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WIP: Research Identity among First-Year Engineering Latina Students at a Research- Intensive Hispanic Serving Institution

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Abstract

This work in progress paper focuses on understanding what students in first- year engineering courses understand about who becomes a researcher and if they see themselves as a researcher, or someone who might become a researcher. Specifically, we compare Latinas to other students in this study to explore the origins of differences in later participation. This work has importance and necessity since it has been noted that the national graduation rate for Latinas with a Ph.D. in engineering is very low; only 91 (< 1%) of awardees in 2018- 2019 identified as Latina. Our research investigates the interest of first year engineering students in research, which might illuminate strategies for addressing the underrepresentation of Latinas in national Ph.D. engineering programs. The purpose of this quantitative study is to characterize early perspectives about research, graduate school, and becoming a researcher. A statistical analysis of the results from a cross-sectional survey was completed. A principal component analysis extracted the following constructs: (1) research self-efficacy, (2) engineering research identity, and (3) perceived cultural compatibility. Self-reported demographics (gender, race/ethnicity, college generation, first year on campus) were collected during the survey and used to group respondents during the analysis. The study population includes all students enrolled in a first-year engineering course for the Fall 2022 (n=215) at the University of New Mexico, a public R1, Hispanic- serving institution. The students were from the following engineering disciplines: Chemical & Biological, Civil, Computer Science, Electrical & Computer, Mechanical, and Nuclear. A regression analysis is used to compare Latinas' perceptions and intentions to students who are well-represented (Asian or White men) in engineering. We hypothesize that the constructs examined in this study explain variance in research persistence. This research has significance if we are to attain more diverse faculty for the emerging student population which requires an increase in the number of Latinas graduating with a doctoral degree and continuing into academia.

Introduction

Innovation is a necessary element for our nation's continued progress in science and technology. Many sources agree that diversity is imperative in STEM if we are to tackle the increasingly complex challenges that require innovative solutions [1]–[3]. The capacities and experiences of engineers from diverse backgrounds enable these novel solutions. Additionally, as the racial and ethnic demographics of the United States continue to shift, with the percentage of minority groups increasing [4], [5], fundamental research that informs our universities on how to support the success of a diverse student population has become a national priority. This is especially true for science, technology, engineering, and mathematics (STEM) disciplines, where minoritized groups are grossly underrepresented [2], [6]–[8]. For academic year 2021- 22, Latinas attained only 13% of all bachelor's degrees in engineering awarded to U.S. citizens here at the University of New Mexico (UNM), and none graduated with a Ph.D. within UNM's School of Engineering [9]. For the data and this study, *Latinas* are defined as individuals who identify as a female, with Hispanic or Latino ethnicity. Unfortunately, this data is not much different for the national data [2], and is shown by comparison in Table 1.

Table 1: Engineering degree recipients for U.S. citizens or permanent residents.

	UNM, B.S. (21-22)	UNM, Ph.D. (21-22)	National, Ph.D. (2019)
All recipients	266	23	4725
U.S., females	79	0	1312
Latinas	36	0	91

Engineering and research identity has been used as an analytical lens for describing and understanding the achievements and persistence of students in engineering curriculums [10]–[16]. These studies have also proposed interventions that might increase student interest and connection to their engineering field of study [17]–[19]. Further these studies have identified the importance of recognition, achievement, experiences, and background/ culture in developing an engineering identity. In this study, we hope to build a connection between the different identity factors and research persistence intentions.

Many scholars have highlighted the importance of intersectionality when studying the impacts of social identity [20]–[23]. These scholars suggest that an intersectional approach, combining at least two social identities such as race/ ethnicity and gender, to understand the experiences of those within overlapping groups [11], [16], [20]–[28] is more accurate and avoids a monolithic approach and/ or assumptions. Two recent studies explored the 'double bind of race and gender' marginalization for women of color in engineering [26], [28]. In the study by Cross et al., the intersections of race and gender were investigated through a mixed methods approach. The study which included Latina participants reported that "the double bind of race and gender affects the education for female (engineering) students of color", many of which experienced high levels of stress and anxiety due to interactions impacted by their multiple identities [26]. Additionally, the study highlights the complexity and variations in identity development for the diverse group of participants. The outcome of the study emphasizes the value of taking an intersectional approach when examining the identity and experiences for females of color. Finally, the study confirms that the generational status (first- generation, continuing generation) has an impact on the identity for females of color [26] and should be considered in subsequent intersectional studies.

Another study sought to understand the factors that influenced engineering identity development of undergraduate Latina students [12]. Using a phenomenological approach, the study examined how five Latina undergraduates, all classified as seniors majoring in engineering, developed their engineering identity through formal and informal experiences and through their intersectional identity [12]. Rodriguez et al. found that classroom experiences were only a partial factor in the Latina engineering identity. In fact, the personal and intersecting identities of Latinas were very significant in their engineering identity development. Latina/o/x family members and identity-based engineering organizations provided mostly positive experiences, while intersecting identities such as nationality status created both positive and negative experiences that influenced the development of the engineering identity for the Latinas in this study [12].

The prior research highlights the complexity, but also necessity to consider the intersectionality of multiple identities and cultural compatibility as we seek to understand the research persistence of Latinas within engineering. Research that delves into the undergraduate interest of graduate engineering programs would illuminate strategies for addressing the underrepresentation of Latinas in national Ph.D. programs.

The scope of this work is to develop a baseline of the data within a single Hispanic serving institution. The analysis completed to this point validates the survey instrument in measuring the identified constructs. This validation is necessary so that this study may be expanded to a larger survey population.

Research Questions

This research investigates several factors that are believed to impact the identity of engineering students as researchers. We seek to assess the role of research self- efficacy, researcher identity, and cultural compatibility on research persistence intentions. These variables were selected as they have been determined to be relevant factors in prior identity studies [16], [29]–[35]. Students that self- identify as a woman with Hispanic ethnicity, or "*Latinas,*" are of particular interest in this study due to their underrepresentation in doctoral engineering programs, even at an R1 Hispanic serving institution.

The research study is guided by the following two research questions:

1. To what extent do the following explain variance in research persistence intentions: (a) research self-efficacy, (b) engineering research identity, (c) perceived cultural compatibility?
2. Do Latinas' intentions to pursue research opportunities differ from their peers?

Experimental Methods

This study involved designing and creating a survey instrument that was administered to first-year engineering students. We selected first year students because we were interested in the emerging interest of students in research and hope to later develop interventions for this specific population of engineering students, which could potentially be used in national first year programs. The survey responses were analyzed using quantitative research methods.

Survey Instrument

During the development of the survey, published and accepted guidelines were followed [36]. The survey instrument was developed by adopting research questions from prior studies [32]–[35] that addressed the identity factors defined in our research questions. The survey included three questions about research self- efficacy, six questions were asked about engineering research identity, and two questions were related to cultural compatibility. We used a 5- point Likert response scale for all questions, ensuring there was a middle option to reduce

measurement error. Questions were also asked about future research plans so that research persistence intentions could be correlated to the variables in our research question.
All responses were converted to a coded value based upon response, as shown in Table 2. In addition to the questions, we requested demographic data (year in degree program, first generation status, gender identity, racial/ ethnic identity) which will help to group the responses during the analysis.

Table 2: Coded values for potential survey responses, based upon a 5- point response scale.

Value	Potential Survey Responses		
5	Very Certain	Very Confident	Very true of me
4	Certain	Confident	True of me
3	Neither certain or uncertain	Neither confident or unconfident	Neither true or untrue of me
2	Uncertain	Unconfident	Untrue of me
1	Very Uncertain	Very Unconfident	Very untrue of me

The survey was offered in 6 first- year engineering courses during the Fall 2022 semester at the University of New Mexico, where respondents had the opportunity to complete the survey either at the beginning or end of the class. We only included students who selected first- year as their academic standing. After removing those respondents that were beyond the first- year, and duplicate responses, we included the data from 215 complete responses in the quantitative analysis. Based upon the responses, 62% of the respondents identified as a man, 35% identified as a woman, and 3% identified as non- binary. According to the self-reported data, 30% of the respondents identified as a first- generation college student and 17% of the respondents identified as Latina.

Data Analysis

We completed a statistical analysis of the survey questions using a correlation analysis and a principal component analysis (PCA). In future work, we will continue the analysis with a multiple regression method, based upon the identified components.

Results and Discussion

From our defined research questions, we identified three constructs: (1) research self-efficacy, (2) engineering research identity, and (3) perceived cultural compatibility. Using the responses from the survey instrument, we looked for correlations in the data to see if survey questions could be grouped into categories that correspond with the constructs. The correlation matrix is shown in Figure 1. We usually associate correlations of 0.6 and above to be highly correlated and we see three of those groupings exist here.

Correlation Matrix

		[I feel like I belong in an engineering research lab.]	[I feel like I fit in with the people who conduct engineering research.]	[I feel included by people who conduct engineering research.]	[My parents and relatives see me as someone who can become an engineering researcher.]	[My teachers and mentors see me as someone who can become an engineering researcher.]	[My friends see me as someone who can become an engineering researcher.]	[doing research with your cultural values?]	[a career in research with your cultural values?]	[use academic literature to understand an engineering research project?]	[generate an engineering research question to answer?]	[use engineering tools, instruments, and/or techniques to do research?]
Correlation	[I feel like I belong in an engineering research lab.]	1.000	.642	.517	.546	.616	.536	.320	.318	.410	.455	.519
	[I feel like I fit in with the people who conduct engineering research.]	.642	1.000	.519	.488	.510	.478	.244	.266	.341	.380	.515
	[I feel included by people who conduct engineering research.]	.517	.519	1.000	.367	.523	.363	.175	.183	.270	.279	.390
	[My parents and relatives see me as someone who can become an engineering researcher.]	.546	.488	.367	1.000	.661	.665	.337	.348	.309	.333	.378
	[My teachers and mentors see me as someone who can become an engineering researcher.]	.616	.510	.523	.661	1.000	.709	.296	.327	.356	.327	.379
	[My friends see me as someone who can become an engineering researcher.]	.536	.478	.363	.665	.709	1.000	.332	.364	.319	.326	.349
	[doing research with your cultural values?]	.320	.244	.175	.337	.296	.332	1.000	.797	.166	.073	.134
	[a career in research with your cultural values?]	.318	.266	.183	.348	.327	.364	.797	1.000	.158	.074	.130
	[use academic literature to understand an engineering research project?]	.410	.341	.270	.309	.356	.319	.166	.158	1.000	.634	.619
	[generate an engineering research question to answer?]	.455	.380	.279	.333	.327	.326	.073	.074	.634	1.000	.684
	[use engineering tools, instruments, and/or techniques to do research?]	.519	.515	.390	.378	.379	.349	.134	.130	.619	.684	1.000

Figure 1: Correlation matrix for the survey questions.

For the principal component analysis, we want to determine the number of components present. We want to include components with eigenvalues greater than 1, which will include components that strongly contribute to the total variance. For this data, it means extracting 3 components with eigenvalues > 1, as shown in the scree plot in Figure 2. Next, we completed a principal component analysis with Varimax with Kaiser Normalization; the rotation converged in 5 iterations. The results are shown in Table 3. This analysis confirms that the survey questions can be grouped into three factors/ components based upon the loadings from the rotated component matrix. These three factors are: research self- efficacy, engineering research identity, and perceived cultural compatibility. The survey responses for Component 1 are all linked to *engineering research identity*. Component 2 aligns with responses that focused on *research self-efficacy*. The responses of Component 3 are linked to *cultural compatibility*. The next step in the analysis will be to complete a multiple linear regression to understand the components further and then analyze how they might explain the variance in research persistence intentions for the total population and for Latinas, specifically.

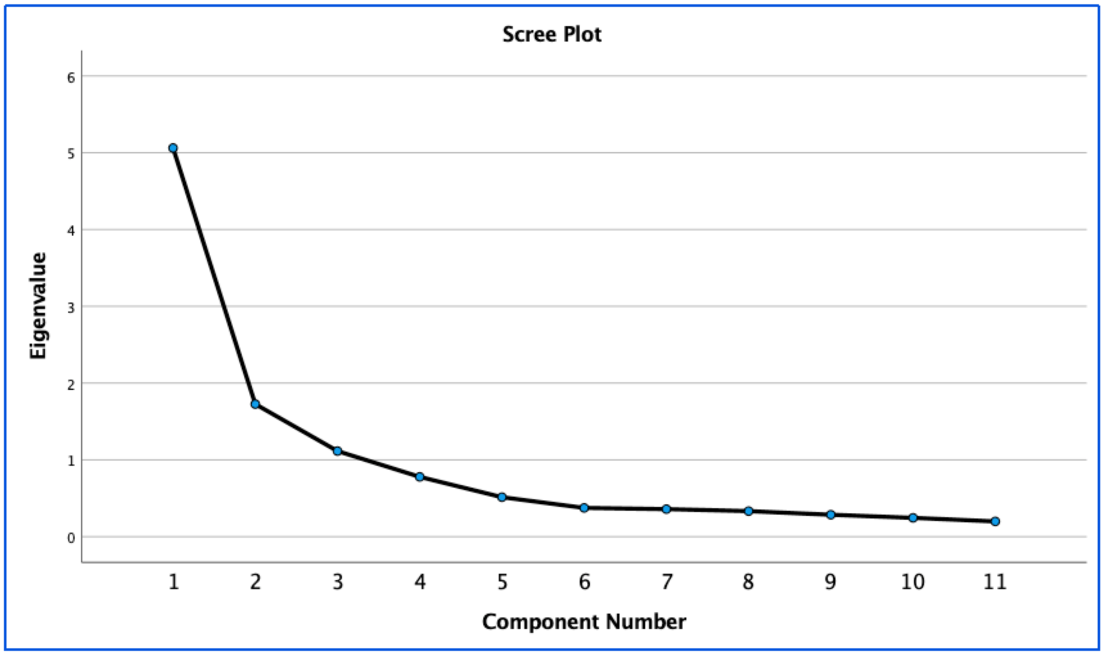

Figure 2: Scree plot showing components with respective eigenvalues.

Table 3: Results of the rotated component matrix

	Component		
	1	2	3
I feel like I belong in an engineering research lab.	.707	.381	.177
I feel like I fit in with the people who conduct engineering research.	.687	.334	.091
I feel included by people who conduct engineering research.	.688	.187	-.031
My parents and relatives see me as someone who can become an engineering researcher.	.747	.156	.249
My teachers and mentors see me as someone who can become an engineering researcher.	.840	.149	.168
My friends see me as someone who can become an engineering researcher.	.761	.135	.256
Doing research aligns with your cultural values.	.175	.058	.923
A career in research with your cultural values.	.209	.039	.916
Use academic literature to understand an engineering research project.	.170	.833	.124
Generate an engineering research question to answer.	.220	.857	-.013
Use engineering tools, instruments, and/or techniques to do research.	.332	.815	.017

The descriptive statistics of the survey responses, grouped by the 3 identified components are shown in Table 4. For this survey group, culture does not seem to be a barrier for conducting or pursuing a career in research, as cultural compatibility scored most favorable. The mean value of 4.05 closely aligns with the survey response that research is compatible with their cultural values. The research self- efficacy component had a mean response value of 3.68, which is in between the response choices, ‘neither confident or unconfident’ and ‘confident’. The engineering research identity component had a mean response value of 3.54, which lies between the response choice of ‘neither true nor untrue of me’ and ‘true of me’. Further analysis using the demographic data would be useful to determine any further patterns in the response.

Table 4: Mean response values grouped by component.

Component/ Construct	Mean Response Value
Cultural compatibility	4.05
Research self- efficacy	3.68
Engineering research identity	3.54

Conclusions

Our analysis has provided evidence that the research identity survey developed in this study provides valid information about engineering research identity, research self- efficacy, and cultural compatibility. We were able to validate that the components aligned with the constructs outlined in the research questions. This allows the next step of the research to proceed, which will address the variation in research persistence among first- year students, and how that variation might differ for Latinas. Future research will also focus on the types of experiences that support research persistence among Latina students in engineering.

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