Engineering Education through the Latina Lens

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Abstract

Less than 20% of undergraduates earning a degree in engineering are women, and even more alarming is minority women earn a mere 3.1% of those degrees. This paper reports on a qualitative study examining Latinas' identity development toward and in undergraduate engineering and computer science studies using a sociocultural theory of learning. Three major themes emerged from the data analysis: 1) Engineering support clusters as affinity spaces contributing to development of engineering identities; 2) Mexican or Mexican-American family contributing to persistence in engineering; and 3) Equity in access to engineering education. Engineering support clusters and Mexican heritage family support were vital in developing and sustaining Latinas' engineering identity. Additionally, data supported the idea that Latinas at the research site experienced gender and ethnic equity in their access to engineering education. The authors call for a more gender-inclusive engineering education and situating education experiences in more effective learning approaches (i.e., critical thinking in community and cultural contexts), which deserves attention in order to move engineering away from a ubiquitous view of inflexibility regarding women in engineering.

Keywords: equity in access, feminist science education, gender-inclusive science, identity theory, Latina STEM education, women and minorities in engineering

1. Introduction

1.1 The Problem

The disciplines of engineering and computer science have served as preeminent and prestigious fields of study, yet historically women have been underrepresented in these fields. While other professions have or are reaching gender parity (Beede et al., 2011), engineering is "one of the few remaining of sex-segregated disciplines" (Camacho & Lord, 2013, p. 1). In 2012, 19.2% of engineering degrees were awarded to females with a mere 3.1% of these awarded to women from underrepresented minorities (National Science Foundation [NSF], 2015). The low representation of women, and Latinas specifically, has been the topic of inquiry by various organizations and institutions that have aggressively reached out to females (National Research Council, 1991; NSF, 2003) without significant impact. Contributing to this national effort are exemplary programs, such as the Computing Alliance for Hispanic-Serving Institutions (Gates et al., 2011), the National Center for Women in Information Technology, WEPAN, Grace Hopper Regional Consortia, CRA-W, ACM-W, and Tapestry. Although the enrollment numbers of females are far from parity, it would no doubt be worse without the dedicated work of these outreach programs. In the literature, studies examine women and minorities in engineering, generally with one study specifically examining Hispanic women. Studies investigating minorities and women in Science, Technology, Engineering, and Mathematics (STEM) focus on equity of access and are looking at data in broad terms, rather than Latinas specifically in engineering and computer science (hereafter referenced as engineering).

1.2 Significance of Problem

The disproportionately low share of Latinas earning undergraduate degrees in engineering is an indicator that the discipline could face its own crisis point. This low representation may be explained by the findings of several researchers, such as Baker, Krause, Yasar, Roberts, and Robinson-Kurpius (2007); Besterfield, Moreno, Shuman, and Atman (2001); Brainard and Carlin (1998); and O'Hare (1995), who found females and minorities more likely to have low self-efficacy and confidence compared to white males. Furthermore, Tonso (2006) and

Crisp, Nora, and Taggart (2009) argue university campus cultures can be unwelcoming and competitive, which can further alienate minorities from full participation and may contribute to others resisting entrance to these possibly hostile and alienating environments.

To resolve the crisis, it is crucial to listen to the voices already in the field, such as the Latinas in our study. Located on the U.S.-Mexico border, the research site is a Hispanic Serving Institution where female enrollment in engineering is 20%, slightly higher than the national average.

1.3 Relevant Scholarship

Trenor, Yu, Waight, Zerda, and Sha (2008) examined the context of females of color, including Asians, Blacks, and Hispanics, in engineering and found their experiences to be more supportive in minority institutions. Similarly, in their study of women, generally, in engineering, Graham and Caso (2001) found academically resilient students seek support structures to overcome barriers; and, for women of color, their active engagement in on-campus activities for which they gain recognition strongly influenced their retention in engineering. Ohland, Brawner, Camacho, Layton, Long, Lord, and Wasburn (2011) examined large, longitudinal data sets to understand the interplay of race and gender on measures of success and found trajectories to be gendered and racialized. These findings strongly suggest the negative influence of the dominant White, male population on the culture of institutions, which may explain the findings of Besterfield et al. (2001) that minority students are more likely to be less confident when entering their engineering studies. Thus, the role of social, or cultural, capital is important for Hispanic women, or Latinas, to counter this lack of confidence and persistent in their engineering studies (Martin, Simmons, & Yu, 2013). This notion is supported by the findings of Samuelson and Litzler (2016) who examined the types of cultural capital that Black and Latino students in universities across the United States employed for success in engineering education, and found navigational and aspirational capital to be most important for these students. These findings support the study undertaken by Martin, Simmons, and Yu (2013) who found the role of social capital important to Hispanic female success in undergraduate engineering studies.

Gainen's (1995) study focused on minorities in STEM fields and found minority student attrition rate in STEM introductory courses higher than the dominant groups who were White and male. Similarly, Hurtado et al. (2006) found Mexican American, Puerto Rican and American Indian students take fewer mathematics, physics, and biological sciences courses, or gatekeeper courses, as compared to their White and Asian counterparts. Crisp, Nora, and Taggart (2009) found minority students more likely to drop out of such gatekeeper courses as compared to their White counterparts. Minority women have the lowest persistent rate in STEM studies, according to Smyth and McArdle (2004), which they attribute to the intersection between gender and ethnicity, or what many refer to as the "double bind".

A paucity, however, exists in examining women's identity development in STEM, in particular engineering undergraduate studies. One such study is that of Carlone and Johnson (2007) who studied women in STEM professions and found their race, gender, and ethnicity disrupted their recognition as scientists by the academic and professional community. DeCuir-Gunby, Long-Mitchell and Grant (2009) likewise studied women of color in the STEM professoriate. While many studies examine minorities and women in STEM and engineering, no study specifically examines identity of Latinas in undergraduate engineering studies or in their trajectory toward engineering. Thus, the dearth in the literature indicates a gap in knowledge that this paper addresses.

1.4 Research Question and Theoretical Foundation

The study reported in this paper was designed to further understand the ways educational institutions may help recruit and retain women and other minorities in engineering and other STEM fields. Qualitative research methods were applied to investigate the life experiences of Latinas toward and in engineering studies. The overarching research question was: What is the relationship among identity, resilience, and persistence of Latinas in computer science and engineering?

To better understand how Latinas make decisions in choosing engineering as a discipline of study, the researchers employed, as a theoretical framework, a sociocultural theory of identity, drawn from Gee (2001; 2005/1995) and Holland, Lachicotte, Skinner, and Cain (1998).

Literature over the past decade has shown that identity is becoming a core consideration in the study of teaching and learning, generally, and in science education, specifically. Identity—who we are for ourselves and in relation to others—is a complex phenomenon in which a core identity develops as we interact with others. As human beings, we engage in authentic and situated activity, interacting with others and our environment in unconscious and tacit ways to inherently make sense of our world. Identity is recognized in an *interpretive system* (Taylor, 1994)

constituted by people's historical and cultural views. Thus, our mental models of identity are culturally situated, as suggested by Gee (2005/1995), who refers to these mental models as "discourse models" (p. 60) defined by how we dress, how we act, and how we communicate. Over time, we develop discourse models through participation in various discourse communities that influence future career choices. These communities exist in the formal educational experiences as well as in the home and social experiences that surround us.

2. Method/Research Design

Based in qualitative methodology, the researchers employed naturalistic approaches to understand, illuminate, and interpret the multiple realities of individuals in a particular context. Data collected through this approach result in rich descriptions of participants' experiences and employ a variety of analytical methods to extrapolate the essence of those experiences (Lincoln & Guba, 1985).

2.1 Context and Participant Selection

This study was situated in a minority majority Hispanic university on the U.S./Mexico border in a region of Texas with the lowest median income (Texas Higher Education Coordinating Board [THECB], 2011). With approximately 22,000 students of which 55% are the first in their families to attend college, the female enrollment in engineering studies at this university is 20%, slightly higher than the national average. The university offers undergraduate degrees in Computer Science [CS] and Engineering, including Mechanical [ME], Industrial [IE] Electrical and Computer [ECE], Civil [CE], and Metallurgical and Materials Engineering [MME]. As shown in Table 1, the distribution of majors among the research participants was IE (N=2), ME (N=8), MME (N=5), CE (N=3), ECE (N=3), and CS (N=5).

Using purposeful sampling technique (Merriam, 2001), 26 female engineering undergraduate students agreed to participate in our study; and each self-identified as Latina. See Table 1 for a listing of participants and demographic information.

Table 1. List of participants

Pseudonym	Major	Ethnicity	Language	Grad Date
Ali	ME	Hispanic	Dominant English and Second Language Spanish	2018
Elena	CE	Hispanic	Dominant English	2015
Diana	ME	Hispanic	Dominant English	2015
Pamela	MME	Hispanic	Dominant Spanish and Second Language English	2014
Sara	EE	Hispanic	Dominant English	2012
Maria	MME	Hispanic	Dominant English and Second Language Spanish	2014
Amelia	CS	Hispanic	Dominant Spanish and Second Language English	2014
Briana	ME	Hispanic	Dominant Spanish and Second Language English	2015
Andy	CS	Hispanic	Dominant English and Second Language Spanish	2013
Natalie	CE	Hispanic	Dominant English	2013
Gina	ME	Hispanic	Dominant Spanish and Second Language English	2015
Alexis	ME	Hispanic	Dominant Spanish and Second Language English	2013
Alejandra	IE	Hispanic	Dominant Spanish and Second Language English	2013

Daisy	ME	Hispanic	Dominant English	2013
Gabriela	ME	Hispanic	Dominant English and Second Language Spanish	2016
Katya	MME	Hispanic	Dominant English	2015
Ami	ME	Hispanic	Dominant English	2013
Karla	CE	Hispanic	Dominant English	2014
Felicia	CS	Hispanic	Dominant Spanish and Second Language English	2015
Ceci	ME	Hispanic	Dominant English and Second Language Spanish	2015
Brenda	CS	Hispanic	Dominant Spanish and Second Language English	2013
Juliet	CS	Hispanic	Dominant English	2014
Lucy	EE	Hispanic	Dominant Spanish and Second Language English	2014
Amber	EE	Hispanic	Dominant English	2012
Autumn	ME	Hispanic	Dominant English	2013
Brittany	IE	Hispanic	Dominant Spanish and Second Language English	2013

2.2 Data Collection

Data were collected using a focused, in-depth interviewing method (Seidman, 2006) in which participants reflected on their educational experiences and life histories both in light of their career preparation and ultimately into their engineering studies. In this qualitative method, semi-structured interviews provided research participants an opportunity to narrate and construct meaning of their life history through three interviews, each lasting approximately 90 minutes and conducted at weekly intervals to allow for reflection. The interview questions were open response rather than questions requiring a direct answer. This was purposeful to allow each participant to guide the information sharing in order to ensure that the participant told the context and concepts in her own linguistic and cognitive framework as thoroughly as possible. The three open, in-depth interview questions were:

· The focused life history: What led you to major in engineering?

· The detailed experience: Tell me what it is like to be an engineering student.

· Reflection on the meaning: Given what you have told us about your engineering education experiences, how do you understand this and what sense does it make to you?

2.3 Data Analysis

The research team digitally recorded each interview and transcribed it verbatim. These hundreds of pages of data were entered into the qualitative software *NVivo 10* and coded using the research questions and theoretical framework as guides while allowing divergent, yet relevant, codes to arise (Strauss & Corbin, 1990). The codes were systematically grouped and categorized; as more codes emerged, these were re-categorized to allow themes to emerge. Using Seidman's (2006) method, profiles of each of the participants were compiled using mostly the individual's words. These narratives allowed the research team to contextualize the emergent themes in order to analyze the data in and across the narratives (Chase, 2005).

3. Results/Dominant Themes

Through the sorting and organizing capacity of the qualitative analysis software *NVivo 10*, the researchers were able to identify dominant themes, sub-themes, and concepts. The majority of participants addressed these three major themes in some detail.

> 1) Engineering support clusters as affinity spaces contributing to development of and persistence in engineering identities.
> 2) Mexican or Mexican-American family contributing to development of and persistence in engineering identity.
> 3) Equity in access to engineering education.

In addition, important sub-themes emerged as data were examined. These sub-themes dealt with how the participants negotiated adversity, in particular moments of uncertainty when their identity as engineers was questioned, and how early experiences with engineering artifacts contributed to their engineering identity. The researchers have elaborated on these subthemes in 26 documents: 8 paper/poster presentations, 4 journal publications (two are under review), and 13 presentations at scholarly conferences. This paper will provide an analysis of the research results relevant to the three dominant themes.

3.1 Theme One: Engineering Support Clusters as Affinity Spaces

This research applies Gee's (2001) *affinity-identity* as a lens to examine how these young Latinas made sense of their lived experiences as engineering students. Affinity identity encompasses the large array of experiences that would draw one towards feeling affinity for a particular thing, which in our case is engineering. Engineering students in a particular affinity space, such as an affinity group, often act and talk in certain ways that are recognized and valued by the other group members. Affinity group members share common goals, have allegiance to the group, and embody its practices. In Gee's perspective, identity is seen as constructed through action and in interaction with a particular group with which one has willingly joined and to which other group members have been allowed access. Therefore, many types of interactions can contribute to affinity identity.

Almost all of the participants mentioned the importance of one aspect of this affinity identity in their persistence in engineering education—their involvement in small groups of peers who studied together and supported each other in their engineering education. For the purpose of this paper, we refer to these small groups as *engineering support clusters*. These engineering support clusters took many forms including study groups, membership in an engineering-related organization, membership in a learning community, or sharing a team-based project. The phrase "*help each other out*" was used repeatedly as participants described the interactions within the group.

Approximately half of the women in our study were the first in their families to achieve a university education. If a student's family or close social circle has no prior experiences with engineering education or other university experiences, the family may have limited social capital for engineering preparation to pass along to their children. When these limitations are evident, students acquire external social capital for how to negotiate engineering education through these engineering support clusters (Martin, Simmons, & Yu, 2013), and the participants in the Martin et al. (2013) study commented about how their peers would advise them with tips on when to take courses, what resources were available, and which professors to seek out.

Eighteen of the twenty-six participants referenced a particular engineering support cluster as beneficial to their success, which suggests its meaningful contribution to forming their engineering identity. These groups met in many places: the university library, their homes, local coffee shops, and in sections of the engineering buildings designed as study centers or snack shops to accommodate this kind of group interaction. As Briana said, "It's just like if you have a study group, you're going to succeed. That's the key."

The groups were constructed in a variety of ways. Karla told about a new member of their study group who found her support cluster by walking around the library until he found a group of engineering students from his class studying together.

> And he was like, "Hey, can I join you guys? I'm also in your class." I was like, "How did you find us?" "Well, I was just walking around all the floors of the library looking for someone who was studying Dynamics." And then we all studied together.

Some groups were assigned by professors to do group projects and collaborative research. Some were similar to cliques of students who had been friends in local high schools and stayed together at the university for friendship and support. A few students entered the university with an interest in engineering and attended orientation sessions or club orientations where they felt welcomed and included in the engineering study and support teams. One

woman entered the university to study architecture, but the welcoming engineering orientations wooed her to an engineering field. The support groups fostered mutually beneficial relationships that were long-lasting.

> That was just like the beginning of the semester when it started. Like, I was by myself. So it was a little harder because I didn't have anybody to ask for questions or to give me examples on the project. But now it's a group of us who get together and study for the upcoming exams. If I understand it, I would explain it. It's like a group, like study group. (Brenda)

Felicia had a small child and rushed home after class to be with him, although she and Jane got together often to study. "I think it's exciting for her [Jane], too, to have another female student because she's in the same boat as far as our friends...... they're not computer scientists." Abundant comments similar to Katya's comment below supported the inclusive, welcoming, and academically beneficial aspects of group participation.

> So then, we were like, "Well, do you understand this?" And they would understand it so this other group would explain it to us, and then we'd get the different concept and explain it to that other group.

Seven participants referenced the importance of campus organizations in developing their engineering identity.

> They were all women engineers as well, so that's also a good big point...... Umm, I would say that that helped me in transitioning since I wasn't completely alone. I had people not only in my classes maybe but also within the faculty that I feel comfortable with in mechanical engineering, like talking to, see how my day was...... Umm, I'm always really excited to tell them that I feel at home here and since I'm within mechanical engineering...... I've been able to progress and getting more into my classes. (Briana)

Sometimes the groups became a family-like cluster providing social support and advice on how to negotiate the engineering program as well as providing academic support. Andi described the time when her sister was in the hospital, and she needed to be with her sister. Her engineering support cluster came to the hospital to be with her, to study with her, and to visit with her family. "And whenever I would have to miss class or anything, they would say, 'We gotcha. Don't worry about it'."

The preponderance of comments from this research discuss the value of these support clusters in ensuring engineering identity development, thus strengthening the call to institutions of higher education to facilitate the organic formation of such affinity groups both inside and outside of class through institutional and curricular re-design.

3.2 Theme Two: Mexican or Mexican-American Family as an Affinity Group

Family played a significant role in participants' career preparation and agency to persist in their studies. The Mexican cultural experiences are informative to the general field of engineering; and, in the border setting of the study, those cultural experiences were often in an international context. Yosso's (2005) notion of familial capital sheds light on how the Mexican and Mexican-American women in this study drew on their families as resources for achieving educational goals. The term familial capital refers to the cultural knowledge that Mexican families pass on to younger generations. From family members, in general, Latina/o youth learn life lessons on caring and resilience, which help them to develop "emotional, moral, educational and occupational consciousness" (Yosso, 2005, p. 79). Using Yosso's framework of cultural capital, Samuelson and Litzler's (2016) study examined the cultural assets that minority students in engineering drew upon to persist. In their study, data from eight Latinas across the United States suggested that familial capital was not a dominant contributor to their success. In contrast, familial capital was most significant for the success of the Latinas in the study at this border university.

Briana started her engineering education at The University of Texas at Austin where she met a cold environment. Her parents helped her transfer to the university near her home, which was the site for our study; and she reported that she felt at home and her excitement for engineering was reignited.

> And, again at [home university] you see that aspect. You have a great majority speaking Spanish. I feel comfortable. I mean speaking English, but when I go home my parents speak Spanish and we have *posole* and that's how we celebrate things. And when I come here at [home university] I have a lot of, you know, friends who also experience that. They speak Spanish, they understand the food interest that I like, or they eat the same things that I do, and that's very welcoming. You feel at home which has really affected me. Like that—I never noticed that but it reflected on my grades and how I do in school.

Most of the women in our study lived with their parents and drew on that support as they prioritized career preparation over other life choices, such as independent living and starting their own nuclear families. They appreciated the financial and emotional support they were continuously receiving from their parents.

> But my parents never let me forget that this is my primary job. You know, I have a job—a part-time job outside of campus but they always remind me, like, "Your education is your job. This is what you focus on. And this is what you need to get done." So, I mean they're definitely my biggest supporters for education. (Elena)

In the context of their own homes, some participants described participating in ritualistic activities such as having meals with parents and siblings while having conversations with them about daily life events and meaningful activities involving other family members. Alejandra draws strength from her family's Sunday ritual.

> Everybody always wakes up around 5:30 … not just to get to the line at the bridge [she crosses the international bridge every day to go to school] and we're like morning type of persons who always do homework and everything in the morning. But my loveable, huggable weekends that I enjoy, ummm…… Everybody wakes up around 9:00. We all go to my parents' room. We just stay like there just lying there—all five of us. It's really hard now cause I mean we're getting bigger so I mean it's really funny. And then my dad always complains, but then he's like fine with it. And then we start discussing what we're going to eat—Everybody has their breakfast. Okay, everybody starts talking and everything. Everybody goes back to sleep for an hour or two and wakes up, gets ready, and then we go to Mass. And that's the fam—with my family on the weekend.

Five participants specifically stressed the key role their mothers played in their persistence in engineering. When they encountered very challenging classes, these participants reported having considered either changing majors or dropping out of college. With the emotional support from their mothers, however, they were able to overcome difficulties and continue pursuing their engineering degree. Mothers were often credited as the source of strength when these participants doubted their engineering identity.

> So she, my mom, was actually the one who pushed me to go to the counselor because I probably would have never gone had it not been for her telling me to go. (Amber)

> And I actually had, prior to going on the internship, I had gotten all the paperwork required to change my major and everything. But when I told my mom, she was like, you better not do it…… And she was like engineers make so much more money than math teachers…… She was like, just hang in there and then you can get your alternative [teacher] certification if you want to…… (Karla)

Two women reciprocated the care and support received from their family members by standing by them in difficult times in spite of the heavy academic load.

> I just think something kept me here; and I'm kind of glad because, when college hit, a lot of stuff happened that required me to be here. My grandma was diagnosed with Alzheimer's. And uh, it was a rough year. Like we would be at the hospital, and we couldn't leave her. So my mom would stay there all day; sometimes she stayed there multiple days. I would spend the night or I would be there during the day, or if my mom had to—like my mom literally didn't have a life and she would call on us. (Diana)

> And, it got so bad where my mom—she had to work and she would work in the morning and then in the afternoon she would go to another work. So, with everything that had been with my dad, and he left us and all of that, my mom got really sick; she found out that she had depression and she wasn't eating anymore, and she had anemia. And then from that emotional breakdown the diabetes kicked in. So, I thought that, since I was working, and since I was secure financially, since I can, uh, work and study, be a work-study student, I felt the responsibility to help my mom so she didn't have to get two jobs. (Pamela)

A few women specifically expressed their sense of responsibility for younger siblings. One woman felt that she had to be a role model and inspire her siblings to pursue a college degree. Another was financially helping her younger brother to ensure that he finished college.

> I was one of the top ten from my high school. And I was like, okay—I can go to Austin, I can go to almost wherever…… But I just wanted to stay here at [university] "cause it was family. I couldn't leave my brothers…… if they have any questions, I mean I can answer it for them. If not, I can find the answer for them, or try to help them. So then I stayed here". (Alejandra)

> So my baby brother was born but there was issues. And since he couldn't walk and there were chances he might not learn how to do it, I remember them giving him prosthetics, and I looked at the prosthetics and they're just like little plastic things with foam inside. But then, I just thought, like, why are they charging so much for just these little prosthetics that are just plastic? I can make them, you know? And that's when I started looking into biomedical. And then here's the path to go with my little brother, just working with biomedical, working with medicine kind of field. (Ceci)

These participants' broader understanding of family seemed to play a central role in educational aspirations and persistence in college. Close relationships with parents, siblings, uncles, aunts, cousins, and grandparents significantly influenced their decisions to enter engineering fields and to persist despite the challenges they faced in and out of school. As Yosso (2005) points out, these close relations among Latino/a families are "healthy connections" that minimize feelings of isolation and build confidence as they can rely on family members as a support system.

3.3 Theme Three: Equity in Access in Engineering Education

Valian (1999) argues that people's perceptions of computer scientists and engineers tend to be masculine-oriented—notions that may influence females at the critical juncture of making career choices. Ahlqvist, London, and Rosenthal (2013) posit that "women who perceive less compatibility between their gender and their STEM identities have a lower sense of belonging, less confidence, and less motivation in STEM fields" (p. 2). This perception may be most threatening when women encounter challenges and transitions.

Data from our study provided evidence somewhat counter to what Ahlqvist et al. (2013) posit. In the participants' narratives, strong evidence indicated they were exerting resistance to this discourse threat; and they developed agency to enroll, persist, and enter into these professions. This is what Yosso (2005) refers to as resistance capital. Nineteen of the participants made specific references to their female identity relating to their engineering education experiences. Comments from ten participants indicated that they welcomed the challenge of being the rare woman in the program and the value of proving and pushing themselves.

> Umm, I guess like before the fact that engineering's considered a male's job held me back from engineering, but at that point when I found out that I could do physics and maybe engineering, the fact that society considered engineering a male's job made me want to do it. Made me want to prove that, as a female, I can do a man's job and that they—that just because they're a man doesn't mean they can do it better than women. It was like a challenge, a challenge to myself, a challenge to everybody to prove that I can do it, and that I will do it. (Gabriela)

> I was really nervous [in high school] actually. Because I was actually the only girl in Computer Maintenance 1, so I had, I felt intimidated, you know. But I also was excited about it, and also had this feeling of like, I'm a girl, I can beat all these guys. I can be just as good as them. So it was really exciting, and like later on in the year they were really accepting of me, so that really helped me out, you know, working on the different projects and everything. (Juliet)

There were six short comments expressing discomfort with the ratio of men to women in their engineering classes. The ratios ranged from one woman in a class of five up to one women in a class of forty men. Five participants perceived criticism from men in their program about women in engineering without mentioning any specific example. Two specifically stated that they had not experienced any such criticism.

Briana mentioned subtle interactions that left her feeling that some men thought she should have easier work.

> So far they've been positive. I don't have anything where I've been scared you can say. Umm, it's very, very subtle. There's very few groups of—I could definitely say guys within engineering that they're not rude but they're just very nice about it in how they might do something. Or, if you're in a group they don't put you to the side but they give you easier work. And they're just like, "Oh, she can take care of that." And it's not of like, oh, they're not rude about it but they're just very, very subtle.

Data imply that the engineering faculty who these women encountered were considerate and inclusive of women in education. Three women mentioned specific efforts at the university to encourage women in engineering, and three mentioned that they particularly enjoyed the teaching style of the female faculty. In a focus group setting with 12 of the participants who had completed all three deep interviews, one of the researchers asked specific questions about encountering sexist language or being excluded from affinity structures related to their engineering education. None of the women provided examples of this or expressed the belief that they had perceived threat or

gender reduction sensitivity (Ahlqvist, London, & Rosenthal, 2013) in their classroom or their engineering group experiences.

Therefore, there is evidence that most of the women in this study had a compatible perception between their status as a female engineering student and academic success. In these situations, at least, gender is inclusive.

That previous statement needs qualifying as absence of evidence is not evidence of absence. The study is not claiming that barriers do not exist in this and other universities in providing equal access to women and minorities who are pursuing engineering careers.

In our team research meetings to pour over these data, the Latinas and Latino researchers offered another explanation. In their own career preparation experiences at various universities, they could recall comments or actions from others that were less than respectful; yet, at the time of the event, they did not register it as a devaluing experience. In other words, as Bruner (1990) posits, the Latina's canonical script includes subtle actions of devaluation. The women may be experiencing inequitable words and actions, but have not breached the narrative to interpret them as inequitable nor to take rectifying actions. Andi explains this in her statement, "But I mean, they never said that but they kind of act like that. But since I already had experiences being in, like, a male-dominated environment, then I kind of just…… I was used to it."

Also contributing to the understanding of equity in access to Latinas in engineering education is the status of the women we interviewed. In most cases, the women were somewhat privileged compared to the large swath of Latinas, and particularly Mexican-American women in border communities who could consider engineering careers. Our participants were women who had social capital through family support, or they had managed the financial demands of their education experiences, and all but two of the women were single women whose extended families provided domestic support required to spend large amounts of time in their academic pursuit.

More research with Latinas who select other career preparation or who leave engineering career preparation should provide more insight into this theme of equity of access to engineering careers.

4. Discussion

The participants at the border-area university in this study had support structures via family and affinity groups. These structures enabled the women to persist and develop agency to overcome any barriers they faced. With support structures in place, minorities and women, like the Latina participants in this study, are more likely to endure the somewhat rigid environment in engineering education. However, Latinas in engineering education are still greatly underrepresented in the field.

Camacho and Lord (2013) write that the institutional character of engineering education is notoriously inflexible and pervasive. The numbers of prerequisite courses demanded force out opportunities for elective or exploratory courses, which may force out students whose skills and talents may contribute to the profession.

Through this study, it became evident that these women, with their own limits in time and finances, were able to develop their identity as engineers and that identity enabled them to navigate the rigid discipline of engineering. Their success demanded multiple support structures and sufficient economic and time resources.

Evidence from the data discussed in this report presents implications for institutions and educators who are seeking to increase the numbers and success of Latinas in engineering career education. The engineering support clusters were vital for the women's success. This university has structured the physical setting to enhance students' access to places to meet with their support clusters. For most students, but especially students whose first language is not English, engineering concepts are complex and the language used to identify these concepts is often technical and difficult. The support clusters allowed the students the option of discussing and interpreting these concepts and terms in-depth with their peers to strengthen their understanding of engineering concepts and principles.

Consistent and persistent in this research with Mexicans and Mexican-Americans was the importance of family and the associated physical and emotional closeness that family brings. In the case of the women engineers in our study, the domestic support that the family provided allowed the women to spend more time in their engineering studies. The families also contributed to the women's engineering identity development through early experiences with engineering artifacts; and their mothers, in particular, lifted the women over any barriers they encountered in their trajectory and contributed to the development of their engineering identity. Universities that are distant from the Latina students' physical homes might develop strategies to maintain family support during their career preparation.

Although they struggled with limited time and financial resources, this group of women drew from their banks of social capital to find success in engineering education. These banks of social capital strengthened their identity as

engineers; and the women in this study did not describe feelings of oppression or marginalization in their access to engineering education.

In 2012, Roxanne Hughes published results of her study that is similar to this study, *Gender Conception and the Chilly Road to Female Undergraduates' Persistence in Science and Engineering Fields*. She argued "[g]ender conception and identity play significant roles in women's persistence......" Her study examined undergraduate persisters and leavers. After interviewing 26 women during their final years of undergraduate education, Hughes found 14 persisters in science and engineering and 12 leavers who had changed their majors to other fields. In the first interview, the women provided information about what contributed to their interest in science and engineering. The second interview occurred later and identified changes in their plans or their career choices as they neared graduation. The women identified what Hughes calls the chilly climate: class size, competition, unsupportive faculty, lack of guidance, lack of role models, weed-out courses, sexist experience, and unsupportive peers.

Both sets of women in Hughes's study experienced this chilly climate, and it was slightly more profound for the leavers. Similar to the women in the current study, those who persisted considered their minority woman status as a motivation to succeed. Those who left experienced deterioration of their confidence or deterioration of their interest. Their STEM identity was not developed, or possibly under-developed, enough to overcome the chilly climate and, thus, continued with career preparation in fields outside of science and engineering.

5. Conclusion: A Call for Feminist Theory in Engineering Education

As a result of her study, Hughes (2012) confirms that, in the current state of STEM higher education, policies aimed at increasing women's involvement focus only on access. We confess that the findings from our study also focused only on access. We see a great need to examine further. We question why the women did not describe learning experiences and understandings about engineering in a feminist context. Indeed, feminist engineering education is a rare component of any engineering education program at the university where this research took place and at universities across the nation.

Camacho and Lord (2013) quote from Donna Riley, an engineering professor at Smith College and author of *Engineering and Social Justice*:

> Generally, engineering students learn to think analytically only in certain ways appropriate to technical analysis. …… We typically do not come away with the ability to think critically, to question what is given, or to question the validity of our assumptions, because we are too busy learning the essentials of problem solving. For this reason, we often cannot see the larger context of the problem…… (p. 8).

Engineering is not value free, and engineering activities permeate society, often vulnerable society, for good or ill. Barton (1998) describes feminist STEM education where learners are exploring multiple ways of learning and doing science so that it includes the social, historical and political context of its activities and decisions. A feminist engineering program would examine political and economic power structures inherent in engineering. This kind of feminist education is not inflexible and rigid like traditional engineering education, and it goes beyond formulas and texts toward critical thinking where learners seek to understand relevant community issues and the long-term consequences of engineering actions.

Alison Wylie (2012) explains further: "Here, women's experience gives rise directly to the questions asked; inquiry is motivated by explicitly activist objectives and designed with the aim of leveling the hierarchy of authority inherent in traditional 'expert' forms of social scientific research" (p. 249).

Our communities are bulleted with examples of severe results when engineering clashes with society. The clashes become political time-bombs and the eventual implementation is flawed through compromise. Water allocation projects often rob one community of its water to favor another community; and, in the process, water is lost through extensive evaporation, native plants and animals are destroyed, and foreign species take over their habitats. In the United States, outdated laws favor the mining industry. The early miners extracted the metals and left the pits abandoned. Thousands of these pits exist unattended across western United States. Toxic wastes are open to the elements and seep into precious water sources. Political and economic posturing restricts any actions to contain or remediate these environmental wounds. And, in this border context, since about 1980, hundreds of foreign factories have been built (and often abandoned) in Mexican cities near the U.S. border. This sudden influx of manufacturing resulted in surges of citizens flooding the northern cities and in tremendous upheavals in the social structure of the already vulnerable border populations.

None of the data in our study could be interpreted to show that the women were approaching a curriculum where learning experiences moved their thinking toward the level of critical thinking described by Barton and Wylie

(1998). Perhaps an extension of gender research could focus on this question to see if and where engineering students might identify learning experiences that are gender-inclusive and/or based in situated knowing and learning. One of the women in our study, Elena, expressed her longing for an engineering experience situated in relevant community experiences where the context and impact are critical (Only two of the 26 participants dropped out of the engineering degree program, and Elena was one of them).

> Umm, when I get emails or see articles or something online that shows how these third world countries, they don't have the drinking water they need, or they don't have the food—a certain portion of the country was wiped out by a tsunami like with Haiti. I definitely feel like I should be down there…… and help in any way I can. And with engineering I hope to be able to do that. Like, at [university] they're starting up a program Engineers without Borders, and, you know, when they're licensed engineers, and they have their degrees they can go to these third world countries and really give back—maybe the buildings need to be more reinforced. Maybe we need to build more emergency centers. Maybe we need to have a better highway system so that we can ship people out. Because, it breaks my heart to hear these—that these peoples' lives are completely ruined. So that's something that I would like to do, definitely.

What if we change the institution of engineering? What if engineering practices were taught within a feminist educational theory that moves to the context of the community—considerations about those in the community affected by the changes, alternative ways of solving design problems to be less intrusive, to use fewer natural resources, to be esthetically appropriate for those on the margins of society?

Ana Julia Cooper (1892), a freed slave and writer, shares her perspective that for most of human existence, man has walked with the ambling gate of a one-eyed giant. Thus, our research is not the destination, but the departure point into new inquiries and new visions about how engineering education might look when viewed and managed with gender and cultural balance.

Acknowledgements

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