role Model	87.06	12.35	85.22	13.56	
Familia	84.96	13.82	85.27	14.22	

ns – no significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$

E. Institutional Factors

The Hispanic Serving Institution (HSI) status of the institution the student attended was also analyzed using a one-way ANOVA. The status was found using the information provided by the Hispanic Association of Colleges and Universities. Statistically significant differences for the overall engineering identity score [$F(1, 540) = 4.70$, $p = 0.03$] and for the Community identity dimension [$F(1, 540) = 6.70$, $p = 0.0099$] were found. In general, the pattern that emerged was that students at HSI institutions had higher engineering identity dimensions compared to those at Non-HSI institutions.

Whether or not the institution where the student attended was public or private was also analyzed using a one-way ANOVA. The institution type (i.e., private, public) was found using the Carnegie Classification of Institutions of Higher Education database maintained by the Indiana University Center for Postsecondary Research. There were no statistical significances found for the identity dimensions between private and public institutions.

Table IV – HSI Status Differences Across Identity Dimensions

	HSI		Non-HSI		Significance
	Mean	SD	Mean	SD	
Total Engineering Identity	84.01	11.24	81.52	12.31	*
Community	90.05	9.60	87.43	11.00	*
Professional	78.79	17.30	75.58	18.21	
Role Model	87.11	13.87	84.97	13.07	
Familia	86.48	13.68	84.27	14.39	

ns – no significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$

V. Discussion

With this work in progress study, we have found that there are ways in which student and institutional factors diversify our current ways of understanding the Latinx student population. Instead of understanding this population as monolithic, this work in progress study highlights the various ways in which this population has diversity within it and how that diversity impacts engineering identity findings.

Some notable differences include in the way that students identified as engineers by their investment in their community well-being. Students who identified as Mexican and those whose parents highest level of education was high school had significantly higher scores for the community dimension of identity. While the roots of the Mexican population in the United States has historic underpinnings and the commitment to community is well-reported upon, the finding about students with parents' highest level of education being high school is perhaps a bit more unexpected.

While other researchers have found that there are gender differences for engineering identity, in this work we found that in the Latinx student population studied there were no differences across any of the identity dimensions between females and males. Also, to note is that while there was no statistical significant difference, the mean value for all engineering identity scores were consistently higher for females compared to males.

We note that as we expand on this work beyond this paper, we also plan to provide a practical interpretation of the significance of the results using the normalized scores calculated.

VI. Future Work & Directions

We plan to expand upon this work by disseminating the survey to Latinx students who were not part of SHPE and performing a comparative analysis of both datasets. Future work in this area could investigate the differences in engineering identity dimensions for non-Latinx students and across other demographics (e.g., race, gender). One particular difference is between students at HSI and non-HSI institutions. Another important direction to consider is how these differences could be elevated in designing courses to increase the retention and persistence of Latinx students in engineering.

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