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A Crack in the Pipeline:

Why Female Underrepresented Racial Minority College Students Leave Engineering

A dissertation submitted in partial satisfaction of the
requirements for the degree of Doctor of Education

by

Jenny Amanda Vazquez-Akim

2014

ABSTRACT OF THE DISSERTATION

A Crack in the Pipeline:
Why Female Underrepresented Racial Minority College Students Leave Engineering

by

Jenny Amanda Vazquez-Akim

Doctor of Education

University of California, Los Angeles, 2014

Professor Mark Kevin Eagan, Chair

Female and underrepresented racial minority (URM) students are indicating their interest in STEM fields at increasing rates, yet when examining the engineering discipline specifically disparities in degree completion rates between female URM students and others in the racial or gender majority are even more severe. This study explored female URM college student perceptions of school and classroom climate and the impact these factors had on their decision to persist or to leave engineering. Through a qualitative interview methodology grounded in Social Cognitive Career Theory (SCCT), this study explored factors including self-efficacy, perceived barriers and supports, other-group orientation and outcome expectations that influenced students' academic decision-making. Interview participants consisted of 5 female URM students that matriculated into an engineering major at a top tier, private university but subsequently left

the discipline in pursuit of another field of study. The perceptions of this target population were juxtaposed with interview data from 4 male non-URM, 4 female non-URM, and 4 male URM leavers in addition to 7 female URM engineering persisters. As a final component in the research design, 9 undergraduate engineering faculty were interviewed to understand their perceptions of why female URM students leave engineering in pursuit of other disciplines. With faculty being a central component of the academic environment, their perceptions of female URM students, as well as how they view their role in these students' retention, provided insight on this other side of retention question.

Salient findings emerged that differentiated female URM leavers' experiences in engineering from other student populations. Female URM leavers were less likely to call upon self-directed learning strategies in response to academic challenges. Perceived academic barriers such as heavy course loads, lack of connection between material and application, and perceived academic deficits deterred these students from persisting in the field. A perceived lack of academic preparation also inhibited female URM students from participating actively in class. Additionally, while targeted support programs were effective in connecting female URM students with their peers and such programs contributed to an overall sense of diversity at the school, a lack of diversity was felt when inside the classroom.

Robert Cooper

Sylvia Hurtado

Jenessa Rachel Shapiro

Mark Kevin Eagan, Committee Chair

DEDICATION

Dedicated to my mother, a lifelong educator and constant supporter of all of my personal, professional, and educational pursuits. Thank you, Mom!

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VITA

- 2004 B.S. Business Administration
University of Southern California
Los Angeles, California
- Veritas Prep, LLC
Malibu, California
- 2006 Certificate in College Counseling
University of California Los Angeles Extension
Los Angeles, California
- GEAR UP
Vista, California
- 2008 MPA, Nonprofit Management and Public Policy
New York University
New York, New York
- Harlem Educational Activities Fund (HEAF)
New York, New York
- 2011 University of Southern California
Los Angeles, California

CHAPTER ONE

Introduction

Statement of the Problem

By the year 2050, 50% of the U.S. population will identify as Black, Latino, or Native American (Frehill, Di Fabio, & Hill, 2008). Although their representation in the broader population continues to grow, underrepresented racial minorities (URM) continue to pursue and graduate with degrees in science, technology, engineering, and mathematics (STEM) at significantly lower rates than their peers. Recent data suggest that college-bound URM students are indicating their intentions to major in STEM fields at increasingly higher proportions, a marked change in this recent decade (Hurtado, Eagan, & Hughes, 2012). Similarly, recruitment of female students into STEM programs has become the focus of many universities, with 33% of freshmen female students declaring a major in a STEM discipline in 2010, approaching the 44% of male students who declare a STEM major (NSF, 2011). However, the college graduation rates for URM students, including African American, Latino, and Native American students, as well as female students in STEM fields are lower than for other groups, highlighting that higher education is one juncture along the science pipeline where STEM talent is lost (C-IDEA, 2000; Frehill et al., 2008; Huang, Taddese, & Walter, 2000; Hurtado et al., 2012).

With percentages of incoming URM students who intend to major in STEM becoming almost equal to those of White and Asian American students (Hurtado et al., 2012), research that explores the factors that impact URM STEM retention in college has become increasingly important. Challenges persist in graduation rates for URM STEM students generally and female URM engineering students in particular. The majority of research studies combine science, engineering, technology, and math when looking at URM or female retention, which limits our

ability to understand the nuances with regard to retention in particular disciplines. When we begin to disaggregate data, disparities become even more pronounced. For instance, women were awarded 59% of all biological science degrees, yet only 18.4% of engineering degrees (NSF, 2011), stressing that an accurate picture of women's retention in these fields cannot be attained when studies combine multiple STEM disciplines in an aggregated analysis. Women's small share of engineering degrees is also further underlined when considering they are awarded the majority (57.2%) of all college degrees nationwide (NSF, 2011).

The call to disaggregate STEM data applies to female URM students as well. The significantly varying retention rates of URM female students across specific STEM disciplines, as well as differences between female URM and male URM engineering degree attainment rates, further underscore the need to disaggregate groups that are typically combined in research studies. The National Science Foundation (NSF) reports that, of engineering degrees conferred in 2010, 9.6% were awarded to URM males and just 3% went to URM women (NSF, 2013). As a point of comparison, URM women accounted for 9.3% of biological science degrees in 2010, highlighting the differences that are uncovered when STEM degree attainment is separated by major (NSF, 2013). While studies on STEM completion have identified some of the potential causes for overall lower graduation rates of women and underrepresented minorities, analysts must disaggregate data by discipline, race/ethnicity, and gender to better understand the problem (Brown, Morning, & Watkins, 2005). Once disaggregated, the severity of disparities in the retention of female URM engineering majors becomes clearer, which fuels heightened lack of racial and gender diversity among engineering graduate students and faculty.

With 92% of engineering faculty being non-Hispanic White or Asian (Frehill et al., 2008) and only 20% being female (NSF, 2011), racial and gender diversity among engineering faculty

is limited, leaving female URM students with very few potential mentors with whom they can identify. Research has shown the positive effect that faculty interaction can have on student persistence in STEM (Campbell & Campbell, 1997; Endo & Harpel, 1982; Kim & Sax, 2011; Kobrak, 1992; Maton, Hrabowski, & Schmitt, 2000). Maton et al. (2000) explain that “contact with faculty outside the classroom, and the development of mentoring relationships, including with minority faculty, can decrease academic isolation, and contribute to positive outcomes” (p. 631). A lack of diversity among engineering faculty deprives female and URM students of the psychological support of having role models who share common backgrounds (May & Chubin, 2003). This lack of diversity among engineering faculty may affect female URM engineering students’ decision to leave the discipline for other majors given the impact professors have on student persistence. As such, colleges and universities find themselves in a self-reinforcing cycle where URM women leave engineering due to the lack of diversity in their undergraduate engineering programs, and these increased attrition rates among undergraduate URM female engineering majors thins the pool of potential female URM engineering professors who could serve as role models.

Hurtado, Eagan, & Hughes (2012) found that, among degree earners, female URM STEM aspirants were 5.2 percentage points less likely to complete their bachelor’s degree in STEM than URM male STEM aspirants. While many STEM research studies aim to look at either URM student retention *or* female student retention, it is rare to find a study that considers both race and gender and the impact this may have on female URM attrition in engineering. Some studies highlight the potential problems of coupling race and ethnicity with gender when looking at underrepresented populations in STEM, though this research has primarily focused on such issues at the faculty or career level (Leggon, 2010; MacLachlan, 2001). However, these

researchers wisely observe that when URM or female populations are aggregated, URM females ultimately fade into the larger group, and important data on this population are lost (Leggon, 2010; MacLachlan, 2001).

My research provides the opportunity to focus on and further understand female URM engineering student attrition specifically as a way to understand the impact of engineering school and classroom climates on students' educational decisions. By branching from existing research yet disaggregating STEM and honing in on engineering specifically, this study offers insight into the unique experiences that engineering students have compared to their peers in other STEM disciplines. By focusing this study on female URM students who matriculated into college as engineering majors, the opportunity exists to discover potential causes for attrition among this population in an effort to ensure more equitable access and success in the field for this highly underrepresented population. As gender and racial diversity diminishes in Ph.D. programs and among engineering faculty, such a study targets a potential fissure in the already-weak pipeline. Fueling female URM students' interest to enter engineering, providing the needed academic preparation, and recruiting this population actively are all important, but utilizing a lens that centers on the college influences that dissuade female URM students' pursuit of their engineering degree moves this study into an under-researched area. Bonous-Hammarth (2000) highlighted that research is needed that explicitly explores contextual factors that cause STEM students, and female URM STEM students in particular, to leave the disciplines, as the researcher's quantitative data left room for additional questions. This study sought to understand those potential environmental factors that cause female URM students to leave the discipline including their perceptions of classroom climate, interactions with faculty and their peers, and perceived barriers and supports in their quest of their engineering degree. Further, I contrasted

these experiences with those reported by other students who also left engineering as well as URM women who have persisted in the major.

In order to understand the potential impact of the environmental factors that influence female URM students' decision to leave engineering majors, this study addressed the following research questions:

1. According to female URM students, what are the social cognitive factors, including perceived barriers and supports, other-group orientation, and perceptions of climate, that influence female URM students' decision to change majors out of engineering? How do these perceptions compare to those of male and non-URM female students?
2. How do female URM students who leave engineering describe the academic environments of both engineering and their second-elected majors as compared to female URM students persisting in engineering?
 - How do URM women who left engineering describe the academic environment within engineering? Do they describe the environment within their second major differently?
 - Are there differences between URM women who stayed in engineering and those who switched in how they perceived the engineering academic environment?
3. How do the perceptions of the engineering academic environment differ for female URM students who have changed majors compared to other groups of students who have also changed majors out of engineering?
4. What factors do engineering faculty believe to be the most salient in affecting female URM students' decision to persist or to leave engineering for other majors?

Background

College completion rates for STEM students have historically been lower than national averages. While 58% of college students complete their degree within six years (Aud et al., 2012), only about 40% of STEM degree aspirants do so in the same time frame (Holden & Lander, 2012; Hurtado et al., 2012), yet that number jumps to about 67% completion when including STEM aspirants who ultimately receive a degree in a non-STEM field (Hurtado et al., 2012). The differences in completion rates become even more pronounced when looking specifically at URM STEM students, with research placing their completion rates below 30% (C-IDEA, 2000; Huang et al., 2000; Hurtado, Eagan, & Chang, 2010; Hurtado et al., 2012)

While there exists a gap in the research that explores female URM engineering retention specifically, a review of the extensive research on URM students in engineering and female students in engineering sufficiently exposes that challenges exist for these populations. In 2009, plans to pursue STEM majors among college freshmen nationwide were almost identical for White and Asian American students as compared to URM students: 34.3% and 34.1% respectively (Hurtado, Eagan, et al., 2010). However, longitudinal studies have consistently highlighted the disparities between racial majority and minority populations in STEM degree completion. The Center for Institutional Data Exchange and Analysis (2000) tracked STEM degree completion for students who entered college in 1993-1994 and found an overall completion rate of 38%. When disaggregating the data by race, African American students were 14.4% less likely to complete their STEM degree in four years as compared to White and Asian students (Hurtado et al., 2012). Similarly, 8.6% of Native American students and 5.3% of Latino students were less likely to complete their STEM degree in four years compared to their counterparts in the racial majority (Hurtado et al., 2012). Huang (1999) found that of 859 science

and engineering students, 46% of the White and Asian American students completed their degree versus 26.8% of URM students.

Looking more closely at the loss of URM students in STEM, researchers have uncovered a phenomenon that many merely change majors out of STEM and complete degrees in other fields at their university. When looking at longitudinal data of 62,115 students who entered into STEM programs nationwide in 2004, five-year STEM degree completion rates for Black and Latino students were 18.4% and 22.1% respectively. However, completions rates jump when considering those who left their STEM majors but obtained degrees in non-STEM disciplines. URM STEM aspirants' graduation rates actually look somewhat better in this case, with 32.2% of Black STEM aspirants and 41.6% of Latino STEM aspirants graduating within 5 years (Hurtado, Eagan, et al., 2010). Hurtado, Eagan, & Hughes (2012) identified multiple factors that impact STEM degree completion versus non-STEM degree completion of URM students. For example, a higher academic self-concept improved odds of URM STEM completion, while a higher social self-concept increased the chances of non-STEM degree completion (Hurtado et al., 2012). French, Immekus, and Oakes (2005) highlighted that further research of this phenomenon is necessary, as similar findings emerged in their research of 678 first year engineering students of all racial backgrounds.

Studies that aggregate data of women's degree completion in STEM mask the accurate representation of where women are pursuing and succeeding in these disciplines and where women are truly underrepresented. However, those studies that explore female STEM retention as an aggregate find unique reasons for attrition for this population as compared to their male counterparts (Seymour & Hewitt, 1997; Strenta, Elliott, Adair, Matier, & Scott, 1994; Vogt, Hocevar, & Hagedorn, 2007). In a study of students who enter science and engineering fields yet

eventually leave, women persisted at lower rates than men, and women who left exhibited a heightened perception of competitiveness in the academic climate (Strenta et al., 1994). Additionally, female students reportedly experienced a greater sense of disjuncture between their high school and college academic environments, with the former fostering self-confidence and the latter more prone to being isolating (Seymour & Hewitt, 1997). All of these factors play a role in the disparate engineering degree completion rates between female URM students and their male White and Asian American counterparts.

A number of studies have looked at students' perceptions of their collegiate academic environments as a potential factor in their ultimate decision to leave engineering (Brown et al., 2005; Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010; Lent et al., 2003; Lent et al., 2005). While there exists a substantial body of work on pre-college, recruitment, and admissions factors that impact female and URM student success, fewer studies look at the influences that students' external environments have on their internal decision making (Brown et al., 2005). Factors such as faculty and peer interactions as well as school and classroom climates can have an impact on students' educational choices. Students' perceptions of this environment and the meaning they assign to their own perceived educational realities also play a role in how these students maneuver through their academic decision-making.

Social Cognitive Career Theory (Lent, Brown, & Hackett, 1994) lends itself to exploring the potential connections between students' perceptions of their academic environment and their persistence in their chosen path. Social Cognitive Career Theory (SCCT) seeks to achieve a deeper understanding of the non-academic factors that affect student persistence, and more specifically persistence in engineering, as it explores one's personal characteristics and environmental contexts that impact academic and career-related interests and choices. As more

qualified and interested female URM students enter engineering yet eventually elect to change majors, the role that their academic environments play on that decision is called into question.

The Problem in a Local Context

In California, where over 57% of the students enrolled K-12 schools identify as Black, Latino, or Native American (CA DOE, 2012), only 14% of incoming freshmen enroll in engineering programs in the state, and of those only 1.3% of degrees are awarded to URM women (EWC, 2008). One top California engineering institution, Western Pacific University (WPU) was selected as the research site due to its high selectivity of students and its active support programs for URM and women in engineering. However, even with its selectivity and initiatives, this institution has lower graduation percentages for female URM students in engineering than others in the major. At the top-tier WPU School of Engineering (U.S. News & World Report, 2011) disparities in retention exist between female URM students and their White and Asian American male counterparts. Table 1-1 below provides a snapshot of engineering student persistence and graduation rates organized by race and gender.

Table 1-1

WPU School of Engineering Persistence Rates

	<u>N</u>	<u>Left University</u>	<u>Persisting in Engineering</u>	<u>Persisting in another Major</u>
Non-URM Male	817	5.4%	86%	8.7%
URM Female	61	9.8%	70%	19.7%
Non-URM Female	398	7.0%	77.4%	15.6%
URM Male	141	9.2%	79.4%	11.3%

Note: Cohorts entering 2008-2011

Table 1-2

WPU School of Engineering Graduation Rates

	<u>N</u>	<u>Left University</u>	<u>Persisting in Engineering</u>	<u>Graduated from another Major</u>
Non-URM Male	994	10%	72.9%	17.1%
URM Female	62	13%	58%	29%
Non-URM Female	337	6.5%	70.6%	22.8%
URM Male	153	15.7%	69.9%	14.4%

Note: Cohorts entering 2003-2006

Although engineering graduation rates at WPU School of Engineering are higher than the national average, disparities still exist both between genders and between racial majority and minority students, with the largest gap occurs when comparing URM female students to non-URM male students. The proportion of female URM students who matriculated into an engineering major but have elected to pursue another degree at WPU more than doubles the percentage of White and Asian American male students. Additionally, as shown in Table 1-2, of the students who obtained their degree from WPU, female URM engineering students are the most likely to complete a degree outside of engineering with close to 30% of URM female engineering aspirants earning a degree from another major outside of The WPU School of Engineering.

The Research Population

By studying female URM engineering student attrition at a university ranked in the top 25 of U.S. News and World Report, an important assumption can be made: admissions standards are competitive and therefore all students admitted into the school of engineering meet the high academic requirements for selection into the university. At WPU, the university accepts less than 25% of applicants with the majority of students holding a high school GPA of 3.75 or above and an average SAT score above 2000 out of 2400 (College Board, 2012). Students admitted into

the WPU School of Engineering must have a strong mathematics and science high school record, typically requiring Advanced Placement or International Baccalaureate coursework in these subjects. Additionally, emphasis is placed on the mathematics portion of the SAT and ACT when reviewing applicants. These variables serve as indicators of likely success in the engineering major. As the students who matriculate into the WPU School of Engineering are deemed academically qualified through this rigorous review process, focusing this study on female URM students who ultimately decide to change majors allowed for a close examination of alternative factors aside from academic preparation that influenced their decision.

At WPU, there were approximately 57 currently enrolled female URM students who entered the WPU School of Engineering between 2008 and 2011 and were either persisting or have changed to another major. Minority and women engineers receive dedicated support outside of the classroom through the Center for Engineering Diversity and the Women in Engineering Program. Despite this additional support, female URM students who demonstrated their preparation for the major through the rigorous admissions review process and confirmed their interest in the field as a declared engineering student were still the most likely to leave engineering for another discipline. There was a clear need to understand the unique experiences of this population.

Research Design

This study aimed to fill gaps in the research for this population and this problem. Currently, research on Social Cognitive Career Theory and STEM adopts a quantitative approach to determining social cognitive factors that may cause students to leave engineering. However, there is limited qualitative data that explores student perceptions more deeply. This study adds voice to the statistics and answers the call in the research for more qualitative methods to

understand the complexities of this problem (White, Altschuld, & Lee, 2008). Quantitative research can only go so far as to explain why students leave engineering. This study sheds light into the perceptions and experiences of female URM students who have encountered the undergraduate engineering environment. STEM retention efforts, in practice, have been largely informed by anecdotal information rather than theory-driven research leading to interventions that may not be effective (Byars-Winston et al., 2010). STEM retention research must instead deepen the understanding of the intricacies that cause the underrepresentation of certain groups to then inform practice (Lewis, 2003). Grounding this study in Social Cognitive Career Theory provided a frame for understanding underrepresented students' interactions with their educational environments. Measures explored participants' perceptions of school and classroom climate, environmental supports and barriers, and other-group orientation in relation to their academic decision-making as a framework for understanding the experiences of female URM students who begin their academic careers in engineering.

This study explored female URM student perceptions of school and classroom climate and the impact these factors had on their decision to persist or to leave engineering. In order to gain a better understanding of female URM attrition in engineering programs nationwide, I researched the environmental factors that influenced their decisions, including the impact of faculty-student interaction and students' own perceptions of the classroom and engineering school environment. Research abounds showing the disparities between retention rates of racial and gender minorities as compared to their counterparts in the majority; however, there is much more limited insight on the social cognitive factors that may play a part in these disparities.

Through interviews grounded in Social Cognitive Career Theory (SCCT), I gathered data focusing on female URM students' perceptions of classroom and co-curricular climates as well

as factors including their perceived barriers and supports and other-group orientation that influenced their academic decision-making. Interview participants consisted of female URM students that have changed majors out of the WPU School of Engineering as well as those that have persisted to provide an opportunity for comparison. To enrich the data, I conducted the same interview protocol with other groups (i.e., male and/or non-URM female students) who have left engineering to further identify how the experiences of female URM students are unique or similar to others. As a final component in the research design, undergraduate engineering faculty were interviewed to understand their perceptions of why female URM students leave engineering in pursuit of other disciplines. With faculty being a central component of the academic environment, their perceptions of female URM students, as well as how they view their role in these students' retention, provided insight on this other side of retention question.

Significance of the Research and Opportunities for Public Engagement

Research on social cognitive factors that cause URM student attrition in engineering programs nationwide is of particular importance at this time given recent research findings and trends. This study sheds light on a new finding in URM student engineering attrition given the increased frequency that students change majors yet persist at the university. It contributes findings to ideally mend a disjuncture in the URM and female engineering pipeline that is primarily happening at the undergraduate level and further exacerbating disparities in graduate engineering programs and in the workforce. As the nation's demographics become increasingly diverse, it is important that graduates of engineering schools mirror that diversity. This study focused specifically on the persistent disjuncture in the pipeline that has been occurring in undergraduate engineering education.

The findings from this study will be utilized to influence programmatic efforts on the micro-level at the WPU School of Engineering, as well as contribute data to the broader scholarship of engineering retention. Additionally, this study may be of interest to national organizations, including the National Action Council for Minorities in Engineering (NACME), the American Society of Engineering Education (ASEE), and the Society of Women Engineers (SWE), who are also seeking answers to the same questions. At the WPU School of Engineering, discussions and strategies for retention efforts are repeatedly an agenda item during the annual Dean's Retreat, providing an opportunity for the research findings from this study to be presented and translated into program and policy recommendations. At the national level, there is an opportunity to present the qualitative data collected through this study as a complement to studies that analyze broad, nationally representative samples to examine the predictors of persistence in STEM (e.g., Hurtado et al., 2012). This research inserts a student and faculty voice in describing the experiences and perceptions of female URM students' who leave engineering and provides comparison data for URM women who have persisted in engineering as well as students from other groups who have opted to leave the field.

CHAPTER TWO

Literature Review

Researchers have studied the reasons for attrition of underrepresented minority (URM) and female STEM students for decades; however, there is a need to explore the challenges in the retention of female URM engineering students in particular as this population's share of engineering degrees conferred is a fraction of other groups. More recently, studies have highlighted trends of URM students entering into STEM majors overall at higher percentages, almost equal to students in the majority, yet disparities in retention remain. Notably, many studies aggregate all STEM disciplines together; however, data from the National Science Foundation shows differences in the proportions of female and URM graduation rates across majors, with engineering being one of the lowest for both URM students and women (NSF, 2011). The scholarship on engineering retention has also primarily concentrated on either URM students or female students separately furthering the call for more targeted research to understand student experiences more deeply.

To begin to understand female URM students' collegiate experiences, it is important to review college retention theories on a macro-level. The following review examines theories of college student retention that will serve as the foundation for this research study. Research has identified many factors that impact student retention. Some of the factors explored in this chapter relate to social cognitive influences acknowledging that external environments often have an impact on students' decision-making. Utilizing Social Cognitive Career Theory as a framework, researchers have investigated variables such as perceived barriers and supports, perceptions of climate, and outcome expectations to determine that the experience of students underrepresented in engineering vary significantly from White and Asian American males who represent the

majority. Following this discussion, I will delve into research focused on retention in STEM more specifically leading into studies exploring the retention of female and URM students in the disciplines. Coupling the facts that the breadth of disaggregated research in engineering retention explicitly is limited and research consistently highlights the varied rates of URM and female participation and completion in each of the STEM disciplines, a closer look at engineering retention studies is warranted. Similarly, a gap in research exists in study populations that couple gender and race together. As such, a review of studies that examine URM populations and female populations separately will provide a more comprehensive picture of female URM student experiences.

College Student Retention Theories

The collegiate success of historically underrepresented students has been the subject of countless research for decades. With less than half of all Black and Latino students completing their undergraduate degree within six years (NCES, 2010), the challenge remains to identify and design systems of support that will guide these students through the college process.

Additionally, while women earned approximately 57% of college degrees in 2010 (NCES, 2012), representation differs substantially when factoring in race and major (NSF, 2008). As such, the language used to describe these retention issues, as well as the theoretical frameworks and the suggested strategies to counter the issues, have been strongly debated among researchers in the field. Tinto's (1975) Integrationist Theory explores the necessity for students to fully integrate into the college environment in order to remain at the institution and succeed.

Alternatively, Tierney (1992), in what has been deemed Multiculturalist Theory, examines the need for the college environment to adapt to the diverse needs of the ever-changing student demographic. In the following paragraphs, I review the social integrationist perspective of

students' successful educational attainment grounded in the work of Tinto (1975) and will compare it to the multiculturalists' approach (Maldonado, Rhoads, & Buenavista, 2005) stemming from the research of Tierney (1992). While the following studies focus on the general college retention of underrepresented students overall, there are implications for understanding the experience of gender and racial minority students matriculating into top engineering schools that will be further discussed later in this chapter.

The social integrationist vs. the multiculturalist perspective. Tinto (1975) presumed that a “lack of integration into the social system of the college [would] lead to low commitment to that social system and [would] increase the probability that individuals [would] decide to leave college” (p. 92). He expanded this presumption by highlighting the distinction between social and academic integration and that students may successfully integrate in one realm, yet struggle in the other, potentially resulting in voluntary or forced withdrawal. Students' own aspirations and expectations of their educational attainment play a significant role in the likelihood that they will complete their degree. Tinto's “model argues that it is the individual's integration into the academic and social systems of the college that most directly relates to his continuance in that college” (p. 96).

Other researchers have revised Tinto's theory of social integration, only choosing to agree with certain aspects and adding depth to others. Berger and Braxton (1998) agree on the logical consistency of some of Tinto's propositions, however, they, along with others (Bean, 1980; Braxton & Brier, 1989; Kamens, 1971), emphasized the organizational attributes of a college that affect students' social integration into the environment, an element into which Tinto did not initially delve.

Nonetheless, the importance of a student's ability to integrate into the college environment remains prominent in the research. According to Astin (1984), students' level of involvement in the college academic and social environment directly affects their level of learning and personal development. The role of social networking is closely reviewed in the work of Thomas (2000). He expands upon the positive impact of student connectedness on educational attainment to include the importance of peer connections in understanding student success. The larger the network a student has on campus, the more likely they are to persist at that university (2000). That leaves the question, however, of whether students from backgrounds underrepresented on campus, and more specifically in engineering, have the same level of ease in developing these networks than do their counterparts in the majority. What has been identified as the multicultural view of student educational attainment (Maldonado et al., 2005) may present a response to this question.

While social integrationists place much of the emphasis of educational attainment on the individual, multiculturalists focus closely on the role of the institution as the crux of the issue (Maldonado et al., 2005; Tierney, 1992). Tierney (1992) adopts a "cultural perspective informed by critical theory" by directly addressing the potential negative implications of Tinto's social integrationist theory on racial and ethnic minorities in particular (1992, p. 603). Tierney responds to Tinto's assumption that students need to integrate into the college environment in order to succeed, equating the social integration model with a process of assimilation (1992). If an institution adopts a multicultural perspective to promote educational attainment among its underrepresented students, then it is assumed that "students of color [would be] more likely to develop a sense of connection, because the institution [would reflect] comparable values, norms, and beliefs" rather than "expecting diverse students to fall into line with White, Eurocentric

norms” (Maldonado et al., 2005, p. 608). This model can also be applied to engineering schools and their ability to be inclusive of women and URM students who are largely underrepresented in the field.

Others echo Tierney’s perspective. As the profiles of college students’ change, increasingly representing diverse backgrounds, the need for colleges to adapt to its student population is paramount (Rendon, 1994). Bensimon (1995) emphasizes that “administrative leaders must relinquish the concept of the university as having a set of shared attitudes, values, goals, and practices and accept the fact that the university is composed of multiple communities with diverse attitudes, values, goals, and practices” (Bensimon, 1995, p. 607). Higher education is in need of theories based on “difference” rather than “sameness” (p. 608), and the work needs to occur structurally. Rendon (1994) concludes a similar perspective in that the diversity, and, more importantly, the embrace of that diversity, is a tremendous strength for colleges given the changing racial, ethnic, gender, and socio-economic make up of college-going students. Other researchers have taken note of other limitations of the integrationist perspective, remarking on the level of assimilation that Tinto’s theory would require of students. Some theorists highlight that the early stages of retention research was primarily conducted by White researchers and at a time when minority students were not a critical mass on campus, thus questioning the applicability to students of color (Hurtado & Carter, 1997; Rendon, Jalomo, & Nora, 2000).

Tinto’s later research ultimately began to incorporate principles from the multiculturalist perspective, although not explicitly identified as such. In a 1997 study of a *Coordinated Studies Program* at Seattle Central Community College, Tinto emphasized the role of the classroom as the primary location for social and academic integration, arguing in support of learning communities and collaborative strategies (Tinto, 1997). Students participating in this learning

environment reported feeling more academically and socially connected to the college, felt comfortable in sharing their diverse experiences, and “gained a voice in the construction of knowledge” (Tinto, 1997, p. 611). For such a learning community to be developed, it requires an institution and faculty that acknowledge and utilize the diverse backgrounds of its student population. The effort of the *Coordinated Studies Program* couples student validation research (Rendon, 1994; Terenzini et al., 1994) with students’ active engagement in the classroom (Astin, 1984) and ownership of the education process (Maldonado et al., 2005).

Rendon (1994) argued that institutions must validate the importance of interpersonal situations and a culture that promotes healthy relationships and cultural pride among students, staff, and faculty. If universities provide opportunities for students to become comfortable in thinking critically and embracing their culture on campus, it will promote their educational success (Maldonado et al, 2005). It is important that all students have a voice on campus, but “having a voice without being heard is often worse than having no voice at all” (Tinto, 1997, p. 616). Multiculturalist theory suggests that universities must provide the space for these diverse voices to be heard.

The underrepresented college student experience. Numerous studies have attempted to capture informative data on the unique experience of underrepresented students in college with the assumption that these experiences differ from their counterparts in the majority and have a differential affect on URMs’ educational attainment. In an effort to gain insight on potential reasons for attrition, researchers have commonly relied on qualitative data to paint a picture of the numerous special circumstances these students are likely to face in their quest for a college degree.

Underrepresented students are concerned about the increased academic rigor of college as compared to high school and in fact defer involvement in extracurricular activities and social aspects of campus life in order to ensure academic success (Terenzini, et al, 1994). However, a pivotal component of these students' successful transition into college is becoming involved in the social network on campus in order to build connections with resources otherwise not obtained (Maldonado, et al, 2005).

In an effort to thwart the alienation and intimidation underrepresented students may feel on predominantly White campuses (Rendon, 1994), students must understand and know how to navigate through the dominant culture at their university (Maldonado et al., 2005). Building cultural capital is key to successfully moving through the college experience and larger social environments (Maldonado et al., 2005) and echoes the research findings of Tinto's Integrationist Theory. In their study conducted on Student-Initiated Retention Programs (SIRPs) at UC Berkeley and the University of Wisconsin--Madison, Maldonado, Rhoads, and Buenavista (2005) looked closely at the experience of student leaders involved with these programs and the potential connection to effects on student retention. Through interviews with 45 SIRD student leaders, researchers found that, while maintaining an understanding of the dominant culture on campus is important, students must remain strongly connected to their own cultures and to others from similar backgrounds on campus to solidify a support structure on predominantly White campuses (2005). SIRPs provide students with a voice in an environment where they otherwise might not have felt comfortable. This is similar to Rendon's (1994) findings that these students need to feel like they belong in order to promote their success. Though gender was not a variable in Rendon's study, it becomes increasingly important when considering female students' ability to thrive in the largely male-centered field of engineering.

Alternately, aligning more closely with the Multiculturalist perspective, Terenzini (1994) and Rendon (1994) found that a critical component of a student's successful transition into college is the validation of academic and/or social belonging as a method of encouraging these students to become involved with campus life. Involvement in institutional life is an indicator of a student's integration into the campus environment. Early validation from faculty has been found to have a positive effect on students' success, primarily in that crucial first year (Rendon, 1994). In a study targeting URM college students participating in a faculty mentoring program, Campbell & Campbell (1997) found that mentored students achieved higher GPAs and persisted at higher rates than those that did not participate in the program. Thus, Rendon (1994) and Terenzini (1994) place the emphasis on environmental factors to support the students, highlighting that faculty should take an active role in supporting and validating the students and promoting a multicultural. Broad research on college retention, including studies that focus on the experiences of URM students, informs the work of scholars focusing specifically on retention of students in STEM.

Social Cognitive Factors Affecting STEM Retention

To understand students' trajectory in their commitment to their engineering studies, researchers have explored potential social cognitive factors and student perceptions most commonly framed through Social Cognitive Career Theory (Lent et al., 1994). "Social cognitive career theory is concerned with the interplay between a variety of person, environmental, and behavioral variables that are assumed to give rise to people's academic and career-related interests, choices, and performance outcomes" (Lent et al., 2005, p. 84). The studies that employed social cognitive theories acknowledge the existence of internal perceptions and external realities that may influence a student's decision to persist in or leave engineering. They

examine variables such as self-efficacy (or one's beliefs in their own abilities), perceived barriers and supports, outcome expectations, ethnic identity, other-group orientation, and perceptions of campus climate (Byars-Winston et al., 2010). For the purpose of this study, perceptions of climate, barriers, and supports and their influence on self-efficacy and outcome expectations have the most relevance and will be reviewed in the following sections.

Perceptions of campus climate can be defined as “the sum total of the daily campus experiences of students...pivotal to their perception of comfort that exists in the college environment” (Brown et al., 2005, p. 264). Many studies have found that students' perceptions of campus climate impact their commitment to an institution and, as a result, their academic persistence (Brown et al., 2005). As engineering schools can oftentimes be more male-dominated and less racially diverse than other schools at a university, perceptions of school climate could potentially vary for minority students in engineering than for those in more diverse disciplines at the institution. Direct relationships between self-efficacy and outcome expectations have been found as they relate to STEM goals, and this relationship is stronger for those who perceive favorable conditions in their environments (Byars-Winston et al., 2010; Lent et al., 2003). In their study of 487 students across 3 college campuses, Lent et al. (2005) found that students at HBCUs reported more favorable perceptions of their college experience and had higher grades. Additionally, higher graduation rates were associated with students' lower perceptions of racism and discrimination as well as with students' greater institutional commitment (Lent et al., 2005). Thus, student perceptions of campus climate can play an integral role in their college experiences and educational choices.

Similar to perceptions of climate, environmental barriers and supports, whether perceived or actual, have an impact on students' belief of their own success (Lent et al., 2003). Researchers

highlight the need to better understand the role of environmental supports and barriers on engineering persistence (Lent et al., 2005); thus, taking a closer look at the climates that students perceive, both on campus and in the classroom, is an important piece to determining the challenges of retaining minority students in engineering.

The limitation of the SCCT research conducted thus far is that studies are done early on in the student's college career, potentially missing important insight only available through student reflection of longer-term experiences after having completed a year or more of coursework and either deciding to remain in the major or to transfer to another major. Additionally, SCCT research is quantitative by design yet poses a potential opportunity for thorough, qualitative research to supplement data on the aforementioned variables with expanded beliefs and perceptions from students (Trenor, Yu, Waight, Zerda, & Sha, 2008). For example, Byars-Winston et al. (2010) conducted a study grounded in SCCT with 223 engineering and biology URM students and found a direct relationship between academic self-efficacy, outcome expectations, and students' goals and expectations using a multivariate analysis. However, what is left unanswered in this quantitative model is why that relationship exists and how students interpret their experiences to be able to directly inform practice. Lent et al. (2005) highlight that there is "a need to better understand the role of environmental supports and barriers relative to choice and persistence in science and engineering majors" (p. 85), and a qualitative research design can begin to describe just that. By extending existing SCCT research, this study followed a deliberate approach into qualitative methods to add students' voices to the statistics of quantitative research.

STEM Retention Studies

STEM retention research echoes many of the discoveries that general college retention studies have exposed and has been under a microscope due to federal agendas pushing for more participation in STEM in an increasingly competitive global economy. However, challenges persist in retaining a diverse pool of talented and committed students in STEM disciplines, and racial and gender minorities encounter added obstacles in their pathways toward success. The following review outlines the important components that either promote or hinder STEM students' successful completion of their degree, highlighting the unique experiences of minority students.

While college retention studies confirm that students are more likely to leave or change majors in the first two years (Tinto, 1993), students in STEM are even more likely to change majors than other students within this timeframe (Chang, Cerna, Han, & Sàenz, 2008; Chang, Eagan, Lin, & Hurtado, 2011; Gainen, 1995; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Reichert & Absher, 1997). One factor that researchers have found to have a negative impact on STEM retention within this first two years are courses that serve as gatekeepers to weed out many and retain only the top few (Gainen, 1995; Gasiewski et al., 2012; Maton et al., 2000). These courses are typically very large and primarily didactic, which create a distanced student-faculty and student-material relationships, disengaging STEM students originally committed to the field. When STEM students were enrolled on campuses where STEM faculty more readily incorporated student-centered pedagogy into their courses, their likelihood to persist in STEM increased (Hurtado et al., 2012). Similar to Tinto's (1997) work on learning communities, Gasiewski et al. (2012) found that students who reported having the opportunity to

collaborate with peers in class were more engaged in the course and connected academically to the discipline.

Additionally, students' perceptions of the quality of math and engineering instruction overall has been found to be a predictor of STEM retention as well (Espinosa, 2011; Hilton, Hsia, Cheng, & Miller, 1995) which can be connected faculty accessibility, approachability, and pedagogical style. In Seymour and Hewitt (1997), poor teaching by STEM faculty was cited as one of the top concerns for STEM students that ultimately changed majors. As students begin their transition into higher education and more specifically into the engineering major at a large research institution, the instructional design of large lecture style teaching is not conducive to the supportive, student-centered method of instruction that research has shown to have a positive impact on retention. They also are not conducive to scientific reasoning (Handelsman et al., 2004), which could have very well been the draw that students had to pursue a STEM degree. Students at times experience curriculum overload, are unaccustomed to the fast-paced teaching, and report having difficulty getting help from professors or TAs (Seymour & Hewitt, 1997). Thus, students are met with the challenge of remaining committed to an academically rigorous discipline with what could be considered less support from the academic environment.

Beyond the classroom, institutional factors have been found to play an important role in STEM retention among all students, but female and URM students in particular. Factors such as targeted recruitment and retention efforts aimed at female and URM students via support centers have been found to be some of the best predictors of retention in STEM (Hilton et al., 1995). Students' perceptions of campus climate have also been found to influence students' satisfaction with their college experience, affecting their likelihood to remain in STEM. Studies report that African American students at Historically Black Colleges and Universities (HBCU) largely

viewed their college experience as positive while those surveyed at predominantly White institutions were much more likely to report negative experiences (Brown et al., 2005; Fleming, Garcia, & Morning, 1995). The more students indicate favorable institutional climate conditions, the more committed they are to the institution, resulting in their retention (Fleming et al., 1995). As schools of engineering can oftentimes be considered unique academic environments within their parent institutions due to their very technical, highly specialized, and sometimes less diverse qualities, it is possible to consider an engineering school as an institution in itself containing unique factors that may promote or deter retention.

While students encounter a number of deterrents to persistence in STEM, many factors promote their retention in the field. Reaffirming the research of on the positive impact of faculty (Astin, 1984; Rendon, 1994; Terenzini et al., 1994), STEM retention researchers have also more recently highlighted the positive role faculty can play on student persistence (Cole & Espinoza, 2008; Gasiewski et al., 2012; Herrera & Hurtado, 2011; Kim & Sax, 2011; Maton et al., 2000; Perna et al., 2009). When a faculty member exhibits genuine concern for student learning and creates a comfortable environment in the classroom for students to actively participate, students are more engaged and consequently become more committed to the material and field (Gasiewski et al., 2012). Professors have a large impact on the climate of a classroom and can significantly influence a student's experience to remain with the major or to leave.

Additionally, students who participated in some form of faculty-sponsored research reported an increased commitment to and understanding of the discipline (Eagan et al., 2013; Seymour, Hunter, Laursen, & DeAntoni, 2004). Maton et al. (2000) interviewed African American science and engineering students and their faculty mentors in the Meyerhoff Scholars Program at Johns Hopkins University to exhibit the impact of faculty on URM students.

“Contact with faculty outside the classroom, and the development of mentoring relationships, including with minority faculty, can decrease academic isolation, and contribute to positive outcomes” (Maton et al., 2000, p. 631). Meyerhoff Scholars highlighted how fortunate they were to have direct access to faculty and the increased level of comfort they experienced in asking questions and seeking support of these faculty members. Of the many individuals on a college campus whose roles are to support college student development and retention, faculty appear to have the greatest impact on students. Students interact with faculty most often during their college experience, whether directly through face-to-face or email conversations, or indirectly through grading policies, syllabi, and classroom attendance. As such, research indicating the substantial impact faculty can have on students’ experiences and potentially their ultimate retention becomes logical.

Students’ interactions with their peers and with their academics have also been found to have an impact on their retention in STEM fields. Similar to the work of researchers who have found the positive impact of building peer relationships in college (Rendon, 1994; Terenzini et al., 1994; Thomas, 2000), increased student interactions and the building of peer networks have been found to also have a positive effect on STEM retention (French, Immekus, & Oakes, 2003; Hurtado et al., 2007; Perna et al., 2009; Seymour & Hewitt, 1997). Students that actively engage with their academic environments through supplemental instructions and/or tutoring also describe a greater level of commitment to their STEM pursuits (Gasiewski et al., 2012; Good, Halpin, & Halpin, 2002; Herrera & Hurtado, 2011; Perna et al., 2009). Positive academic climates presumably foster students’ motivation to build peer relationships and engage with their academic disciplines. As researchers have discovered the connection between motivation and higher GPAs (French et al., 2003), as well as higher levels of academic engagement (Gasiewski

et al., 2012), the link between retention and positive peer and academic interactions becomes clearer. Research suggests that a student's collegiate environment plays a role in their academic decision-making. As such, the engineering school environment and the student experiences it promotes or inhibits may be key in a student's decision to stay or to leave the major.

The Need to Disaggregate Engineering out of STEM

A primary limitation of prior STEM research is the commonly aggregated reporting of the data (Newman, 2011). Research in this area largely investigates retention issues in science, technology, engineering, and math collectively, while data show that retention across these disciplines varies substantially, particularly for women and URM students (NSF, 2011). Disaggregating STEM and analyzing data for engineering students separately can more accurately represent the severity of the retention problem in the discipline, as majors with strong retention percentages such as biological sciences cannot inflate the data. It is difficult to gauge the potential uniqueness of engineering students' experiences as they travel through the pipeline when their data are infused with data from others disciplines. Research is not finding that students leave engineering due to academic reasons as has previously been assumed (Borrego, Padilla, Zhang, Ohland, & Anderson, 2005; Seymour & Hewitt, 1997). In fact, Seymour & Hewitt (2000) found that, rather than academics, students left due to perceptions of environment and success. Though fewer research studies disaggregate engineering out of STEM, those that do offer discipline-specific data provide insight to the distinctive experiences of undergraduate engineers yet begs the opportunity for further research into engineering retention specifically. The following discussion of racial and gender minority retention inserts engineering-disaggregated research when available amidst the more common approach of combining all STEM disciplines for these populations.

URM Retention

To approach an understanding of the under-researched female URM students' experience in STEM, and more specifically engineering, a review of the more comprehensive bodies of research that explore the retention URM and women separately serves as an initial step. As previously discussed, research has shown that URM students' reduced likelihood of being retained in STEM is often affected by factors that differ from or that do not affect White and Asian American STEM students in similar ways. URM students are less likely than their White and Asian American counterparts to maintain their STEM interests through to graduation (Herrera & Hurtado, 2011).

One particularly salient factor that adversely affects retention in STEM for URM students is negative racial climates. Students who reported having experienced negative racial climates at their institutions were more likely to leave (Chang et al., 2011). This was even the case for students who were highly domain-identified. In other words, many students who initially indicated a strong commitment to their STEM major yet also reported a high level of negative racial experiences ultimately left. However, when little or no negative racial experiences were reported and the student was highly domain-identified, students had significantly higher probabilities of persisting in a science major (Chang et al., 2011). Students' perceptions of racial climates can be real or perceived and may also be influenced by their prior exposure to similar environments (Chang et al., 2011; Fleming et al., 1995).

While hostile racial climates can obstruct URM students' academic success in STEM, they can also have negative effects on all students' sense of belonging at an institution (Hurtado, Newman, Tran, & Chang, 2010), which connects to the work of Rendon (1994) and Terenzini, et. al. (1994) that emphasized the connection between sense of belonging and student retention.

A longitudinal study following 6,290 high-ability URM students found that the best predictors of persistence, or lack thereof, included factors in the students' college environment (Hilton et al., 1995). For example, involvement in co-curricular activities including pre-professional organizations and major-related clubs increases a student's likelihood of retention (Chang et al., 2011; Good et al., 2002). Building a network of social and academic resources is thus pivotal in securing a URM student's persistence in the major and it likely is only possible in positive racial climates.

In an effort to combat URM student attrition, many engineering programs have created support programs for these students. Studies have shown the positive impact of such support programs on the URM retention (Good et al., 2002; Seymour & Hewitt, 1997). In their study of STEM students' reasons for persisting or leaving the disciplines, Seymour and Hewitt (1997) found that all URM students who persisted identified a support program as a key to their decision to remain in the major. In a longitudinal study of students who participated in a URM engineering support program as compared to those who did not, over 75% of program participants remained in engineering while less than half of nonparticipants persisted (Good et al., 2002). Participants of these programs were also more likely to seek out and utilize additional academic support programs at their institutions (Good et al., 2002), which connects with later work linking engagement with academic resources to students' commitment to the major (Gasiewski et al., 2012).

These findings are echoed in the mixed methods study of the Meyerhoff Scholars Program, a support program dedicated to increasing the number of URM student in science and engineering at the University of Maryland, Baltimore County (Maton et al., 2000). Through semi-structured interviews, Maton et al. (2000) explored the role the Meyerhoff Program played

on the success of its participants. Students attributed the recognition and support from faculty as important factors in their commitment and success to the discipline.(Maton et al., 2000).

While faculty can play a positive role in URM students' success, as in the Meyerhoff Program, they can also serve as a deterrent for students as they pursue their academic and career goals (Newman, 2011). In his qualitative study of 12 African American engineering students, Newman (2011) found that students could feel encouraged or deterred from based on their interactions with faculty. Students in this study also noted the lack of same-race faculty that they could look to as mentors (Newman, 2011). The impact faculty have on URM engineering retention is evident. What is important to distinguish is whether or not that impact is positive.

Additionally, URM students who report studying with peers in their major are 9.66 percentage points more likely to remain in the major (Herrera & Hurtado, 2011). Participation in a learning community, receiving advice from upper-division students and even cross-cultural interactions all have been found to positively impact African-American students in particular to engage in science research (Hurtado et al., 2007; Hurtado, Newman, et al., 2010), potentially increasing their level of commitment to their field. This experiential learning and application of science concepts solidifies URM students' active engagement with the discipline and has been found to have a significant impact on their academic and social adjustment in their college transition overall (Hurtado, Newman, et al., 2010).

African-American students' self-concept has also been found to have a positive effect on their level of engagement in the sciences (Hurtado et al., 2007), and there is an opportunity to research how factors in these students' academic environments influence the development of their academic self-concept. Seymour and Hewitt (1997) uncovered the potential detrimental impact that environment can have on URM students' academic self-concept and commitment to

STEM disciplines in particular. Their interviews with URM STEM students exposed the unique experience these students have in STEM, including the differences in ethnic cultural values and socialization, their internalization of stereotypes, and their ethnic isolation and perceptions of racism on campus (Seymour & Hewitt, 1997). Those who ultimately left STEM often moved to majors where they were less ethnically isolated (Seymour & Hewitt, 1997).

As evident in the research, multiple elements in URM students' interactions with their academic environment play a role in their STEM retention. Negative racial climates adversely affect a URM student's persistence in the major, while positive influences such as peer networks and support services promote their commitment.

Female Retention

As the gender minority in engineering, research has found that women, like URM students, have a unique experience in the discipline that differs from their counterparts in the majority. In a five-year longitudinal study with engineering students at nine institutions, Borrego et al. (2005) found that female engineering students attending private universities were more likely to switch out of engineering in pursuit of another major. Female students were found to leave engineering much sooner than their male counterparts and also left with higher GPAs, implying that other factors are potentially at play (Borrego et al., 2005). The most common major women elected after leaving engineering was largely business (24%), with biology, physics, and education following distantly (Borrego et al., 2005).

A female student's interaction with her engineering academic environment and curriculum has been found to differ substantially from her male counterparts, as self efficacy in science and math among female students is less evident than for male students (Leslie, McClure, & Oaxaca, 1998). In a study that followed a cohort of students through five semesters of

chemical engineering coursework, considerable differences emerged between men and women (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). Although women entered the chemical engineering major with academic preparation equal to or greater than the men, they experienced a gradual loss of confidence and commitment as they progressed through the coursework (Felder et al., 1995). Women were more motivated to study and reported more clarity on their understanding of the importance of school and attaining their academic goals, yet they were less likely to persist in the major. Of the men and women who failed one of the courses in the sequence, a higher percentage of women ultimately decided to transfer out, potentially highlighting their susceptibility in facing academic obstacles in a male-dominated environment (Felder et al., 1995). Nonetheless, women were more likely than men to transfer out of engineering in good academic standing while men who transferred out exhibited more academic challenges through poor grades and/or falling behind in course sequences (Felder et al., 1995). These findings underscore the existence of non-academic factors that impact a female engineering student's decision to transfer out of engineering.

Stereotype threat has been found to have an impact on women's interest in STEM. In an experiment on 68 undergraduate women Shapiro, Williams, and Hambarchyan (2013) found that women's STEM interest suffered when encountering a stereotype threat. However, when exposed to a female role model intervention, the impact of some elements of stereotype threat seemed to be buffered (Shapiro et al., 2013). As female engineering students have limited opportunities to interact with female engineering role models due to the scarcity in the field, such a buffer against stereotype threat is unlikely. This controlled experiment on stereotype threat provides additional context to research that highlights the disparate experiences between male and female students in the engineering discipline. Female engineering students were found to

have more uncertainty in their background knowledge about engineering and lower confidence in their abilities to succeed in engineering than did male students, though male students were less confident in their study habits (Besterfield-Sacre, Moreno, Shuman, & Atman, 2001). Male students, on the other hand, reported feeling more closely aligned with the skills and qualities necessary for engineering, including being more technically- and mechanically-inclined, traits that most female respondents did not identify with (Besterfield-Sacre et al., 2001). In the post-test administered at the end of the first year, female students continued to question their abilities as engineers.

In their longitudinal study that followed five cohorts of chemical engineering students, Felder et al. (1995) found that female and male engineering students also differed in their attributions of success, with females citing hard work and help from others as their top reasons for being successful and male students identifying hard work and their own academic abilities as factors for success. Conversely, female students felt their lack of ability was a significant reason when they did not perform well academically, while men most often attributed “not working hard enough” as their reason for not attaining higher grades (Felder et al., 1995). These differences in attributions of success and failure expose the different experiences of men and women as they navigate through an undergraduate engineering experience.

Faculty have also been shown to have an impact on female students’ experience in STEM fields. In a study that surveyed 100 women about their perception of the undergraduate engineering climate, students indicated that supportive and approachable faculty was even more important than the amount of perceived support in the environment (Gallaher & Pearson, 2000). Seymour and Hewitt (1997) found that 80.3% of women in STEM reported dissatisfaction with faculty and those interviewed primarily attributed that dissatisfaction to the minimal support they

received from their professors. The researchers noted, however, that a “failure to encourage is taken as discouragement” for female STEM students who are often experiencing a disjuncture between the supportive and encouraging high school environment and their new collegiate STEM environment (Seymour & Hewitt, 1997). Furthering the research on the impact faculty have on women in STEM, Espinosa (2011) found that women of color left STEM majors partly due to faculty insufficiently connecting course content to students’ goals.

Disparities in the retention of men and women in engineering become exacerbated by the final years of college. Even for women that remain in engineering through to their degree, a disjuncture emerges in their disinterest in pursuing graduate coursework. Felder et al. (1995) found that, toward the end of their fourth year, 54% of male students expressed intentions of continuing on to graduate school compared to only 18% of women, and this disparity helps to explain the very poor representation of women in engineering Ph.D. programs and among the engineering faculty (NSF, 2011). It is possible that at this juncture, female students’ lower level of confidence and their perceived lack of ability eventually influences them to forego graduate education in the field.

Female URM Retention

There is limited scholarship that explores the unique experiences of female URM students in engineering. Collectively reviewing the separate bodies of research on URM and female engineering students potentially supplies relevant data for female URM engineer retention. There exist, however, a handful of studies that explore female URM engineering students specifically, solidifying the existence of disparities between female URM engineers and White and Asian American male engineers. Bonous-Hammarth (2000) discovered that of the 330 students who began their college career as a STEM major, African American, Latina, and

American Indian female students exhibited the largest decline in attrition, with 63% ultimately deciding to leave STEM, making an already small population even smaller.

Researchers who study the experiences of female URM students in STEM acknowledge that this population is often living a different STEM reality than their counterparts in the majority (Carlone & Johnson, 2007; Espinosa, 2011; Johnson, 2007; Leslie et al., 1998). While 43% of White men perceive their science and math ability better than most, only 16% of African American women and 17% of Latina women hold a similar perception of their abilities (Leslie et al., 1998). In her qualitative study of 16 female URM students in science, Johnson (2007) dug deeper into these students experiences and found that decontextualizing science and approaching the teaching of science without making connections to the students in the room or people overall ultimately was very discouraging to the study participants, many of whom were entering science for social reasons. Additionally, the absence of discussions around race, ethnicity, and gender was also something that these students noted (Johnson, 2007), implying the lack of a multiculturalist perspective in this field and exhibiting that it is in fact having an impact on student perceptions of the discipline.

In a case study at an HBCU, Perna et al. (2009) found that many of the influential factors that impact all students' retention (i.e. peer networks, faculty involvement, and a positive campus climate) were the same factors that influenced African American women to persist in STEM (Perna et al., 2009). African American women have been found to have lower self-efficacy than African American men, further highlighting that gender differences exist among racial minorities in STEM (Gainor & Lent, 1998). Espinosa (2011) closely explored the factors that affect female URM STEM retention and discovered that many factors resided in the college environment including increased interactions with academic peer groups. Similarly, the more this population

engages with co-curricular opportunities in STEM, the more likely they are to remain committed to the discipline (Espinosa, 2011). Johnson (2007) found that large class sizes made connecting with the professor very difficult for female URM students and the didactic lecture style even more distant. Even professors' approach to opening up the floor for questions was abrupt, and none of the participants in the study were observed to take that professor up on the offer (Johnson, 2007).

Researchers have also discovered the impact that same-gender and same-race mentorship has on female and URM students in particular (Blake-Beard, Bayne, Crosby, & Muller, 2011; Maton et al., 2000). With the instructional design of many introductory courses being somewhat detached from the student and those courses often being taught by faculty in the gender and racial majority in the field, it would appear almost impossible for female URM to obtain that needed mentorship. It is important to highlight that, while informative, many of these studies do not disaggregate their findings by STEM major, once again calling upon the need to explore the unique experiences of female URM in engineering specifically.

Conclusion

As evidenced by the research, multiple factors in students' collegiate environments play a part in their perceptions, satisfaction, and sometimes their decision-making when it comes to their academic pursuits. Students' ability to build a network of peer, staff, and faculty supports in a positive and comfortable climate promotes their ability to succeed. However, the ease in which a student can achieve this differs greatly among student populations and disciplines. In the White and Asian American male-centered engineering majors, the synthesis of research suggests that female URM students likely have a much more difficult time navigating in and benefitting from the academic environment. With a lack of faculty from similar backgrounds to serve as mentors

in the field and few peers that share the same racial and gender identities, successful retention of female URM engineers requires deliberate and thorough research to give voice to the unique experiences of this population.

CHAPTER THREE

Research Design

Introduction

The goal of this study was to explore the perceptions of female underrepresented racial minority (URM) engineering students about school and classroom climate and the impact these factors had on their decision to persist or to leave engineering. While percentages of female and URM students entering into science, technology, engineering, and math (STEM) are increasing compared to prior decades, completion rates still remain considerably lower than White and Asian American males (Hurtado, Newman, et al., 2010). This research project explored this issue by disaggregating engineering from STEM because data from the National Science Foundation show significant differences in participation and completion rates of URM women among the different STEM disciplines with engineering being the lowest at 3.1% of degrees earned among this population (NSF, 2008). Additionally, the majority of research studies on the retention of underrepresented engineering student populations do not explore women and URM students separately. This study aims to contribute to the knowledge of potential causes of attrition for this population specifically. This was explored through the following four research questions:

1. According to female URM students, what are the social cognitive factors, including perceived barriers and supports, other-group orientation, and perceptions of climate, that influence female URM students' decision to change majors out of engineering? How do these perceptions compare to those of male and non-URM female students?
2. How do female URM students who leave engineering describe the academic environments of both engineering and their second-elected majors as compared to female URM students persisting in engineering?

- How do URM women who left engineering describe the academic environment within engineering? Do they describe the environment within their second major differently?
 - Are there differences between URM women who stayed in engineering and those who switched in how they perceived the engineering academic environment?
3. How do the perceptions of the engineering academic environment differ for female URM students who have changed majors compared to other groups of students who have also changed majors out of engineering?
 4. What factors do engineering faculty believe to be the most salient in affecting female URM students' decision to persist or to leave engineering for other majors?

In this chapter, I discuss my research design and justification for utilizing qualitative research methods to explore the experiences of female URM students who matriculated into a top-tier engineering school and have either remained in the discipline or have elected to change majors. I describe the reasoning behind utilizing an interview-based data collection method to explore the perceptions of the target population and others in their academic environment and explain the data analysis methods to derive a body of rich data. I conclude this chapter with a candid discussion of potential threats to credibility and limitations that were countered through elements of my research design and strategies of inquiry.

Research Design

This research design aimed to fill gaps in the research for this population and this problem. This qualitative study was grounded in portions of Social Cognitive Career Theory (SCCT), analyzing social cognitive and environmental factors that may influence female URM engineering students to change majors. Factors include perceived barriers and supports,

perceptions of climate, other-group orientation, and outcome expectations. Additionally, I explored elements stemming from prior research on factors that influence female and URM engineering attrition such as the impact of faculty interactions and students' sense of belonging in the engineering environment.

Currently, research using SCCT and STEM adopts a quantitative approach to determining social cognitive factors that may cause students to leave engineering. While researchers of engineering education have primarily preferred quantitative approaches, there is a push in the field to diversify the methods of these studies with qualitative research as there is limited qualitative data that explores student perceptions more deeply (Borrego, Douglas, & Amelink, 2009). This study adds students' voices to the statistics. Quantitative research cannot explain *why* students leave engineering. This study sheds light on the perceptions of female URM students who have experienced the undergraduate engineering environment. STEM retention research must deepen the understanding of the intricacies that cause the underrepresentation of certain groups in the discipline (Lewis, 2003). Grounding this study in SCCT provided a frame for understanding underrepresented students' interactions with their educational environments and aims to deepen the knowledge of STEM retention with theory-driven work.

Female URM students who enter as engineers were interviewed to explore the aforementioned SCCT factors where quantitative data fall short. In-depth interviews function as a method to understand the experiences of others and the meaning-making they attribute to those experiences (Seidman, 2006). This population included both current engineering students as well as former engineering students who have since elected to pursue another major at the same university. As a point of comparison, male students and non-URM female students were also

interviewed using the same protocol. To expand on student perceptions of their academic environments, the interview protocol explored other elements including:

- Classroom climate
- Participation (or lack thereof) in co-curricular opportunities
- Faculty interaction
- Peer interaction
- Academic self-concept, defined as one's perceptions of one's own academic ability (Bong & Skaalvik, 2003)

As a complement to students' perceptions, engineering faculty were interviewed on their perceptions of female URM engineering student attrition, as well as how they viewed their role in these students' retention. The qualitative method that this study used is a series of interviews with students and faculty. Given the nature of the research questions in looking to gather participant perceptions and their description of an aggregate of experiences, semi-structured, person-to-person interviews were the most appropriate approach. Semi-structured interviews account for respondents' unique interpretation of the world around them, thus allowing me, as the researcher, to explore emerging themes and respond to opportunities for richer data (Merriam, 2009). This maintained the structure of a consistent and deliberate protocol to be able to identify themes in the data while also allowing for flexibility to explore emerging perceptions and prevalent responses for added depth to the research.

Study Population

In order to collect data on student perceptions of their academic environments and the potential impact of being a racial and gender minority in engineering, the following populations were a part of this study:

- Female underrepresented minority students who matriculated into an engineering major and completed at least one semester of engineering coursework, but were currently enrolled at the university in another major
 - The reflections of this population were central to the purpose of this study. This population provided insight on the reasons for their attrition.
- Female underrepresented minority students who matriculated into and were persisting in engineering and completed at least one semester of engineering coursework
 - Exploring the perceptions, experiences, and beliefs of female URM students persisting in engineering provided a counterpoint in comparison to those that decided to leave.
- Male students and non-URM female students who matriculated into an engineering major and completed at least one semester of engineering coursework, but were currently enrolled at the university in another major
 - The perceptions and experiences of this population served as an opportunity for comparison analysis to identify where the female URM experience was unique and where it was similar most students.
- Engineering faculty members who teach lower-division undergraduate courses and have had female underrepresented minority students in their classes
 - As a core factor of academic environments, specifically in the classroom, faculty perceptions of female URM engineering student attrition served to supplement data and create potential connections between faculty perceptions and investment in the retention of these students and students' perceptions of their classroom environments and faculty interactions.

Target student populations were identified via university records. To align with federal standards, WPU follows the Integrated Postsecondary Education Data System (IPEDS) guidelines in recording students' race and ethnicity. The WPU School of Engineering considers students of African American, Hispanic, and Native American descent as historically underrepresented racial minorities (URM), including biracial students.

Data Collection Method

Interviews began in January 2014 and culminated in February 2014. There were 57 currently enrolled female URM students that began their academic careers in engineering and were either persisting or changed to another major. Thirteen students elected to pursue another major at the university, while 44 were persisting in engineering. The male population and non-URM female population were considerably larger, allowing for increased opportunity to identify interview participants. Concurrently to student interviews, faculty interviews took place. There were approximately 169 faculty members at The WPU School of Engineering available to participate in interviews.

Outreach and incentives varied by targeted population. Student email addresses were obtained via the university database and students beginning their sophomore, junior, and senior year were emailed once in January 2014 inviting them to participate in the interview. Participants were offered \$20 cash as compensation as well as entered into a raffle for a \$100 gift card to the university bookstore. There was no monetary incentive for faculty to participate in the study; however, email outreach included more background on the potential implications of the work, fostering a desire to impact research and practice as an incentive.

As students indicated their interest in participating in the study, their gender and URM status were noted to track the representation across different target groups. The interview sample

included the following: 1) five female URM students who changed majors, 2) seven female URM students who were persisting in engineering and 3) 12 male and/or non-URM female students who have changed majors. Within this third group, four were non-URM women, four were URM men, and four were non-URM men. Additionally, nine faculty members representing different academic departments within the engineering school were interviewed.

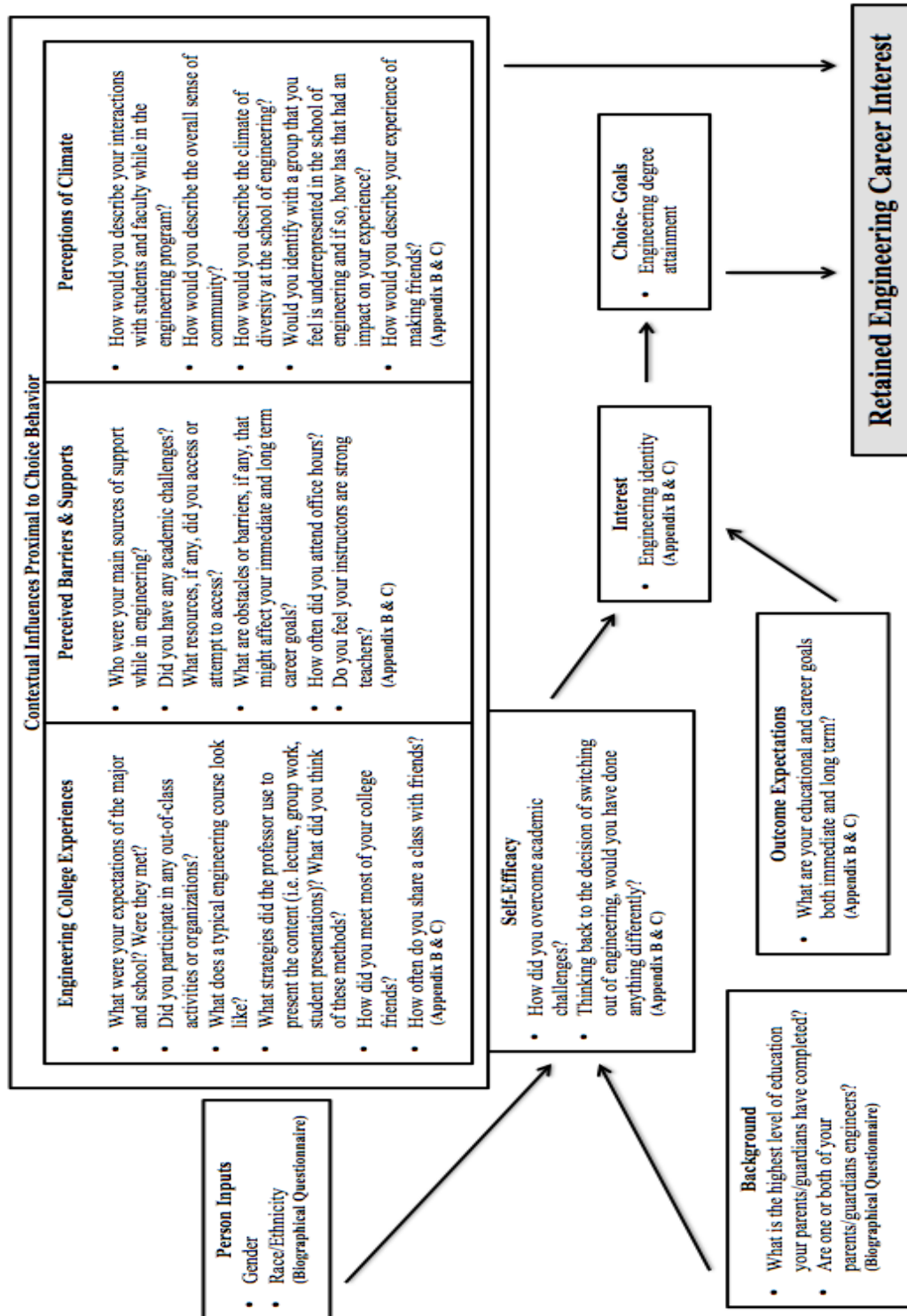
Interviews were up to one hour in length and took place in a small conference room in the WPU School of Engineering. Prior to the interview, all students were asked to complete a brief demographic and biographical questionnaire requesting relevant background information including their self-reported gender, race, and ethnicity (see Appendix A). The interview protocol varied slightly among each category of participant:

Students who changed majors. This interview protocol emphasized research questions #1 and #2 through students' descriptions and perceptions of both the engineering academic environment and the environment of their current major. This interview protocol was administered to both female URM students as well as those in other groups (see Appendix B).

Students persisting in engineering. This interview protocol mirrored the interview questions posed to students who changed majors, exploring descriptions and perceptions of the engineering academic environment. Utilizing the same interview questions here allowed for comparison of perceptions between students who persisted in engineering versus those that did not (see Appendix C).

Faculty. Faculty followed a slightly different interview protocol based on research question #3 (see Appendices D and E). Faculty were asked about their perceptions of why female URM students leave engineering and questioned on their perceived role in female URM student retention.

Figure 3-1 provides a study diagram connecting this study’s theoretical framework to the interview protocols



Adapted from: Herrera & Hurtado, (2011); Lent, Brown, & Hackett (1994)

Data Analysis Method

Interviews were recorded using an iPad, with an iPhone serving as a back-up recorder. During and immediately following all interviews, I took field notes of relevant observations to improve the data collection process. I transcribed 29 interviews, while an outside vendor transcribed 4, capturing the data soon after its collection to adequately manage the two-month interview window. Concurrent with the data collection process, participant responses were analyzed and organized into emergent themes. Appendix D provides a snapshot of the data matrix used in analysis. This continuous analysis of the data refined the data collection process and promoted the development of themes within and across respondent groups (Merriam, 2009). From this I began with open coding and an expansive list of potential themes before moving into an analytical coding process that required more categorization and interpretation of the data (Maxwell, 2012). Throughout this process, I employed a constant comparative method to identify similarities and differences among the study populations (Merriam, 2009). Conducting this level of analysis concurrently with data collection left room for themes to emerge and the analysis to influence subsequent processes (Merriam, 2009). I exercised the anonymity of the respondents, yet maintained their categorical label (i.e. student—changed major; student—engineering; faculty member), in order to be able to explore connections, or lack thereof, between participant categories. Once all data was collected, I underwent multiple iterations of developing and refining codes to finalize the coding structure and identify findings from the resulting themes (Gasiewski et al., 2012).

Special Site Considerations and Researcher Positionality

As a student affairs staff member at the WPU School of Engineering, I had increased access to the study populations, however there are special considerations that needed to be taken

into account as a result. Through my position, I was able to identify and contact students that left engineering as well as the female URM students that were persisting. My position at The WPU School of Engineering may have meant that I developed personal and professional relationships with some of the study participants. When considering student participants, this could have resulted in a positive impact on the study through an increased level of emotional access leading to true candidness in the interview responses. Additionally, as a female, underrepresented minority, I could potentially establish an additional layer of emotional access as someone with whom respondents may have been more comfortable sharing experiences. However, having developed a relationship with some respondents may have also increase the likelihood of reactivity. This potential limitation is addressed in the section below.

To further manage my role as a researcher, I did not conduct any interviews in my office to create a physical disconnect between the research study and my role at the school. Additionally, in all communication regarding the study, I connected myself with UCLA ELP, removing my signature in email communication; however, during interviews I acknowledged my position at the university.

As a staff member at the research site, there are some benefits to conducting this study at this location. I will be in a position to share findings from this study with key stakeholders on campus in positions that can institute programmatic and policy changes in response to my recommendations. I will be able to directly share the results of this work with faculty and student affairs staff at the school who can subsequently identify improvements to retention practices.

Credibility and Limitations

This study was susceptible to threats of bias, reactivity, a small sample size and a lack of generalizability as a result.

Bias. My own bias as the researcher existed as a result of professional experience working with female URM students in engineering, as well as working with students who are either the racial or gender minority in their educational environments. My bias assumed that there do exist factors in a minority student's educational environment that cause him or her to make certain decisions about their academic goals. As such, this study was conceived from this bias but was grounded in existing research that supports the assumption. In this study, interview data from female URM students who matriculated as engineers provided rich and thorough direct quotes from this population that supported and contradicted this bias. Additionally, qualitative data collected from students who can provide a comparison of their engineering academic environment as opposed to their second-elected major's academic environment provided detailed descriptions in place to support or contradict the aforementioned assumptions. While my bias as a researcher could have been considered a potential threat to credibility, the study's research design served as a reliable check to counter that threat.

Reactivity. Having previously worked with some of the participants in the study, a threat of reactivity may have existed. It was possible that students provided responses that they believed I might have wanted to hear. This threat was minimized by utilizing an interview protocol that encouraged participants to go into depth in their descriptions of their academic environments in a manner that promoted their comfort with the discussion. Participants were encouraged to be as forthcoming and honest about their experiences as they were comfortable, reminding participants that there was nothing in particular that the study is searching for aside from hearing about their experiences from their own voice.

Small Sample Size / Lack of Generalizability. As this was an in-depth qualitative study, the sample size of female URM engineering students at a top-tier university was limited.

While this can be viewed as a potential threat and there is not an opportunity to generalize the data, this study's purpose was to launch research that disaggregates engineering out of the more common STEM research; additionally, this study aimed to add depth into a largely understudied population of female URM engineering students who may have unique experiences in the field that warranted a closer look. By having a small sample size, this study was able to delve deeper into this population's academic experiences, potentially creating reader generalizability and influencing the research questions and design of future studies.

Conclusion

By conducting in-depth interviews with female URM engineers who are either still enrolled in an engineering major or have elected to pursue another degree, I was able to add depth to the existing quantitative research on STEM retention. This research provided the opportunity to give voice to a population that is often folded into larger groups, whether within all female students or all URM students in engineering, or within all STEM fields. Conducting this study at my institution also presented the opportunity to bring the findings of this research directly to the staff and faculty who can have an impact on programmatic and policy changes for the underrepresented populations at the school. In the following chapters, I will discuss findings that emerged from the conversations I have with these students as well as with faculty. From there, I will connect these findings to implications for further research and practice in the effort to retain more female URM students in engineering.

CHAPTER FOUR

Findings

Introduction

This study explored the academic experiences and environmental factors that influenced female URM students' decision to leave engineering in pursuit of another major at their university. Utilizing a qualitative interview methodology, 24 students and nine professors provided their perceptions of the engineering school environment. The data were organized into emergent themes through an open coding process. As themes emerged, I employed a constant comparative method to identify the similarities and differences between the study's populations. I explore these emergent themes in this chapter, addressing the following research questions:

1. According to female URM students, what are the social cognitive factors, including perceived barriers and supports, other-group orientation, and perceptions of climate, that influence female URM students' decision to change majors out of engineering? How do these perceptions compare to those of male and non-URM female students?
2. How do female URM students who leave engineering describe the academic environments of both engineering and their second-elected majors as compared to female URM students persisting in engineering?
 - How do URM women who left engineering describe the academic environment within engineering? Do they describe the environment within their second major differently?
 - Are there differences between URM women who stayed in engineering and those who switched in how they perceived the engineering academic environment?

3. How do the perceptions of the engineering academic environment differ for female URM students who have changed majors compared to other groups of students who have also changed majors out of engineering?
4. What factors do engineering faculty believe to be the most salient in affecting female URM students' decision to persist or to leave engineering for other majors?

This chapter begins with a summary of student and faculty participant demographic data. The paragraphs that follow discuss the engineering academic experience as described by female URM students who initially matriculated into an engineering major but have since elected to leave the discipline and pursue another degree. Female URM students' perceptions of and experiences in engineering are continuously compared to the perceptions of female URM persisters in engineering as well as the perceptions of other student populations who have left engineering, including males and non-URM females. I then present female URM students' perceptions of their second-elected major with emphasis on comparisons to how they described their engineering experience. Lastly, the chapter highlights undergraduate engineering professors' observations of factors that they believe may influence female URM students to ultimately leave engineering. This section also provides insight into professors' perceived role in student retention. To conclude, the chapter underscores the salient findings from my research that are addressed with recommendations in the following chapter.

Demographic Data of Sample

Thirty-three student and faculty interviews were conducted to obtain data addressing the study's research questions. Twenty-four students were interviewed including: A) five female URM students who elected to leave engineering; B) seven female URM students who are persisting in engineering; and C) four male non-URM, four female non-URM, and four male

URM students who elected to leave engineering. Table 4-1 includes demographic data of student participants.

Table 4-1

Student Participant Demographic Data

Demographic Category	<u>URM Female</u>		<u>Non-URM</u>		<u>URM Male</u>
	Leaver	Persister	Female	Male	
N	5	7	4	4	4
Ethnicity					
Hispanic/Latino	2	6	0	0	3
Not Hispanic/Latino	3	1	4	4	1
Race					
American Indian or Alaska Native	1	0	0	0	0
Asian	0	0	2	2	0
Black or African American	2	2	0	0	1
Native Hawaiian or Other Pacific Islander	0	0	0	0	0
White	1	3	2	2	2
Multiracial	0	2	0	0	0
None selected	1	0	0	0	1
Year in School					
Sophomore	2	2	1	2	0
Junior	1	2	1	0	0
Senior	2	3	2	2	4
Mother's Education					
Some high school	1	0	0	1	0
High school diploma/GED	2	1	0	0	1
Associate's Degree	0	1	0	0	0
Bachelor's Degree	1	3	2	2	1
Master's Degree	0	1	1	1	2
Doctorate	1	1	1	0	0
Father's Education					
Some high school	0	2	0	0	0
High school diploma/GED	2	0	0	0	1
Associate's Degree	1	0	0	0	0
Bachelor's Degree	1	4	3	2	2
Master's Degree	0	1	1	2	1
Doctorate	1	0	0	0	0
Engineering Parents					
One parent	1	2	2	3	1
Two parents	0	0	0	0	0
Neither parent	4	5	2	1	3

Notably, of the female URM leavers, most did not have a parent in the engineering field as compared to most male non-URM students who had at least one parent who was an engineer. The majority of other URM students did not have engineering parents as well, while half of female non-URM students did have at least one. Additionally the majority of female URM leavers had one or both parents with an educational level below a bachelor's degree compared to all female non-URM students who had both parents obtain a bachelor's degree or above.

Table 4-2

Student Engineering and Second-Elected Majors

Student Population	Matriculated Engineering Major	Second-Elected Major
Female URM Leavers		
1	Aerospace	Biology
2	Civil	Business Administration
3	Biomedical	Political Science
4	Biomedical	International Relations
5	Chemical	Biology/French
Female Non-URM Leavers		
1	Computer Science/Business Administration	Business Administration
2	Chemical	Accounting
3	Chemical	Neuroscience
4	Mechanical	International Relations
Male Non-URM Leavers		
1	Biomedical	Philosophy
2	Chemical	Human Biology
3	Biomedical	Neuroscience
4	Industrial and Systems	Business Administration
Male URM Leavers		
1	Mechanical	American Studies & Ethnicity
2	Aerospace	International Relations
3	Mechanical	Economics
4	Computer Science	Psychology
Female URM Persisters		
1	Chemical	--
2	Mechanical	--
3	Civil	--
4	Astronautical	--
5	Chemical	--
6	Civil	--
7 ^a	Civil	Public Policy and Development

^aFemale URM Persister 7 changed majors out of engineering, but subsequently returned after a year in the second-elected major

Table 4-2 summarizes the engineering majors each student population matriculated into as well as the second-elected major for those that left the engineering discipline. With the exception of electrical engineering, all engineering majors at WPU were represented in the student data.

Nine undergraduate engineering professors were also interviewed as part of the data collection sample. Table 4-3 provides a summary of faculty demographics.

Table 4-3

Faculty Demographics

Faculty	Gender	Race	Engineering Department
1	Male	African American	Electrical
2	Male	Asian	Biomedical
3	Male	Asian	Computer Science
4	Male	White	Chemical
5	Female	White	Aerospace and Mechanical
6	Female	Asian	Chemical
7	Female	White	Engineering Writing
8	Male	White	Aerospace and Mechanical
9	Male	White	Engineering Writing

When including faculty data, all eight engineering departments were represented in this study.

Given that female URM students who left engineering are the core of this research study, the five participants in this group have been given pseudonyms that will be used as they describe their experiences choosing and eventually leaving the discipline.

Paige. Paige is a bi-racial senior of American Indian and White descent. She matriculated into aerospace engineering but will be graduating with her biology degree in spring of 2014. Her initial interest in aerospace engineering sparked from an automotive class she took in high

school. Neither of her parents have an engineering background. Her mother's highest level of education is a high school diploma or GED while her father has received his associate's degree.

Lydia. Lydia identifies as Latina and is a first generation college student. She highlighted that she entered into college as a civil engineering because the discipline touched home for her. Her mother is from a town in Mexico where the driving conditions are very poor and where she has even lost relatives to the dangerous roads. She explains, "That's why I wanted to be in civil engineering, and that's why I really chose that because it touched me, where I could possibly do something." She is currently a junior majoring in business administration.

Jamilah. Jamilah is an African American sophomore who entered into college as a biomedical engineering major. Her father is a mechanical engineer and remembers being encouraged by many to enter the engineering discipline because of the few African American women in the field. "People were telling me that, you know, it's good to have African American women in engineering because, you know, they're wanted and there are not very many and of course you can get a job," she explains. Jamilah faced some academic difficulties during her time in engineering, ultimately resulting in academic disqualification from the university. However, she has since returned as a political science major. Both of Jamilah's parents have bachelor's degrees.

Alexis. Similar to Jamilah, Alexis is an African American sophomore who initially began her college career in biomedical engineering but has since left the discipline to pursue a degree in international relations with an emphasis in global economics. Alexis' parents did not attend college; however, she spoke of exposure to engineering via her sister and sister's husband who are both engineers.

Anna. Anna entered college as a chemical engineering major. She is a Hispanic/Latina student in her senior year, currently double-majoring in biology and French. Her parents have achieved the highest level of education compared to the others, both receiving doctorate degrees. She admits that she did not have an idea of what engineering was before college as neither of her parents or family members are engineers. Nonetheless, she explained that she wanted to do something science-based. “Engineering has more of, like, practical applications and something that, if I graduate, I could do something with it,” highlighting the practicality of the major as a factor in her decision to enter engineering. Table 4-4 summarizes the demographics of these five female URM leavers.

Table 4-4

Female URM Leavers’ Demographic Data

Student	Year	Race	Ethnicity	Engineering Major	Second-Elected Major
Paige	Senior	Not Hispanic	American Indian/Alaska Native & White	Aerospace Engineering	Biology
Lydia	Junior	Hispanic	No Response	Civil Engineering	Business Administration
Jamilah	Sophomore	Not Hispanic	Black or African American	Biomedical Engineering	Political Science
Alexis	Sophomore	Not Hispanic	Black or African American	Biomedical Engineering	International Relations
Anna	Senior	Hispanic	White	Chemical Engineering	Biology/French

Notably, Paige and Anna both indicated that they were biracial, also being of White descent. In their discussions of their experience in the engineering school, they were the only two participants in this target group that did not identify with a group that is underrepresented in

engineering. I highlight this distinction at this point as many of the perceptions and experiences that Paige and Anna discussed were noticeably different from those that Lydia, Jamilah, and Alexis described. The findings in this chapter expose these differences, highlighting distinctions that only those who were not biracial perceived such as academic deficits and a lack of diversity in the engineering classroom.

Marisol. Marisol is a unique participant in this study. She entered into college in the civil engineering program but decided to switch out and pursue public policy and development after her first semester. When discussing her expectations of and reasons for switching to public policy, she stated:

I thought that's what's gonna interest me and, like, really draw me in, and, you know, it was gonna be similar to kind of like, allow me to do the things that I enjoyed, like in high school, like community service type of things, and more community-based things.

After a year in the major, she realized it wasn't what she expected and ultimately returned to civil engineering. Marisol identifies as Latina and is a first generation college student. While Marisol is considered a female URM persister in this study, her comments and perspective will be highlighted in portions discussing the academic experience in engineering and the impact it had on her decision to initially leave the major.

The remaining sections of this chapter describe the perceptions and experiences of Paige, Lydia, Jamilah, Alexis, and Anna, highlighting why they entered the discipline, what they experienced while in engineering, why they ultimately decided to leave, and how they perceive their current academic major and future plans. Throughout their descriptions, comparisons are made to the thoughts of female URM persisters, female non-URM leavers, male non-URM leavers, and male URM leavers. Those students will be identified by their categorical labels rather than pseudonyms.

Pre-College Experiences and Influences: STEM Interest, Success, and Access

All five female URM leavers mentioned a high school interest in math or science or a perceived strength in the two subjects as an initial impetus to explore engineering in college. As Paige pointed out, “when you're really good at math and science, they shift you to engineering.” Lydia echoed Paige’s experience when she described how she initially was introduced to engineering: “I knew that I wanted to do something math related, but I wasn't sure, so one of my, my English teacher, he recommended me to look into engineering.” An interest or strength in high school science and math was a commonality across all female populations interviewed. Six of the seven female URM persisters explicitly stated that an interest in math and science was a primary reason they pursued engineering as well as three of the four female non-URM students who left engineering. One persister stated, “I just fell in love with the idea of physics so I researched programs that were revolving around physics and I saw engineering.” A female non-URM student explained, “Well like all high school students, I had no idea what I wanted to do with my life, but I really liked chemistry and math.” Only one male URM and one male non-URM mentioned an interest in the math or science as the initial motivation to pursue engineering.

Pre-college programs also played a role in exposing three of the female URM leavers to out-of-class math, science, and engineering opportunities. Lydia participated in the Upward Bound Math/Science Program at her school, while Jamilah and Alexis participated in summer programs at MIT and Cal Tech, respectively. Jamilah expanded on her pre-college program experience:

I did an MIT program over the summer, the summer I think it's after my junior year of high school or something like that. I just did it to see what it was like and for me it was pretty cool. So a lot of really cool projects.

No other students mentioned that additional level of exposure as an influence to pursue engineering aside from one female URM persister who participated in Discover Engineering programs at WPU. She stated, “I did a summer program at [WPU]-- the Discover Engineering program here. And so then I became interested in engineering.”

Unique to female URM leavers, entering engineering as a means to having a larger impact in their community and on society was discussed. No other population mentioned being driven to have an impact in that way. As previously discussed, Lydia entered civil engineering to make improvements to her mother’s hometown. Alexis also talked about the impact she hoped to have by entering biomedical engineering:

I think that I kind of narrowed down BME just...my kind of like my goals in general revolve around helping society, trying to like make an impact, and I thought that BME was the most direct way I could do that through like a health field.

Alternatively, male non-URM students more frequently cited job security as the motivation for entering engineering. As one student describes, “I mean it's a very safe major. You go into chemical engineering, if you graduate, you'll have a job, right. It might not be your favorite job in the world...but you'll have a job, you'll be set.”

Female URM students’ pre-college influences aligned closely along gender lines with persisters and non-URM female leavers. An interest in or strength in math or science was the initial impetus to exploring engineering as a major for most female students in this study, while only mentioned by two male students. Largely unique to female URM leavers was their mention of involvement in pre-college programs as an added layer of exposure to the engineering field. Of all the others interviewed, only one female URM persister identified a pre-college program as an influence. Two female URM leavers were the only participants to also state a desire to pursue engineering to have a social impact, which represented another factor unique to this group.

Misaligned Expectations of Course Content and Rigor

Expectations of the engineering major did not align closely with the experiences of female URM students who left engineering, and similar sentiments were expressed by other groups of students who decided to leave engineering. Two female URM students found the coursework more difficult than they expected and did not feel adequately prepared for the academic rigor. Lydia explained, “I knew it would be difficult but I didn't realize how difficult it was going to be.... For me the most rigorous course was physics. I didn't have any background in it from high school.” Even though Lydia was aware of her academic deficit coming in, she expressed that she could not understand the material while in the course and quickly fell behind. She elaborated, “I knew I wasn't going to be as strong in that area, but when I was actually in the classes, it just seemed so much more difficult and I didn't, I understood nothing.” Lydia cited her difficulty in physics as a factor in deciding to leave the engineering discipline.

Similarly, Jamilah knew that engineering would be hard, but she did not realize that having taken chemistry in her sophomore year of high school would adversely impact her performance. Jamilah was not able to recall much of the material during her biomedical engineering class. She stated, “I expected it to be challenging, but I didn't expect that I would be like unprepared.” She expanded,

It was just hard for me because I hadn't taken chemistry since my sophomore year in high school, and then a lot of people in that class was taking chemistry with the class and I wasn't which was not helpful for me.

Jamilah perceived herself at a disadvantage compared to her peers in the introductory biomedical engineering class who were able to access chemistry concepts more readily.

Male URM students who left engineering shared the sentiment that engineering was much harder than what they expected, with three of the four participants highlighting that

challenge. One student stated, “I knew it was going to be really difficult going into it, but I guess I didn't anticipate how difficult it was, or how quickly courses would move.” Another explained, “It was different than what I expected. It was a lot harder....When I came here it was like, ‘oh you actually have to do a lot of work’ and I just wasn't prepared for that.”

In contrast to URM students who left engineering, none of the male or female non-URM students claimed that the coursework was more difficult than they expected. Student experiences varied with no prevalent theme emerging. One female non-URM students stated simply, “I was just hoping it would be something that would fit me but turns out it wasn't.” Others highlighted that they expected the level of difficulty. One male non-URM student expressed, “I just figured it would be very difficult,” and another female non-URM student even stated, “I thought it would be hard basically, but it wasn't as difficult as I thought it would be.” Thus, of the students who left the discipline, students in the racial minority were more likely to identify an unexpected level of difficulty in the major as a common experience, while non-URM students never made mention of that experience.

Similar to students in the racial majority, none of the female URM persisters mentioned the engineering coursework being more difficult than expected. Two students explicitly stated that they knew that the major would be hard. One said frankly, “What I expected were challenging classes” while another also directly claimed that “[she] knew it was going to be hard.” Two other female URM persisters did not have any particular expectations about their engineering program when they first entered college. One student expanded, “I kind of went in completely, like, blind of, like, the way that college works,” noting that not only did she not have a particular expectation of the engineering major, but she also did not know what to expect coming to college.

A common experience among some students in each of the study populations was the difficulty in being able to connect the experience in the classroom with their future engineering interests. Paige explained, “I thought [the courses] were more flexible on what you could design for projects and kind of the options you have once you graduate,” but she was not able to make those connections in her introductory aerospace engineering course. Alexis concurred in Paige’s sentiment of a lack of connection when she stated, “there was never that explicit, let me show you the connection. It’s just these are the concepts and you put it together or not.” The opportunity to connect coursework to applications and future goals emerged as important for female URM leavers and was cited as a missing element in their classroom experience.

A male URM student also highlighted a similar experience in having trouble connecting coursework to his interests in engineering. This student said, “My attitude did change once I actually started taking the classes here. I felt like, I didn’t kind of see how some of the classes kind of related to what I wanted to do originally with cars and stuff.” Faculty corroborated the sentiments of students in this regard, but from another angle. One engineering writing professor noted, “They just want to know the skills that are directly applicable to what they see themselves as doing.” An upper-division computer science professor highlighted, “using examples makes the material come to life. When the examples are related to them, that seems to make a huge difference.” However, none of the leavers would have taken this senior-level course. An introductory chemical engineering professor shed light on the lower-division course structure “where the traditional role of the class is to dump knowledge in the student’s head.” Faculty appeared aware of the importance of students making connections between the material and its application; however, opportunities to incorporate those connections in lower-division courses seemed challenging.

Unique to female URM persisters by nature of continuing with the discipline and entering upper-division courses, and, echoing the sentiments of faculty, some spoke of being on the other side of this trajectory beginning with classes where it is difficult to see the connection to ultimately taking courses where they applied the theories. One female URM persister detailed this experience explicitly:

Once I kind of got past the general courses and I started taking more space-related courses, then it started clicking and it was like oh ok this is kind of what it actually means. Because you kind of lose your guidance a little bit, like ‘why am I in this major? I’m not learning anything about it’ but my junior/senior year I kind of started realizing, oh ok this course is really cool.

This student revealed that at one point she was doubtful about her decision to continue in the major, as were others, but eventually persevered on to academic experiences she hoped to have.

Another student corroborated the sentiment explaining,

I really do think that what I’ve learned in the past four years in my classes is exactly what I wanted to know coming in as a freshman. But it took me awhile to realize that. In junior year going through all these difficult classes along the way, I realized that this is actually what I really wanted to learn.

Having persisted through to upper-division courses, these students explained the new perspective they held of the less applicable, more foundational coursework they took as freshmen and sophomores.

Female URM leavers and persisters spoke very favorably about their expectations of the engineering school and primarily attributed their positive impressions to their involvement in a summer bridge program for URM students prior to their freshmen year. All female URM leavers participated in the summer bridge program with the exception of Anna who actually was the only one to express criticism of the school, highlighting its curriculum rigidity. Jamilah expanded on the impact the summer program had on her transition into the school saying, “I just felt really comfortable in the space. And I began to have really close relations with some current students

because they would just reach out to me.” A female URM persister equated the program to being treated “like you’re a family member.” Access to resources and support was also something commonly mentioned by both female URM populations as an expectation that was later met, but only brought up by one male non-URM student among the other student populations. Even though she was unhappy with the overall curriculum, Anna did express her positive impression that “they have a lot of good resources for students” in the school.

While female URM students who both left and stayed echoed each other in their positive comments about the summer program and the access to resources, the other student populations tended to speak more of either not having any expectations at all, or only thinking of the school’s prestige prior to attending. Three of the four male URM students admitted that they really didn’t have any expectations coming in. As one student stated, “I never really thought about the school in general and what it offered to me,” while another commented on a similar experience-- “I just didn’t know very much about [WPU School of Engineering] or its standing or any reputation it has. I just decided to do it.” Alternately, half of non-URM students more frequently mentioned the school’s reputation as something they were aware of prior to enrollment. One female non-URM student plainly stated that this reputation was her only expectation: “It’s a big name...I know it’s a very strong engineering school, I did my research. One of the top in the nation. Other than that, no, I didn’t have any other expectations.” Study participants, aside from female URM students, appeared to be more likely to simply have no expectations of the experience, or to be influenced by the school’s status.

Expectations clearly varied among the different student populations interviewed. Of students who left the discipline, both female and male URM students more commonly highlighted that the major was more difficult than they expected, while none of the leavers in the

racial majority indicated as such. Female URM persisters also did not mention that the coursework was more challenging than what they anticipated. Students across all populations commonly cited challenges in connecting material to their original interest and future goals in the discipline. Faculty corroborated the student experience with their observations of what students are looking for in the classroom and perceptions regarding lower-division courses being limited in how the material can be presented. Persisters who had reached upper-division coursework were able to verify professors' varying descriptions of lower versus upper division classes, emphasizing the increased opportunity for application. Lastly, student populations varied in their initial expectations and impressions of the school. Female URM leavers and persisters both spoke positively about the many resources available to them, while URM males primarily highlighted that they did not have any expectations at all. Alternatively, the school's reputation emerged as the common draw for both male and female non-URM students.

Classroom Competition and Lack of Preparation Undermine Persistence

When discussing their academic experience in engineering, the majority of students in all of the populations emphasized how challenging the coursework was. All five female URM leavers discussed these challenges openly. Paige commented on the impression that she had of being weeded out stating, "It's a heavy load for freshmen. They kind of scare people out of the field. It's kind of viewed as weed out classes almost." Jamilah spoke more specifically about her experience in the introduction to biomedical engineering (BME) class:

It's assumed that you remember from high school or, you know, you'll just catch up the next semester, but like you do need to know some basic chemistry concepts to be able to succeed in that BME class, and that I think was a huge challenge, because I was trying to pull from like two years before.

Lydia and Alexis each discussed feelings of being behind; Lydia with college physics and Alexis with not feeling like she had enough Advanced Placement (AP) or International Baccalaureate (IB) units.

Within the other groups interviewed, nine of 12 leavers also classified their academic experience in engineering as challenging. One male URM echoed Lydia's difficult experience with physics. Another male URM spoke similarly to Paige regarding the weeding out he perceived:

I found the material really, really, really interesting. It was perfect to what I wanted to learn about in an aerospace class, and I loved going to class and doing the reading and doing the homework for it, but I just found the class to be so focused on just kind of weeding out students.

The student later went on to say that this negative experience in his introductory aerospace engineering class caused him to leave the major. He stated, "I just kind of got a bad taste in my mouth about doing engineering, so I decided not to." Two female non-URM students spoke about tough and sometimes unclear grading policies that added to the challenges. One student elaborated, "you didn't know your grade until the end because everything was curved, so that was weird. I never experienced that in high school. I was like 'What is a curve?'" Another female non-URM leaver gave an example of her experience with an engineering professor who poorly communicated his grading policies. Her professor "wasn't going to curve the class at all....and then at the very end he decided to curve the class but then he was like 'No questions on how I'm going to curve the class.'" She went on to explain, "you really don't know where you stand until the grade actually comes out and you're sitting there thinking, oh my god I'm failing this class, but then at the end of the day you're doing fine." She attributed this lack of clarity in grading policies as "one of the major problems with engineering classes. Two male non-URM students highlighted the shock they experienced transitioning into college engineering from high

school academics. One student explained, “It's kind of a shock when high school students come here. It was for me. Yeah, I didn't like the homework. It was just tedious, you know?” Another student mentioned that “there's a lot of focus on the class being difficult from everybody, from students as well as professors” taking away from the actual learning.

Discussions of the challenging coursework were not unique to populations that left the discipline. Five of seven persisters also indicated that the curriculum is challenging, and four more specifically identified the heavy workload and amount of homework as a main factor in the challenges. One student described, “[the classes are] very intense. They give you a lot of work. It's difficult when you cram in, you know, six classes into one semester.” While the majority of female URM leavers discussed feeling unprepared, only one persister cited the same experience. Marisol, the persister who left the engineering discipline for some time, did not mention academic deficits as the cause to her challenges but explained, “It wasn't necessarily difficult, or something I couldn't grasp. It was a matter of how much time I could dedicate to it when having all these other classes.” Largely unique to persisters was their mention of successfully utilizing resources to address challenges, “whether it's your friends or your professors to ask questions if you are stuck on something.” Persisters more commonly cited successfully addressing their academic challenges by utilizing a variety of resources.

Female URM leavers described their access to resources a bit differently. Lydia and Jamilah spoke of accessing resources for help with their academic challenges but discussed that their attempts were unsuccessful. Lydia attended supplemental instruction session for physics, but stated the pace of “those are pretty quick as well” so she did not find it helpful. Jamilah attended her professor's office hours for additional help but described it as a “weird vibe” and even though “they'd say ‘come to see me’ ...that is their obligation to have office hours.”

Contrary to Jamilah's experience, the one persister who mentioned having doubts about her high school academic preparation described her success in utilizing resources:

You go in with your high school background, but I think sometimes it may not be enough when you're going in here and you're realizing OK this is some hard stuff, you know. So just getting as much....like going up to my professor, explaining, hey I don't understand this can you help me out....The resources that [WPU] has is amazing. I've been able to keep up thankfully.

While female URM persisters were forthright in discussing their strategies to address academic challenges, other populations shared their approaches when probed further. Their processes, both overlapping and unique in certain cases, are explored in the follow sub-sections.

A Missed Opportunity: Using Self-Directed Study to Address Academic Challenges

Female URM leavers reported varying approaches to addressing their academic challenges, but they most commonly cited utilizing the school's academic resource center, forming study groups with others, and studying in the Center for Engineering Diversity office. Paige described the engineering diversity office as a small study space where "you have older students who were there to help you, and most of them were willing to help." Alexis mentioned reaching out to the staff in the center as well as the other students she met there for support.

Along with female URM leavers, other students in the sample identified working with peers as a key strategy with the exception of male non-URM students where it was cited by only one participant. Alexis explicitly identified her peers as a major source of academic support stating that "study groups were big for me. So that was my biggest way of facing academic challenges." Another female non-URM explained, "I think that I definitely try working with friends, so helping each other out if someone knows one problem you'll know the other." Female URM persisters also spoke of their reliance on study groups as one of their academic success strategies. One student described her experience:

I need to kind of work in a group for me at least because it just goes quicker; it's less time consuming and less challenging because it may not be as challenging as I made it out to be with other people helping.

Cited more commonly by other groups but not by female URM leavers is utilizing self-directed learning strategies in addition to accessing other sources of support. Self-directed learning involves self-management, self-monitoring, and motivation that students employ in their learning (Garrison, 1997). Essentially, it is how students learn on their own. Paige was the only URM female leaver to discuss how she modified her study approach to be more effective as she became more experienced with college-level work. Paige was also one of two female URM leavers to remain in the STEM fields, switching to biology. Three female URM persisters discussed their self-directed learning approaches, often including them as part of a suite of strategies for success. One student explained that she has “learned along the way what to do better and what to do differently. Some of it's been trial and error,” similar to Paige’s experience. Another student also described her new method of tackling the work: “one thing that I started this semester I've just, I go to the lecture, and I take notes and at night, if I don't have homework, I go over the notes.” Prior to this, she admitted that merely taking notes and not reviewing them did not work for her. She explained that reviewing her notes was her first step in comprehension, and, if challenges persisted, she would ask classmates for help, and lastly her professor as part of a multi-level strategy to understanding the material. All female non-URM students also discussed self-directed learning as their primary approach, with two highlighting that they attempted to access formal academic resource programs but found they were not as helpful as expected. Along with two male non-URM students, this group was more likely to indicate that they relied on themselves solely to get through the challenges.

Female URM persisters most commonly mentioned accessing professors for academic support with four participants identifying faculty as a primary resource. While Jamilah and Alexis did mention attending office hours at times and only for some classes, persisters discussed professors' role in their success more fully. One student explained her experience after receiving a poor grade by stating, "after the midterm, after I saw that bad grade, I started going to the professor and he started helping me and I'd go to him every week to make sure I was learning it properly." Another student identified the very first step in approaching challenges as simply being class attendance. She declared, "Well you have to be in class because your professor needs to know you, if nothing else." Of the other student populations, only one male URM student mentioned accessing office hours.

Female URM persisters tended to rely more heavily on professors and their own self-directed learning as part of their strategy to address academic challenges. On the other hand, URM students who left, both female and male, seemed to rely more on friends and other university resources. While non-URM students also spoke of learning on their own as their strategy to tackle academic obstacles, they differed from persisters in that studying and addressing challenges alone were often their sole response to the academic obstacles compared to persisters who also utilized other resources in addition.

Making Connections: The Importance of Relevant Content and Interactions.

As described by nearly all students' interviewed, engineering courses are primarily lecture-based. However, opportunities for group work and projects were welcomed, primarily among female URM leavers who discussed their enjoyment of that aspect most often of any population. Alexis described her experience:

I like the fact that we did a lot of group projects. Well, we didn't do a lot, but we did a group project, which was nice, just to give us an opportunity to kind of like work with other students.

Three other female URM leavers described the positive experience they had with group work.

Paige highlighted her preference for group projects when she stated, "that was actually my favorite part was doing the project. That's what I thought engineering was, and I wanted to do it all." She later revealed that the emphasis of the class was less about doing projects and instead focused more on memorizing formulas. Lydia saw group projects as an opportunity to get to know other students, which she really enjoyed. Other students in the sample also referenced group projects but on a more limited basis and did not particularly highlight their preference for them.

Connections to real-world examples and applications were important to female URM leavers and persisters. Lydia and Jamilah both appreciated when their professors would invite guest speakers from industry. Jamilah explained, "That was engaging for me because I was learning about the real world and like the field;" however, similar to Lydia, Jamilah later made clear that the course focus went elsewhere. She followed her statement regarding guest speakers with:

The classes were more like OK, you just learned this math and this chemistry and hopefully you'll realize how it connects to the practical world and I didn't see that. But again, since that's a freshmen weed out class, maybe that's how it's supposed to be structured.

Lydia liked the guest speakers because they "give different perspectives and different fields of study so [she] really enjoyed that." Paige described the limited connections that her professor made to applications, stating, "He doesn't kind of connect it to like, 'oh this formula is important because it helps this plane fly that way.'"

Similar to URM women who left engineering, URM women who persisted in engineering appreciated real-world examples. One persister highlighted her preference for examples being provided during class. She stated, “That's the one thing I like is when a teacher does examples because they can explain it and I'll understand what they're saying.” Another student wished more in-class demonstrations were included. She explained, “Every once in awhile I kind of wish they had an actual demonstration in class but they normally don't...When you get to see it it's nice. It definitely makes it all more real.” Making connections between content and application was important to both female URM leavers and persisters but was not mentioned by other student populations.

A common preference among all student leavers was to have more in-class interactions among students and between students and professors. Anna described the classroom environment as follows:

I don't think there was really a whole bunch of student-professor interaction just because I don't think that that was the kind of class where it could be. Of course, if people ask questions they ask questions, but it was mostly him talking.

Jamilah had the same experience and found the lack of interaction a challenge when trying to engage with the material. She ultimately spoke to her professor to schedule midpoint breaks in the 2-hour lecture to lead icebreaker two hours is just not helpful, and then I'd do exercises to try to be like ‘OK can I like personally engage myself more by like having this break?’” She was thankful her professor allowed her to lead those exercises during a break, “but it didn't necessarily change the intensity of the class and how it was like, you know, there was like no breaks and you know either you got it or you didn't.”

Alexis described the distinction between a true discussion versus merely being able to ask questions to the professor because “that doesn’t always translate to instant understanding of the

material.” One male URM student discussed his disappointment with the lack of interaction, expressing that he felt the classes were ineffective because “there needs to be more interaction when you're trying to learn something.” One male non-URM student stated that he “just [didn't] want to be talked at,” a sentiment expanded on by a female non-URM student when she stated,

I like it a lot better when we get to like discuss back and forth kind of, but I guess when you're just doing math and stuff you don't really need to as much. But I just didn't like sitting there, just like learning.

Another male non-URM echoed similar sentiments, and described “I do much, much better in discussion-based environments than a lecture-based environment. I learn through conversations.”

Female URM persisters largely did not identify a lack of classroom interaction as an issue. In fact, Marisol who experienced a non-engineering major as well stated that she preferred that her engineering classes were not discussion-based. She expanded, “It’s kind of like one of those things where you’re lost, and they tell you, like, okay, work on this problem in a group, and everyone’s lost...I haven’t found that to be effective for me.” Another persister emphasized the necessity for a lecture-based style stating “I like the way that it was laid out more because you learn in the beginning all the different concepts that you need....It was really important to have that foundation before they kind of let us....set us free.” Thus while leavers commonly highlighted the lack of in-class discussions as not ideal for their learning experience, persisters seemed to understand the necessity of the lecture-style delivery of content.

Unique to female URM leavers was the mention of smaller class sizes as a preference. Lydia felt that “for the difficult subject like physics, it would help if it were smaller.” She compared her large physics class to her 40-person calculus class where she “really didn't have any difficulty understanding the professor or asking questions.” Alexis also identified smaller class sizes as her primary preference while she was in the school of engineering.

All students identified the typical engineering course structure as lecture-based. Leavers largely emphasized their wish for more in class interactions in these courses while persisters, on the other hand, explicitly stated that the lecture style was necessary given the content and that a discussion-based engineering course may in fact take away from the learning. Common to female URM students, both persisters and leavers, was a preference for professors to incorporate real-world connections in the classroom. Female URM leavers went on to also highlight that they preferred group work and wished their courses were smaller, relating these elements to opportunities for increased class interactions.

Perceived Academic Deficits as a Deterrent to Classroom Participation

Female URM students often discussed difficulties in participating in class. Lydia, Jamilah, and Alexis each talked about their hesitation to speak either due to not feeling knowledgeable about the material or the pace of the class being too fast. Lydia described her experience in physics: “I kind of just sat there and just listened, because I really didn't have much to contribute because I was already confused myself.” Jamilah highlighted that she typically is not one to shy away from class participation, but that was not her experience in engineering. She expanded, “like I love asking questions and being involved but in that class I just wasn't that much because I felt like I had so many questions I just wasn't even sure what to ask.” She went on to explain:

Maybe it's wrong for me to believe but I was like intimidated by it like....I wasn't afraid to ask questions in class, but I was like there's just so much and people would be like ‘you're slowing us down or like you're stupid’, which is weird because I don't feel that way about myself in general.

Alexis also discussed her concern about participating in class stating, “There were opportunities to ask questions, definitely. But, I mean, the pace was kind of fast, so sometimes you would just have to kind of, like, you know, put your questions aside.” Other students, aside from one

persister and one male URM leaver, did not express this sentiment. The female URM persister highlighted that she would only participate if she was sure of an answer but followed up by confirming she's been able to participate often in her engineering classes. The male URM student explained his perception of the experience as follows:

Like if you're like an outsider, you don't want to like embarrass yourself too. In the end I bit the bullet and just asked a bunch of questions. And I think some people were a little annoyed by that but I had to do it.

While Paige and Anna did not indicate any difficulties with participating in class, the other three female URM leavers each spoke of the sometimes-intimidating experience.

Positive but Infrequent Connections with Faculty

Female URM leavers described their relationship with engineering faculty as largely positive. Anna described her introductory class professor as “very likable and willing to work with the students. He understood that people probably didn't know what he was talking about and he was very good at explaining everything.” Alexis also spoke favorably of her engineering professors. She stated that “they were concerned, and they really wanted to like make sure that we knew what was going on, or like what to expect.” Paige’s engineering professor offered her a research position in his lab the second week of school, and she appreciated how available he was to answer questions at any time. Lydia and Alexis both mentioned that they spoke with their professors when considering their change of major out of engineering. Alexis provided the example that she “really used that professor for, to like say, ‘so I’m having doubts about this, like what do you think if I were to do this instead?’”

Female non-URM students also spoke positively about their engineering professors. One student stated that her engineering professors were still some of her favorite, even after switching to her new major. Another student described her experience accessing research opportunities—

“They were actually really nice and open. Yeah I went to one of my professors to ask for research projects and got into like some of that before I switched.”

Both male populations primarily described a very different experience than their female counterparts. Five of the eight male students who left engineering indicated that they did not connect with engineering faculty at all. One male URM student described his impression of his professor—“I didn't think the teacher was very approachable...He just, like he really wanted us to work through the struggle, so he was just not about to give much help.” Another male non-URM student echoed that opinion, stating “that faculty were definitely very hard to-- like, some of them aren't very approachable, and some don't take the time to meet students or connect with them oftentimes.” One male URM student felt that it was his fault that he had not made a connection with his faculty because he never attended their office hours.

Female URM persisters spoke of their connections with professors a bit differently than other groups. They were the only population to explicitly state the importance of connecting with professors as part of their academic success. One student described her process:

Within the first week I try to make sure that they know my name at least. I try to go into their office and present myself, and tell them who I am and what I'm studying, things like that, just to make sure they know my face and my name as well, and try to build a relationship with them.

Another student highlighted how her parents encouraged her to connect with professors early. She expanded, “I have realized I guess more the hard way that it's better to have a good relationship with your professor that way you can go ask them questions and they can really be supportive.” Another student reflected on a similar experience – “That was always something I knew....I learned early on. I need to go see the professor in whatever class I was struggling with and they were all really, really friendly.” No other students in the interview sample described this importance.

While comments about professors were primarily positive, students in every population acknowledged that connections with professors could vary. Most commonly noted were professors who appeared more interested in conducting research than teaching their courses. Jamilah spoke about that impression she experienced, describing those particular professors as “not used to being a teacher so they're not necessarily that engaging.” A male URM student also described his experience with some of his professors similarly-- “[the professor] would know a lot about his topic, but he wouldn't be able to like express it to us. Those guys, they were good, but they weren't like teachers.” One female URM persister reflected on the same notion, attaching it to the university environment. She explained, “some of them they seem like they're really into their research, and I think that's because this is such a huge research university; they have pressures for that as well.”

Female URM leavers described their overall academic experience as challenging as did others. Their reaction to the challenging environment was largely based on their interactions with others; utilizing peers as academic support, seeking more interactions in the classroom, attempting to find a comfortable space to participate in class, and making connections with professors. They also consistently desired a connection between the material they were learning and the real world applications they initially were drawn to in the field, while some also were uncertain about their high school academic preparation. These challenges begin to shed light on why this population ultimately decided to leave the discipline, but their engineering experience also was significantly shaped by their general connections with the engineering community, which is explored in the following paragraphs.

Connections with the Student Community: Varied Experiences In and Out of the Classroom

Paige and Jamilah were the only two female URM leavers who participated in engineering-related organizations during their time in the major, though Jamilah clarified that she did not attend very much. She explained, “I didn't go to AeroDesign that much. I just thought it was really cool to see what they're doing, how are these you know problems that they're solving or math they're doing connected to my classes in any way,” reiterating her desire to apply what she was learning. Jamilah and Alexis both were active in a diversity-centered organization; each joining the National Society of Black Engineers (NSBE) and both indicating that the group was important in forging connections with their peers. When discussing her experience as a URM student, Alexis expanded on the role NSBE had in her experience, stating that “it definitely had an impact” as a source of support. Lydia and Anna did not participate in any engineering co-curricular opportunities.

All female URM persisters were involved in diversity-related engineering groups with three involved in the Society of Women Engineers (SWE), three involved with the Society of Hispanic Professional Engineers (SHPE), and two involved with NSBE. Four were involved in engineering-related organizations. Four had taken on leadership positions within these organizations furthering their connection with the groups.

Two female non-URM students discussed their involvement in an engineering-related organization and three were a part of SWE, though two highlighted that they were not able to connect with others in the organization. One student described how she did not identify with the mission of SWE stating; “I discovered that I don't really like looking at it that way, like ‘oh, we're different.’ I really don't like that so I kind of like quit after my first experience.” Another

female non-URM student expanded on her attempts in making connections in the engineering school—"I tried to get involved and I tried to find some little niche of support but it just wasn't working out for me." Seven of the male students interviewed, both URM and non-URM, were not involved in any engineering co-curricular activities indicating that female students appeared to be more concerned with creating connections outside of the classroom through organizations.

As female URM leavers previously identified the pre-college summer bridge program as an important piece of their transition into college engineering, they also described the impact it had on their connections with other students. Lydia, Jamilah, and Alexis each identified the summer bridge program as a primary source of their friendships. Lydia and Jamilah went on to explain that making friends in their classes was not as easy as what they experienced in the summer bridge program. Lydia explained, "The only students that I was able really to connect with were the ones that I met through [the summer program] because in my classes it was really all about competition." Jamilah also discussed the contrast of her experience attempting to connect with students in the classroom versus through the summer program. She provided the following example to illustrate:

In BME 101 class, I would connect with some of the students and ask if we could study together...It's like I worked with some, I studied with some sometimes, but a lot of them, for some people I experienced what I experienced in high school which was me asking them a question like 'Hey, do you understand this?' And they would automatically be just like 'I don't know,' even though they clearly know and that was like a weird competitive thing that didn't make me feel comfortable.

Lydia and Jamilah both emphasized the challenges in connecting with their engineering peers due to the competitive nature of the classroom environment. Female URM leavers did not identify grading policies and curving as an influence on classroom competition; however, the reliance on curves that female non-URM leavers noted provides context of how these courses

were structured. Curving grades can promote in-class competition as students are up against each other as they vie for a good grade.

Two female URM persisters mentioned the occasional instances of competitiveness but described it as an inevitable part of the school that did not in fact take over the collaborative nature they experienced. As one student explained, “there's always going to be a little competitiveness amongst each other, but I also feel that [the WPU School of Engineering], we kind of help each other out more so than competing with each other.” Another echoed the necessity of grading on a curve, but also recognized the challenges of being on the other side of the competition when she stated, “it's kind of like a little clique-ish...but some of it's necessary as far as like you have to get a study group. But if you're not already in a study group, I can see how it can be hard.” Being on the outside of already-formed study groups echoed the experience that Jamilah described when she discussed the competition she experienced in class. While persisters noticed the competition, they were largely able to connect with a group of peers to study with despite the competitive environment. Those in-class study group connections did not seem to form for students like Lydia and Jamilah.

While Alexis did not mention any challenges connecting with students outside of the summer bridge program, she highlighted that she primarily aimed to connect “with people who had similar interests, whether it be like outside of engineering, or whether it be like just like research interests, or just similar backgrounds.” Paige and Anna each described positive experiences connecting with their fellow engineering students. Paige indicated that she made good friends in her introductory engineering classes and Anna happened to live in a dormitory where a lot of engineers resided so she became close with them. As previously mentioned, Paige and Anna were also the only to female URM leavers to not indicate a perceived deficit in their

academic preparation coming into engineering. When asked in the interview if they identified with a group underrepresented in engineering, Paige and Anna were the only two to say no from the group of female URM leavers. Both self-reported as biracial, also identifying as white. These factors may influence the divergence in the experiences and perceptions of the five female URM leavers.

Female non-URM leavers had the most difficulty connecting with engineering students of any group interviewed. Three of the four students discussed the challenge explicitly, identifying a lack of social connections or perceived commonalities as the cause. One student explained, “I didn't really feel like I related very much. People seemed really, really focused on studying and stuff and I joined a sorority right when I came to college, so I was more interested in the social aspect.” Two of the students specifically attributed the reason for the lack of social connection was the fact that they had joined a sorority. One student described the isolation she felt as a result:

I couldn't make friends; people were not nice. They were really judgmental of just things about my lifestyle and the fact that I went Greek so they automatically wrote me off as really dumb so no one wanted to talk me.

Male students shared varied experiences in connecting with other students. One male URM student also highlighted the impact of the summer bridge program, but the others did not. Another male URM student echoed the sentiment about the instances of competitiveness, particularly because he felt some students were just trying to “protect themselves.” Male non-URM did not mention any challenges connecting with other engineering students. Two male non-URM students indicated that their main circle of friends were not engineers while they were in the major. One student explained, “I didn't really go to classes to make friends....I didn't necessarily try.” Compared to female non-URM leavers who appeared to place substantial

importance on connecting socially with their peers, male non-URM leavers did not express trouble or concern in making those connections while in the engineering program.

All female URM persisters spoke positively of their impression of the engineering community. Three students described it as “tight knit” and like “family.” Two others emphasized the pride and “mutual respect” that comes along with being an engineer. One student described the existence of a strong engineering identity, explaining that “when you're in [the WPU School of Engineering] and you're an engineer there's like a lot of passion being an engineer and everyone's very proud of that.” Paige was the only leaver that picked up on the sense of engineering identity, describing it as “kind of like if you're an engineer, everyone's an engineer with you. You can instantly have something to talk about, instantly have a struggle to go over because you're taking all of the hard classes together.” Persisters commonly spoke of the larger student community they witnessed and always perceived themselves as part of that community.

Many of the female URM leavers mentioned the existence of smaller communities within the larger engineering community, whether through the Center for Engineering Diversity, which houses the summer bridge program, or through specific classes. Anna described how she experienced the community within her engineering major explaining that “you become close with the people that are in your major because you kind of...a lot of it you rely on each other to kind of figure stuff.” Alexis also had a similar experience within the biomedical engineering major. She highlighted-- “I feel like when you’re a BME major, when you’re whatever major, there’s, like, these communities get even smaller, so it just feels more close-knit.” Jamilah also discussed the existence of smaller communities, but observed that there could often be separation among these groups. She described what she saw by saying that “there's a community, it just depends on where you are. Like if you're in CED or if you're in the women's group...then like

you feel a sense of community...but I don't think that there's that family sense of community.”

Lydia observed the community that existed, but did not feel that she belonged in it:

I myself didn't feel that I fit in, but I did see that other people did have that community vibe, but I just wasn't part of it. I think it was mainly the fact that I come from a Latina family and my high school, we didn't really have support for people that wanted to be in engineering...I think my peers were so far up ahead that I wasn't able to communicate well with them.

Marisol also talked about her struggle as a Latina student trying to find a community in engineering. She explained her experience:

Like for a girl, and especially for, like, somebody who's a minority, it's just you don't see a lot of people who look like you. So, I don't know. It's just hard to make those initial connections with someone that you're...as shallow as that is, with someone that you don't immediately identify with.

Marisol revealed that this lack of connection with other students was one of the reasons she initially switched out of the major. This challenge of finding others of similar background in the classroom is explored in more depth below in students' perceptions of the school's climate of diversity.

Climate of Diversity: Varied Perceptions In and Out of the Classroom

Female URM leavers differed in their perceptions of the school's diversity. Paige and Anna both classified the engineering school as diverse without hesitation. As previously mentioned, they were also the only two within this group that did not identify as URM. Potentially connected, Paige and Anna were the only biracial students in the target population, indicating they were of Caucasian background in addition to American Indian and Hispanic, respectively. They also were the only two female URM leavers to remain in a STEM field, both electing to pursue biology as their second-elected major. Lydia expanded on the lack of racial and gender diversity that she quickly picked up on and the shock she experienced as a result. She described the experience:

When I came here, I was really surprised that I was the only Latina, let alone minority in my classes, because I, I knew it was going to be hard for me, being Latina, and a girl. I did see more girls in my courses. It was just not being able to see those minority students that shocked me.

Both Jamilah and Alexis revealed that they felt a greater sense of diversity than may have actually been present due to added exposure through the Center for Engineering Diversity.

Alexis explained how that exposure shaped her perception-- “I think that it’s diverse, but I think that I’ve also had like a lot of experience to expose me to that diversity.” Jamilah admitted that she felt it “created some sort of selective attention for [her].” She went on to explain, “You see the same people you know, so the sense of diversity I think is there more than maybe it actually is.” Nonetheless, for Lydia, Jamilah, and Alexis, organizations that support racial minority students in engineering such as SHPE and NSBE were a source of community and support as an underrepresented student in the school.

Six of seven female URM persisters considered the engineering school to be diverse. Two students spoke more specifically of the presence of gender diversity but highlighted the lack of racial diversity. Two students also repeated Jamilah and Alexis’ sentiment that the Center for Engineering Diversity played a large role in the perception of diversity. One student explicitly stated that “the Center for Engineering Diversity is where it's making it more diverse.” While diversity is felt through involvement with the center, five students revealed that within their major and in the classroom, there was less of a sense of diversity. One student who classified the engineering school as diverse also went on to explain—“in my classes I've realized that the majority are of not a diverse background, so I have noticed that I'm only the Latina girl in my class for a lot of my engineering courses.” Another student highlighted that there were only two other African American women in her major and year. Another counted three other African American women in her major.

Unique to female URM persisters was their mention of having a sense of pride of being one of the only female URM students in the major, a sentiment not shared by Lydia and Jamilah who sought connections with peers who looked like them in the classroom. One persister expressed, “I feel like I’m....like I’m at a disadvantage or anything like that. If anything I like the challenge, I love being the only Latina. I feel special.” Marisol, now back in the engineering discipline, also shared the same feeling even amid the challenge of being able to identify with others. She explained:

I think I also find, like, a kind of a little sense of pride, knowing, you know, I’m one of the few. It’s kind of a cool feeling. But then it also sucks a little bit when you, like, can’t find anybody to identify with.

Three students discussed the importance of helping others to feel like they belong in the discipline as an underrepresented minority. When discussing the lack of diversity in her classes, one student stated, “it’s just my classes are like that you just have to go with it. You shouldn’t feel in any way disadvantaged. Just kind of keep going and motivate other students to do the same.” Another student took on a leadership position with the Society of Women Engineers to motivate “younger girls excited for engineering.” Another spoke openly about why she was so actively involved in NSBE although she also identifies as Hispanic but is less involved in SHPE:

I associate more with NSBE and being an African American because we’re smaller here and I just feel like I need to show and make a presence here because we’re so small and we need to kind of bring more African Americans into engineering and help them when they’re freshmen to stay in engineering, because a lot of times we just lose them to other majors.

Six female URM persisters identified as underrepresented in engineering: three as a racial minority, two as a gender minority, and one as both a racial and gender minority. This population also uniquely discussed how their experience of being underrepresented in high school primed them to not be affected by being underrepresented in engineering. As one student stated, “I didn’t

grow up going to diverse schools, so I don't really notice it as much anymore.” Another reiterated by saying, “I came from a school that wasn’t very diverse, so it’s kind of like, not too much of a shock to me.”

Of the other students interviewed, all four male URM students identified as underrepresented and three of those four students perceived the engineering school as diverse. Half of female and male non-URM students indicated that the school was diverse. Three female non-URM students did not identify as underrepresented, and the fourth did so based on being in a sorority. Conversely, three male non-URM students identified as underrepresented. One male non-URM student, after identifying as underrepresented, elaborated, “We don't need to go and actively pursue more of one race, you know. I think that's ridiculous. It was already plenty diverse and that was a good thing.” Another identified as underrepresented because he was an athlete. The third explained that while he was of Indian descent, he was Sikh, which was a religious minority among the Indian population at the university. Thus, while URM students were more likely to identify as underrepresented due to their race or gender, non-URM students identified themselves as underrepresented based on other factors aside from race and gender.

Limited Sources of Support Amidst Perceived Academic Barriers for URM Women Leavers

As previously discussed, female URM leavers perceived a number of barriers during their experience in engineering, including uncertainty of their academic preparation, challenges connecting with other engineering students, inability to link the content presented to the real world applications they were looking, and the inflexibility of the curriculum. Common to all populations interviewed is their utilization of their peers as support. Paige, Jamilah, and Alexis identified peers as their primary source of support with Jamilah and Alexis reiterating that the

peers they met through the summer bridge program were their closest support group. Lydia and Anna identified family members as their main supports. Lydia spoke of the encouragement her sister provided as architecture student at another university where she was one of few Latinas in her program. Lydia highlighted her sister's message to her, stating:

She just told me 'you know what? You're here for a reason and you just do your best. Don't worry about what they're telling you or the type of work that they're doing. You do as much as you can.' I think having her there was really helpful to get through that shock.

Anna attributed her parents as her main source of support mentioning that they backed her on any decision she made with regards to her major. She explained, "My parents didn't care how long I took" as she was considering how to include her interest in French while pursuing engineering. Lydia and Anna were also the only two among this group that did not mention more than one resource that they reached out to for help. Female URM persisters had the most varied and diverse set of supports of any group. While other groups' main commonalities were utilizing peers and, at times, family members, most persisters listed three or more key resources, including: 1) the academic resource center, 2) their academic advisor, 3) upperclassmen, and 4) professors, in addition to their peers. Persisters created more of a system of support that often relied on various resources rather than one or two primary sources of support that leavers tended to reference. This difference exposes a key distinction among persisters that may have influenced their success in the major. One persister even outlined her academic triage process:

What I've learned to do is go over my notes and whatever I don't understand from there I go to my classmates and say 'Hey, can you help me out with this idea or this concept?' And if they're not able to help me or if I need more help, I go to my professors and they're really able to, you know, not only help me, but expand the ideas."

Persisters' utilization of resources was layered and diverse, while female URM leavers appeared to have an isolated source of support that rarely included an academic resource.

Future Plans: Uncertainty Persists in Educational and Career Goals

Three female URM leavers stated that they were still unsure of their future academic and career goals, a finding shared by male URM students, but not others. While Anna shared the she “still not 100% sure what [she wants] to do,” Jamilah also expressed, “I think I'm still trying to figure out the educational goals.” Alexis explained further, stating, “I really don't know for career goals yet... I really want to find my place, like where I can contribute most, and just a good fit for me.” Paige shared that she will be attending veterinary school but also receiving her Ph.D. in Genetics, while Lydia hoped to enter the workforce in management consulting.

Three male URM students were also uncertain of their future plans. One student explained, “I don't know. I think about this a lot actually. Probably since I left [the WPU School of Engineering] like ‘OK I'm not going to be a computer scientist. What do I do?’” Another admitted, “I know I'm not going to be able to fight off my interest in aviation” but with an international relations degree he was “going to have to cast a really wide net and just try all [his] options.” URM leavers in this study were more likely than other students to be uncertain of their post-graduate plans.

Only one other leaver from the non-URM populations mentioned uncertainty about her future plans explaining, “Before I decide to go to grad school, I want to know what I want to come out of it doing“ Six male and female non-URM students expressed their intent to go on to graduate school, with three female non-URM students also adding that they plan to enter the workforce. As an example of non-URM students' clarity of future plans, one female non-URM student specifically outlined her future—“I'm going to graduate, hopefully get a job at a pretty

good accounting firm, get my CPA, and then work longer until they will force me to get a master's degree.” Six female URM persisters planned on entering the engineering workforce, and four had plans of pursuing a graduate degree. Descriptions of future plans shed light on the dichotomy of URM leavers’ uncertainty and non-URM leavers’ certainty of what is to come post-graduation. This alludes to their confidence in their expected professional outcomes given the academic choices they have made in leaving engineering.

The Female URM Experience in a Second-Elected Major: Fewer Perceived Academic Barriers

Aside from some of the aforementioned challenges that female URM leavers described, three students revealed that they felt pressured to major in engineering before coming to college. That pressure ultimately guided them toward a discipline they retrospectively felt was not what they wanted. Paige described the messages she would hear from others around her, saying “When I went to college, everybody told you, you're going to be an engineer, it's amazing, it's your only option.” She later realized that it was not what she expected it to be and, as a result, switched out. Alexis disclosed, “There was some family pressure that caused me to do it,” and felt that others around her were under similar pressure as well. Anna wished she had entered college as undeclared because “then there wouldn't have been more of a pressure to kind of make a decision on what [she] needed to do.”

Both Alexis and Anna identified the increased flexibility and versatility of their second-elected major as a primary factor in their decision to leave. Anna was able to add a double-major in French by switching to biology. Alexis felt limited in the BME major, highlighting, “I didn’t see myself really maximizing or just like using all of my gifts and abilities,” and as a result changed to International Relations because “it was just a little more versatile, and it gave me

many more options, as far as career.” Lydia and Jamilah, both feeling underprepared for the coursework and experiencing academic difficulty, expressed that they looked for another major where they felt they would be more successful. Lydia explained her decision to switch to Business Administration stating, “Once I got to doing the work it came really, really easy, and I love the subject. Yeah, I just wanted to keep doing something math related because that's one of my strongest points.” When Jamilah was on academic probation, she risked losing financial aid, which she disclosed was a big factor in her being able to attend the university. She explained her thought process saying, “If I already have a pattern in one particular major of not doing well and their ability to give me money is based on my grades, then it's like it makes sense for me to change.”

At some point in their decision-making processes, four of the female URM leavers felt uncertain about the decision, preceding their noted uncertainty of future, post-graduate plans as previously discussed. Jamilah shared, “When I first switched, I felt a little bad because I was like well I never really got to get into engineering that much to say for sure that I didn't like it.” Alexis was unsure of what the consequences would be when she switched. She thought, “I kind of was put in a dilemma, where it was like, okay, well this would be a really, really valuable degree, and practical career, but would I be happy in the end, and will I regret things?” Lydia had a tough transition out of engineering as well, hoping that “maybe engineering will fall into place” since for a time she had no idea what other major to choose. Anna actually considered Biomedical Engineering and declared the major for a few weeks before ultimately committing to switch out of the engineering discipline altogether.

All of the female URM leavers described how their new majors met the expectations they were looking for that engineering did not provide. Paige and Alexis emphasized that they were

able to apply what they were learning in their new majors to what they will be doing in the future. Paige described the difference between Biology and Aerospace Engineering, explaining:

I can understand how it's applied to real life more, versus in engineering it was learn all these formulas and eventually it's going to make sense why you're learning them. While in bio you're learning it, it automatically makes sense.

Alexis summarized her thoughts succinctly by saying, “I can see myself in these settings a little better than I could have seen myself in engineering.” Lydia was able to find the student connection in her business major that she felt was lacking in engineering. She described the business major as very centered on group work:

It kind of connected to me having that shock that I was one of the few Latina women here, even at the university, and I was able to see and work with other people that weren't from my background yet we were able to accomplish this goal and I really love that.

Jamilah also found in her political science classes that she definitely “was more engaged with participating in class” —something that she struggled to experience in her BME 101 class. Anna experienced the genuine interest in the content of her biology and French courses that she did not experience in her engineering courses. Overall, although most of the female URM leavers questioned their decision to leave the engineering discipline initially, they all spoke of their experience in their current major positively.

By contrast, all male URM students who left engineering expressed that they wished they had been able to make engineering work either by finding another engineering major or sticking it out because they still liked the content. This also coincides with an uncertainty of future professional plans indicating that their doubt about their post-graduate plan may stem from originally being hesitant about leaving engineering. Three of the male URM students left engineering due to academic difficulties. On the other hand, about half of the female and male

non-URM students who left engineering cited a lack of interest in the content as the reason for leaving.

Differing from the academic challenges that stemmed from the rigorous course content and the heavy course load, none of the female URM leavers indicated that they had experienced any academic challenges in their new major. While some would consider the coursework as challenging, there was a clear distinction between the intensity of the challenge compared to engineering. Alexis explained, “Naturally the non-technical subject matters are just easier to digest, and just like a little easier to picture. So it’s definitely not easy, but it’s not the same challenge I was having at [the WPU School of Engineering].” Four of the students indicated that the class structure was still lecture-based; however, three students highlighted that there was more discussion incorporated into a course compared to engineering. Anna described her experience now that she had reached upper-division courses in biology, stating, “In the upper-division classes, they get a lot more, kind of, practical and so there's definitely a lot more interaction especially when you have to do research.” Alexis also elaborated on the distinction between her engineering and economics courses: My econ classes are completely lecture-based, but they’re more of discussion lecture-based, because in math and science you don’t really discuss anything. You’re just like really trying to learn the material. So you’re asking for clarification, whereas in these classes, you can ask questions for clarification, but there’s also debate, which can lead to different perspectives, or just lead to you understanding the material in a different way.

Female URM leavers generally spoke positively about their connections with faculty in their second majors, similarly to their positive impressions of faculty in engineering. Jamilah highlighted that “even if the classes were like over 100 people, they were still engaging and

would like try to get people to talk.” After having good experiences with professors in engineering but not being able to attend office hours due to class conflicts, Lydia shared that in the business school “professors reach out to you and their office hours, if they don't work, they try to make, make room for you elsewhere,” which she appreciated. Alexis expounded on her experience with professors in both majors highlighting,

I think that's been just as easy to connect with these faculty members than it was the faculty in [the WPU School of Engineering]. I think it's really about initiative. It's not like any of them have been inaccessible to me at all.

Marisol also had a good connection with her professors while she was in the public policy, planning, and development major, attributing it to the skills needed for that field. She explained, “Like those kinds of things, I think it kind of does foster a more, like, social aspect part of your personality that I think could be helpful with, like, communicating with students.”

Conversely, three female URM students identified a significant contrast in the student connections they were able to make in their new major. Paige, Lydia, and Alexis mentioned that the connections were more superficial. Paige expanded, “They tend to not be as like life-long friendships as I'd gotten in engineering. It was more of you're an acquaintance in my class and that's kind of where the connection ends.” Even though Lydia had difficulty connecting with her engineering peers in class due to her perceived lack of academic preparation, she admitted that she would not “end up having long-term relationships” with the students in her business classes, but nonetheless enjoyed the group work experience she had with them. Alexis was more explicit, stating, “I just don't feel the same, like, belonging. It's not the same sense of community,” attributing it to the larger size of the College of Letters, Arts, and Sciences where her International Relations major is housed. Even though they were not able to achieve deeper connections with students in their second-elected major, none of the students classified this lack

of connection as a challenge. Nonetheless, these descriptions of peer connections varied noticeably to how Lydia and Alexis, in particular, spoke of the close friendships they built through the summer bridge program and the Center for Engineering Diversity. Paige also had the opportunity to participate in the summer program and create friendships outside of the classroom. Connections in the second-elected majors seemed to be limited to inside the classroom, which as a result, did not evolve into deeper relationships. Anna, having built strong connections in biology, even noted that rarity stating; “I think I had a little bit of a unique experience where I lived with the people that I had classes.” When comparing experiences in engineering to second-elected majors, students’ peer connections outside of the classroom seemed to lead to more meaningful friendships, something they did not encounter as easily as they did in engineering.

Similarly to their experience in engineering, only Lydia, Jamilah, and Alexis identified as underrepresented in their second-elected major while Paige and Anna did not. Paige and Anna also classified their second majors as diverse as did Lydia because she was able to “see” more Latino students. Jamilah and Alexis reiterated the caveats to their perceptions of diversity that they shared when describing the diversity they experienced in engineering. Jamilah believed the diversity, and her perceptions, were similar between engineering and political science; while neither was especially diverse, she connected with the others of similar background. She explained, “It could also be my selective attention because I know a lot of people so I happen to gravitate towards them and you know and see them.” Alexis described what she perceived:

Remember when I was saying the exposure? Like I was exposed to a lot of the diversity in engineering because people wanted to make sure that I knew that this was a diverse environment. I don’t think there’s the same priority put on diversity [in international relations].

She highlighted that, while there exists a National Society of Black Engineers, there does not exist a “Black National Society of Economists, but there could be such a thing.”

Compared to their experience in engineering, female URM students most commonly reported an increased ability to connect their new major’s content to applications, a similar experience successfully connecting with faculty, and fewer opportunities to build deeper friendships with other students.

Faculty Perceptions of the Engineering Discipline and Female URM Attrition

Nine engineering professors discussed their perceptions of the engineering academic environment, the potential reasons why female URM students elect to leave the discipline, and what they see as their role in student retention. Four professors indicated that they have been teaching at the university for less than 10 years, with three professors teaching at the university for five years or less. Five professors have taught at the university for more than 10 years.

In the classroom: Towards a more engaged classroom environment amid content constraints. While female URM female leavers desired more opportunities to interact in the classroom, six professors described their classroom environments as interactive. An upper-division computer science professor described his class, explaining, “I encourage them to read their textbook before showing up for the lecture and to use the lecture as the means to ask questions, participate, and treat it as a dialogue.” Two professors teaching introductory courses in biomedical and chemical engineering discussed their recent transition into the flipped classroom model in an effort to make their course more engaging. The biomedical engineering professor described, “I’ve done this kind of flipped classroom type of method where I have the videos on YouTube, and then we do homework in class, and it’s actually the homework that I assign.” The

chemical engineering professor detailed his experience and why he was attempting a flipped model, stating:

My teaching style is completely in flux right now. I've been spending a lot of time thinking about active learning and thinking about ways of engaging the students. What I want is engagement, and traditionally I've tried to achieve that through your standard lecture with reflective questions, trying to get responses from the students on the fly. That works for maybe 15% of the students in the class because the vast majority of the class is not engaged with the lecture.

As this study was being conducted, this professor was planning out his first semester of flipping the classroom; thus, none of the students interviewed would have experienced that model with him. Jamilah and Alexis both took the introductory biomedical engineering class; however, their comments on the lack of interaction in class imply that they may have taken another section. Both professors became aware of the flipped classroom model through their participation in engineering education organizations, including the WPU Division of Engineering Education and the National Academy of Engineering.

Five professors mentioned that a group project was a component of their course, something that most of the female URM leavers appreciated. An electrical engineering professor believed, “students learn more from one another than they do from me so I strongly encourage the interaction among students and between students.” An aerospace engineering professor reflected on her reasoning for adding a project to her course, stating “when I started this course two years ago, I knew that the previous several years there hadn't had any hands-on projects, and I felt in fluid mechanics you need to do something hands on, and they're engineering students.” Faculty participants appeared to be very aware of the need for increased engagement and have identified strategies, influenced either through their involvement in engineering organizations or through observations made in their teaching experience.

As professors discussed their strategies to engage their undergraduate students, many revealed how difficult it could be to achieve engagement given the material. An upper-division aerospace engineering professor highlighted, “Eventually it's hardcore engineering so you can....you cannot avoid it, you see. You cannot make it into a literature course.” A chemical engineering professor explained her constraints:

In a class like heat transfer/fluid dynamics, you have to cover a certain amount of material within the semester because it's ABET-accredited. That kind of format, there isn't much you can do because you have to cover so much material.

A computer science professor claimed that “the technical material is very dry” and followed up by expanding that, “The topic is so technical to begin with that I need to be on top of it to be able to lecture effectively and not to misguide,” and therefore has limited opportunity to engage students. A chemical engineering professor confessed, “I feel a deficit in effectiveness to be honest with you...as an engineer, the undergraduate engineering curriculum can be quite dry and that's nobody's fault. That's the nature of the beast.” So while the majority of professors interviewed were concerned about utilizing effective engagement strategies with students, many shared the limitations they felt the material imposed. Female URM leavers may have felt the impact of those limitations as they described the minimal opportunities to connect what they were learning to their own interests or to real world applications.

The engineering academic experience: Echoing student perceptions and providing support. Professors noted the tight curriculum, heavy course load, and increased pressures that female URM leavers also discussed. One aerospace engineering professor described it as “they're under much, much pressure because time is very, very limited so they don't really have time to sit and think.” An engineering writing professor compared engineering to other majors, stating that “you need much more discipline and the load is much higher...you cannot just not study.” A

chemical engineering professor expressed that he believed the “curricula tend to be a lot more crowded” than other fields. As a result, one aerospace engineering professor felt that students were generally “very focused on high grades.” Two other professors identified the crowded curriculum as one of the biggest challenges for engineering students, regardless of background. One engineering writing professor noted that there is “not much flexibility in their schedules” and that they “perhaps may be too narrowly focused,” a sentiment expressed by Alexis and Jamilah as they described their reasons for switching out of the discipline. A chemical engineering professor described the efficacy and resilience required to do well amidst the challenges. She stated:

Students who don't do well are the ones who come in and are like ‘oh this is really hard’ and so then they convince themselves it's too hard and then they use that stereotype that they have decided is true and then they let it be hard the entire time. So, like, they're just convinced they're a C student and they're convinced that it's hard. The self-fulfilling prophecy.

This statement mirrors the experiences of Lydia and Jamilah expressed when describing the academic difficulties they faced in physics and the introductory engineering course, respectively.

Professors varied in their perceived roles of supporting students through the academic challenges. Two professors emphasized that their role is to be forthcoming and realistic about what engineering entails in an effort to help students decide early on if they are truly interested in pursuing the discipline. An engineering writing professor provided an example of what he does: “Letting them know what an engineer does day in and day out and you know, ‘is this really what you want to do?’” An aerospace engineering professor echoed the sentiment, saying:

Especially in the first year, you have to explain to them what engineering is all about and first find out really if they're in the right discipline, if it's really what they think engineering is, or the type of engineering they want, or what are they good at.

A biomedical engineering professor described, “What I personally don’t want is for students to go through four years of a very difficult engineering curriculum to say ‘gee, this is not really what I signed up for. This is not what I wanted.’ So four years, \$160,000+, it’s just....you gotta make the best possible choice in the beginning.” Other professors indicated that it’s important to help students maintain perspective. The chemical engineering professor explained:

I have students who come in who struggle, and I’m always like, they come in and they’ve done badly on their exam and their like ‘what can I do?’, and I say ‘well you have another exam, so let’s like forget about this scenario. Not that it goes away, but you gotta keep going.’ You’re kind of like their cheerleader.

An aerospace engineering professor highlighted the use of examples as a tool to provide perspective—“I have to provide them with some kind of like ‘If you do this you can design the next slides at Disneyland, how cool wouldn’t that be?’” As Paige highlighted, these types of connections may have helped her connect what she was learning to what she wanted to do.

Engineering school climate: Strong engineering culture, adequate gender representation, but limited racial diversity. Two professors noted the presence of a strong engineering culture at the school, primarily due to the rigorous coursework. One professor described it as “everyone’s working really hard and that’s just what defines an engineer. So you can get this really large engineering culture that keeps you....its your comfort blanket.” The same professor continued, specifying, “The engineering culture is dominating any other culture. So there’s no like White culture, there’s no Hispanic culture, there’s no Asian culture. The culture is engineering.” However, like Lydia and Marisol discussed, it is much more difficult if students feel like an outsider to that culture.

With regards to the climate of diversity, five professors classified the school as diverse at the undergraduate level. Two used their own institutions as a point of reference to determine that the WPU School of Engineering is much more diverse. However, three professors went on to

clarify that racial diversity is minimal. A chemical engineering professor specified that about 8% of her class may classify as racially underrepresented—“We have an occasional racial minority...I would say in last year's class, out of 60, maybe 5 students might have fit some kind of either whether it was Hispanic or African-American.” An engineering writing professor also noted minimal racial diversity, stating “I think people of color tend to, you notice them more, because they're, as a factor of population, there's fewer of them... From my years I think it's getting better at least as far as the percentage of women.” He went on to note the impact he perceived on those students in the minority, mentioning, “I think it depends on the person. I've known some who find it very empowering in that you know they're going against the odds,” echoing the sentiments of some of the persisters who spoke of that pride. As explored below, however, most professors spoke more confidently of their perceptions of the experience as a gender minority student but were a bit more uncertain when it came to considering the experiences of URM students.

The female URM experience in engineering: Professors' perceptions of academic and environmental factors as deterrents to female URM persistence. Professors provided their impressions of what they have witnessed among their female, URM students. Professors spoke most often of their perceptions of being a gender minority in engineering. Five professors spoke specifically of the challenges female students likely face in the major. A chemical engineering professor stated, “I think that there is a persistent, though subtle, and pernicious bias against women in technical fields. You know, it's something that's very hard to see on a day to day basis.” Another chemical engineering professor provided an example of the dynamics she has witnessed in group presentations. In mixed-gender groups, she noticed that the male students would present the more technical and challenging aspects of a project, while women took the

softer portions of a presentation. “It wasn't showing what people were capable of, but showing what risks they were willing to take. So I saw females taking less risk in the classes.” An electrical engineering professor expanded on the gender dynamic in the classroom, explaining, “There's discouragement rather than encouragement all too often, and, oftentimes in the classroom, female students are hesitant to compete. Again I don't want to generalize, but male students tend to dominate particularly in technical areas.” Echoing this, while five professors indicated female URM students attended their office hours and achieved grades about the same as other students, five indicated that they participated in class at a lower rate than other students. One female, aerospace engineering professor called on her own experience as a female engineer, disclosing, “I realized that some of my colleagues or the senior people, they couldn't handle women.”

Some professors admittedly stated that they were not as familiar with the URM experience as they were the female experience. The chemical engineering professor who spoke of the “pernicious bias against women” revealed that he has less of an understanding of the URM experience, mentioning, “that I have less experience with because I don't know many because there are so, so few.” An aerospace engineering professor stated, “it's always nice to have, to feel like you belong, and I don't know, if you don't, I don't know. It's hard. I haven't really thought about that at all.” A computer science professor spoke openly on the issue confessing, “I'll be honest with you, I don't have an answer. I just don't think in those terms.” While students like Lydia, Jamilah, and Alexis described their unique experience as an underrepresented racial minority in the classroom, some professors had not thought of what that reality may be like for their URM students. This unfamiliarity with the URM experience could inhibit the development of learning environments that are cognizant of that diversity.

Professors who did speak to the female URM experience in engineering gave varying examples, but all acknowledged that the experience may be unique as compare to those in the majority. An engineering writing professor provided an example of discussions she would have with her female, URM students. She explained, “Some of the, the minority students, or also the women, especially like in mechanical engineering that sometimes people would be surprised that they’re an engineering major.”

A biomedical engineering professor hypothesized that female URM students felt less prepared for the coursework, echoing the experiences of Lydia, Jamilah, Alexis. He reflected:

I do get the sense that they did not come from a high school that had good STEM preparation. I think as a consequence to that, they do feel a little bit intimidated and maybe discouraged about continuing with engineering because they do see that there's a lot of catch up that they would have to do.

Some professors also discussed a lack of faculty diversity as having an impact on students, although only one male URM student brought the issue up and no female URM students mentioned it. The electrical engineering professor explained:

I really believe the fact that Latino or African American or American Indian students will go through four to five years of engineering study and never ever have a faculty member who looks like him or her in front of the classroom has an impact and it puts the question in mind "Should I be here?"

One chemical engineering professor explicitly stated, “I think people need to see role models.”

Another female chemical engineering professor of Indian descent described the unique situations she has been in as a professor for female URM students: “I’ve seen underrepresented minorities ask me how I feel being in a racial minority. And then I’ll be all confused and I’ll be like oh, that's because they perceive me as thinking I am, which is good for them.” Across the board, professors perceived the importance of role models of similar backgrounds more than female URM students stated.

Professors varied in their perceptions of why female, URM students leave engineering with most stating that they were uncertain or that it was something they had not paid attention to it based on a lack of interaction with students considering leaving. Others identified familial pressures as a potential reason for leaving. One professor expressed that engineering is “not respected as a profession” and that “many times people coming from a background where their family has not had a lot of college education or they may be the first generation attending college, they want to be a respected professional” giving examples such as lawyers and doctors. Another professor mentioned a similar perception stating, “I think there could be more challenges that I don't even know about like from home or if you're first generation going to university.” A chemical engineering professor explained that there's like a lot of societal stuff that tells women that their values are....they have a different set of values” and that “you kind of need a family to tell you” to pursue engineering, like her own family did. While professors felt that a lack of supportive messages, from family or society, could be one of the reasons female URM students do not persist engineering, female URM leavers expressed quite the opposite experience, as they often felt pressured to enter the discipline not realizing they were not interested.

Professors’ perceived role in female URM retention. Professors largely felt their role in retention was to provide a positive and affirming picture of the field for all students. One faculty member elaborated:

Faculty felt that their job was to weed out students and that was a high priority. Whether that's true or not, that was certainly the common feeling. I think faculty have to present a completely opposite picture, that we expect you to be successful and that positive attitude toward all students I think is very important. It's particularly important for underrepresented minority and female students-- they need to know that they're in an affirming environment.

Another professor touched on a similar perception, indicating that the role of professors is "to show them that their ideas and the work they do here has value. Once it has value they will do fewer things to jeopardize that." Another professor discussed his perceived responsibility with retention saying, "I never saw myself as having a role in retention... I tell them that BME 101 is not a weed out class...the real course goal objective is to see if they want to major in it." Jamilah echoed this experience from her BME 101 class stating "[the professors] really wanted to like make sure that we knew what was going on, or like what to expect," though she later went on to explain that her BME 101 professor was not very approachable, nor were her peers in the class. While "weeding out" academically may not have been perceived, weeding out may be occurring through subtly difficult interpersonal interactions with faculty and peers.

Professors elaborated on their perceptions of what female URM students need in particular by first highlighting that "they need the same thing as all other students but just more" as one professor said. Another expressed it as making sure these students "receive some extra encouragement to know that there are, there's help to get extra help." Faculty seemed to understand that all students need some level of support in engineering, and support for female URM students does not necessarily need to be different, but just increased. Another professor offered the idea of "some kind of additional mentorship by a senior female underrepresented minority" as an added support mechanism. In the classroom, one professor highlighted that it is important "to be as personable as possible" while another emphasized to "know where obviously the potential of subtle biases and avoid those scrupulously. Be careful in the language that you use." He explained that language is important in creating an inclusive environment for students of diverse backgrounds, reflecting:

I haven't thought about the language issues that might arise with underrepresented minority students. It's easier when thinking about gender issues because it doesn't take

that much practice to check gender language. Yeah, I would be interested to think about language issues when thinking of underrepresented minority students.

One professor explicitly expressed his hope for his colleagues, stating that “[he’s] not suggesting that faculty members treat anybody differently, but they need to be sensitive to the fact that these students are more likely to need their support, their warm encouragement, sensitivity to their needs.” Another more simply stated, “Just being there. I think, you know, if you accommodate their needs I think that's what is the best.” Consideration and concern for underrepresented student populations was common among faculty, even as some expressed uncertainty of how to specifically identify and address their unique needs.

Salient Findings and Conclusion

In summary of the previous sections, the following are salient findings stemming from the experiences of female URM students who have left the engineering discipline, as compared to persisters, other students who have left that are in the gender or racial majority, and faculty.

Finding #1. URM identity influenced female URM leavers’ perceptions of the engineering academic environment and of the climate of diversity in the school. Two leavers who did not identify as URM felt the school was diverse, while three URM-identified students felt the school was either not diverse, or was perceived as diverse due to access to the Center for Engineering Diversity. Differences in perceptions among these two groups continued to emerge in many of the subsequent findings as well.

Finding #2. Compared to others, female URM leavers were less likely to utilize self-directed learning strategies as an approach to addressing challenges. Only one female URM leaver referenced an element of self-directed learning, such as changing study habits, versus over half of other students. Compared to persisters, female URM leavers were also less likely to reference a network of multiple and varied sources of support.

Finding #3. Perceived academic barriers including heavy course loads, lack of connection between material and application, and perceived academic deficits deterred female URM students from persisting engineering. All five female URM leavers reported one or more of these academic challenges as a factor in leaving the major, however, the three female URM leavers who identified as URM were the only ones of the group to discuss perceived academic deficits. Faculty reiterated this reality by identifying the same factors as reasons they perceived female URM students left engineering.

Finding #4. Female URM students experience difficulty participating in class due to perceived lack of academic preparation. Related to the prior finding, the three URM-identified leavers reported hesitation to speak either due to not feeling knowledgeable about the material or the pace of the class being too fast. Professors largely indicated that while female URM students attend their office hours at a rate similar to other students, most participate less in class.

Finding #5. Targeted support programs for URM students were effective in connecting female URM students with their peers. Four of five female URM students participated in a pre-college summer bridge program targeted to URM engineering students. The three URM-identified students indicated that this program played a significant role in their ability to connect with other students. Two of these students elaborated further expressed that connecting with peers inside of the classroom was not as easy.

Finding #6. While diversity is perceived school-wide, a lack of diversity is felt inside the classroom. Of the female URM leavers, once more, the sentiment was shared among those that self-identified as URM. Both female URM leavers and persisters indicated that they experienced a lack of diversity within their classes. Female URM leavers referenced issues of gender diversity less frequently, focusing their perceptions on the lack of racial diversity.

Finding #7. Along with male URM leavers, female URM leavers were more likely to be uncertain about their professional outcomes. Three female URM leavers expressed doubt while only one female non-URM student did so of the other populations. The following discussion will connect research and recommendations to these salient findings as well as other notable data

CHAPTER FIVE

Discussion

Female URM students often have a unique experience in the STEM discipline compared to their counterparts in the majority (Carlone & Johnson, 2007; Espinosa, 2011; Johnson, 2007; Leslie et al., 1998). This study explored those unique experiences as shared through the stories of five female URM students who switched from their engineering major into a non-engineering discipline. As presented in the previous chapter, there also exist some similarities with other student populations, often aligning along gender or URM identity lines. This chapter discusses the study's salient findings as related to the project's theoretical framework.

Lent's (1994) Social Cognitive Career Theory (SCCT) served as the core framework of this study. Findings emerged within the factors of SCCT, including self-efficacy, perceived barriers and supports, perceptions of school climate, other group orientation, and outcome expectations. For example, the study's first finding sheds light on female URM leavers' level of self-efficacy while navigating through the engineering environment. Unlike persisters, female URM leavers were less likely to implement self-directed learning strategies in response to academic difficulties. Conversely, leavers in the racial majority oftentimes indicated that they largely responded to challenges on their own, displaying an increased confidence in their abilities, which connected to their likelihood of indicating factors other than academic difficulty as their primary reason for leaving the discipline.

Prior research has found that women have lower levels of self-efficacy in math and science than their male counterparts (Leslie et al., 1998). However, the findings in this study expand on previous research, as female students in the racial majority relied on their own study abilities most often. Nonetheless both populations in the racial majority were much more likely

than female URM leavers to view themselves as an academic resource, as well as more likely to attribute their decision to leave engineering to factors other than the discipline's academic difficulty. This exemplifies the confidence these students had in their own academic abilities, a self-assurance much less prevalent among female URM leavers. This finding and other connections are explored in the paragraphs below, responding to the study's research questions and drawing connections to the literature. I conclude with a discussion of the study's limitations, the implications for future research and the recommendations for practice.

The Influence of URM Identity on Academic Perceptions

When students were asked whether they identified with a group that they felt was underrepresented in engineering, Paige and Anna, said they did not. Paige and Anna were also the only two in this population to consider the engineering environment as diverse. Given the connections between how URM women self-identified as underrepresented and their perceptions of the diversity within engineering, findings from this study revealed that URM identity influenced female URM leavers' perception of the diversity of the engineering school. It is important to highlight the distinction here, as oftentimes the experiences that Lydia, Jamilah, and Alexis described differed from what Paige and Anna depicted. Paige and Anna did not describe difficulties in connecting with others in their classes, never perceived the environment as competitive, and never questioned their academic preparation for the work. While the connection between URM identity and these unique perceptions of the environment cannot be made, this study exposes the relationship between URM identity and perceptions of a diverse environment, which could influence other perceptions of the experience.

Social Cognitive Career Theory

Factors including self-efficacy, perceived barriers and supports, perceptions of school climate, other-group orientation, and outcome expectations were explored in relation to how female URM students perceive the engineering environment. While SCCT studies have been quantitative in nature, this research provides qualitative data that add students' voice to the statistics. The subsequent paragraphs connect salient findings and other pertinent data to the factors included in SCCT and address the research questions pertaining to the social cognitive factors and perceptions of the engineering academic environment that influenced female URM students' decision to change majors out of engineering as compared to male and non-URM female leavers.

Self-Efficacy. Byars-Winston et al. (2010) explored self-efficacy as one variable in connection to students' persistence in engineering. Self-efficacy has been found to have a direct relationship with outcome expectations of STEM degree attainment and the relationship was found to be stronger among those who perceive favorable academic environments (Byars-Winston et al., 2010; Lent et al., 2003). Reported differences in self-efficacy were most specifically conveyed in Finding #2: Compared to others, female URM students who switched out of engineering were less likely to utilize self-directed learning strategies as an approach to addressing challenges.

Self-directed learning was exemplified in instances when students dedicated more time to learning course content on their own when they encountered academic challenges in their engineering major. Female URM leavers mentioned responding to challenges on their own much less frequently than their counterparts in the racial majority. For example, one female non-URM described that she would "just go back and read...go back to the lecture part and go back to all

the questions they assign and even the ones [the professor] didn't really assign just to get more practice.” Student leavers in the racial majority were more likely to be confident in their own academic abilities, exhibiting that confidence in their discussion of addressing academic challenges on their own. These students were also less likely to indicate that they left engineering due to academic difficulties, implying that they felt they could have succeeded if they had elected to continue. Compared to students like Lydia and Jamilah, who were both acutely aware of what they perceived to be an academic deficit, leavers in the racial majority described a very different experience academically as exhibited by their reliance on themselves as their primary academic support.

Paige was the only female URM leaver to reference her own study strategies as part of her response to academic challenges versus over half of female URM persisters. The remaining four female URM leavers discussed utilizing one or two external resources of academic support, including their peers or attending supplemental instruction sessions. However, they made no mention of adjusting their own study approach in response to the difficulties.

Accessing resources and actively engaging with the academic environment has been found to create a greater sense of commitment to STEM (Gasiewski et al., 2012; Good et al., 2002; Herrera & Hurtado, 2011; Perna et al., 2009). However, this study expands on this research, exposing a key difference between female URM leavers and persisters who both accessed many of the same resources. Both female URM leavers and persisters identified their peers and the Center for Engineering Diversity as important sources of support. Both groups also mentioned academic support programs as a resource, but persisters referenced them much more frequently. In addition to peers, the Center for Engineering Diversity, and academic support programs, persisters included self-directed learning strategies as a factor of their academic

success, whereas most leavers made no mention of it. One persister described how she adjusted her approach over time, stating “before I used to take notes and like ‘OK, there we go, done with that week,” but with the demanding course work learned she had to review her notes more often. It was uncommon to hear female URM leavers describe their response to challenges with similar self-assurance.

Subtly, the language that persisters used as they described their response to academic challenges was unique in comparison to leavers. Persisters were more likely to speak from a place of authority, with five of the persisters commonly using “you” in a manner of providing advice as to what a student needs to do to succeed in engineering. For example, statements such as “Well you have to be in class because your professor needs to know you” and “You need to like set deadlines for yourself” varied noticeably from how female URM leavers were describing their approach. What seemed to be missing from female URM leavers’ stories was their ability to view themselves as an academic resource while persisters appeared comfortable enough to view themselves as an authority in engineering success.

Three of the five female URM leavers expressed some doubt over their academic preparation and their ability to keep up with their peers. Those three leavers also happened to be the three participants who identified as URM. Paige and Anna, the biracial students who did not identify as URM, never expressed such doubt in their abilities. Besterfield-Sacre, et al. (2001) found that female engineering students are more uncertain about their background knowledge about engineering and have lower confidence in their abilities to succeed in engineering than male students. While one male non-URM student reflected, “I guess it wasn’t as hard, for me, as it was for some of my colleagues,” another was more frank about his academic ability, stating, “I didn’t leave engineering because it was too difficult. I left because I didn’t want to do it.”

At the other end of the spectrum were female URM leavers, particularly Lydia, Jamilah, and Alexis who each explicitly described their self-doubt. Lydia seemed to have entered into college aware of her deficit in physics, revealing that she knew she “wasn't going to be as strong in that area” and subsequently switching out of the major entirely because of that difficulty. As demonstrated in the preceding comparison of female URM leavers with their male non-URM counterparts, self-efficacy in science and math among female students has been found to be less evident than for male students (Leslie et al., 1998). However, data in this study also notably evidenced the need to investigate race in addition to gender as it relates to self-efficacy, as levels of self-efficacy seemed to break more along racial lines rather than gender. If using self-directed learning as one indicator of self-efficacy in math and science, male URM students also showed lower levels of self-efficacy as only one student mentioned utilizing his own study strategies to succeed and most of them left the discipline due to academic challenges. Conversely, female non-URM leavers were similar to male non-URM students in their level of confidence and reliance on their own abilities leaving the opportunity for future research to explore self-efficacy among specific racial and gender groups more explicitly.

Perceived barriers. Perceived academic barriers were a primary reason female, URM students left engineering. Reflecting the literature, Finding #3 highlights that perceived academic barriers included heavy course loads, lack of connection between material and application, and perceived academic deficits deterred female URM students from persisting engineering. Seymour and Hewitt (1997) found that students experienced curriculum overload in STEM, an experience that Paige mentioned explicitly when describing the heavy load freshmen are required to take. She provided feedback explaining that “if you give freshmen the time to kind of break it up, like maybe one intro course and a couple of GEs or just not as scary of material,” the first-

year transition would feel a little more manageable. Relatedly, Alexis, Jamilah, and Anna each discussed how limited they felt given the curriculum rigidity and lack of space for some of their other interests, ultimately causing them to pursue another major that allowed more room educationally. Anna explained, “I was just like you know, just going to do biology, it's more flexible. I think that was one of the main things...reasons that I changed was the flexibility.” Within Alexis’ first year in engineering she realized, “I like math and science, but I like so many other things too, and I kind of had to put them down to pursue the BME degree.” The ability to incorporate other interests was important to female URM leavers and exposed their unique view of what the engineering discipline would, and would not, provide for them.

Statements describing the inflexibility of the major were more common to female URM leavers than with any other group. Male and female non-URM students were more likely to indicate that they simply wanted to study something else and did not mention engineering’s inflexibility as a factor. For instance, non-URM students were more likely to express that they’d always wanted to pursue another discipline even while they were in engineering. Male URM students also did not identify the inflexibility of the major as a reason for leaving, focusing their discussion on the level of rigor being the impetus. As opposed to students in the racial majority, male URM leavers largely indicated that they wished they could have continued to pursue their engineering interest. Female URM leavers uniquely appeared to hold interests in both engineering and other disciplines falling somewhere in the middle on the continuum of engineering commitment, between the uncommitted non-URM students who reported never having a true interest in engineering and the highly committed male URM students who felt that they had to pursue something else due to academic difficulties.

Research has found that women of color leave STEM partly due to the lack of connection between course content and the student's own goals (Espinosa, 2011). Echoing the literature, of the students who left engineering only female URM students indicated the importance of making connections between classroom content and its application. Paige and Jamilah explicitly discussed their challenges making these connections while Alexis and Anna spoke of their loss of interest in the discipline due to their introductory engineering courses not providing them with the content they expected. Paige expanded on what she observed early on in the major, stating, "Everybody seemed to be working with some government agency on weapons. That's kind of the exact opposite of what I wanted to do. I wanted to design cars. I switched after one year." Alexis shared, "biomedical engineering, I just assumed that it would be just like the medical spin on it. But, I mean, they're different..."

Although female URM persisters were clearly committed to the major, they too echoed leavers' sentiment of wishing for more real-world examples. This highlights that, in comparison to other student populations, female URM students uniquely seek an engineering academic experience that is applicable to their goals regardless of whether they elect to persist. It is possible that these students entered into the discipline with an unclear perception of what engineering would entail; however, most of the female URM leavers in this study were exposed to some type of pre-college engineering program or course, more so than any other student population interviewed. Thus, there seems to be a disconnect between what is being presented in a college engineering classroom in the first year compared to what these students had previously experienced engineering to be.

A lack of academic confidence, coupled with a fast-paced classroom environment contributed to female URM leavers' having difficulty participating in class due to a perceived

lack of academic preparation. Notably, this sentiment was only shared among the three URM-identified participants. Lydia admitted that she “kind of just sat there and just listened, because [she] really didn't have much to contribute” due to feeling confused. Even if professors open up the floor for questions, the transition from lecture to discussion with students may be abrupt and not conducive to questions (Johnson, 2007). Jamilah provided her experience, which echoed the literature when she described her challenges participating in her introductory biomedical engineering class. She spoke of her professor:

He was very like an expert in his field so he talked that way, like ‘Oh yeah, I just know about all this stuff’ you know? So it didn't, it wasn't, because he wasn't engaging, I think that attitude, the like impermeability of being able to ask questions and stuff like that. I didn't feel like it was that open.

Jamilah also spoke of the speed of the teaching and its subsequent limitation in allowing for her participation in class. The experiences reported by Jamilah and Alexis connected with Seymour & Hewitt's (1997) research on students' perceptions of fast-paced teaching in engineering and the added layer of challenges it creates. Other students, aside from one male URM leaver and one female URM persister, did not describe such an experience. These female URM leavers, as a result, largely did not feel they had the space and time inside the classroom to successfully process the information and participate actively.

Faculty perceptions in this study largely echoed the experiences of female URM students with many professors identifying at least one of the aforementioned academic barriers as a reason female URM students elect to leave the discipline. One engineering writing professor noted the difficulty in “achieving satisfaction with the discipline” while an aerospace engineering professor attributed the fact that “there's a lot of work to do under little time” as another primary challenge for students. Added to the discussion from the faculty perspective was the challenge they shared in trying to create an engaging classroom given the highly technical material. As

research suggests, STEM students who are enrolled on campuses where STEM faculty more readily incorporate student-centered pedagogy into their courses, their likelihood to complete their STEM degrees increases (Hurtado et al., 2012). Most faculty in this study seemed to acknowledge this and described their experience putting forth changes to their classroom to increase student engagement, including flipping the classroom and more providing real-world examples. However, many of the same faculty reported that challenges persist given the nature of the content, described more explicitly by a chemical engineering professor as “a significant pedagogical challenge” in the work.

Perceived supports. As previously discussed, while students who actively engage with their academic environments through supplemental instructions and/or tutoring also describe a greater level of commitment to their STEM pursuits (Gasiewski et al., 2012; Good et al., 2002; Herrera & Hurtado, 2011; Perna et al., 2009), all five female URM students who left engineering engaged academically. When explored more closely, a primary difference between female URM leavers and those that are persisting are the number of academic support resources identified.

Five of seven URM women who persisted in engineering identified at least three different sources of academic support and often included professors as a resource. All five URM women who left engineering identified just one or two sources of support, and only Paige mentioned her professor as a resource. Paige, Jamilah, Alexis, and Anna indicated that their peers were a primary resource and study groups were a common part of their experience. Lydia only indicated that she attended supplemental instruction sessions and relied on her sister for additional support. Jamilah and Alexis also mentioned accessing free tutoring through the academic resource center. In comparison, female URM persisters more commonly listed a string of varying support resources. For example, one female URM persister listed supplemental instruction, the academic

resource center, and her academic advisor as her primary trio of support. Another persister indicated that her professor, study groups, upperclassmen, and her own study strategies were how she handled academic difficulties. So while it was evident that leavers do actively engage with *some* academic resources, which the literature would indicate an increased commitment to engineering, persisters accessed a suite of varying supports pinpointing an important difference between the two groups.

From the results of this study, it appears that the depth and diversity of support resources plays a role in a student's likelihood to persist. Alternatively, it may be that a student's shrewd understanding that accessing multiple sources of support is necessary for success in such a rigorous program promoted their persistence. Nonetheless, this study uncovered a distinction between the way female URM leavers and persisters perceive and access available supports.

A core element of SCCT is the understanding that environmental barriers and supports, whether perceived or actual, have an impact on students' belief of their own success (Lent et al., 2003). Female URM leavers accessed some of the same academic resources as female URM persisters, but leavers were less likely to have an academic support strategy that pulled on multiple resources, nor which included themselves as a potentially valuable resource. Oftentimes, persisters discussed many of the same academic challenges in the engineering discipline, and one student even spoke of the uncertainty she felt about continuing at one point. Nonetheless, all of them persisted within the discipline amidst those challenges. As the data from this study indicate, a primary difference between female URM leavers and persisters was the level of perceived self-efficacy to succeed in the discipline. Leavers were less likely to perceive themselves as an academic resource and less likely to access a varied set of supports. As a result,

this outlook may have influenced their own perceived self-efficacy in tackling the same academic barriers that persisters described and overcame.

Participants in this study also revealed that targeted support programs for URM students were effective in connecting female URM students with their peers. Recruitment and retention efforts aimed at female and URM students via support centers have been found to be some of the best predictors of retention in STEM (Hilton et al., 1995). Alexis highlighted that “she knew a handful of students very well” before classes started due to the summer bridge program, and Jamilah described the positive experience connecting with others, explaining, “it was really easy because like I said I did that pre-freshmen year program.” Paige and Lydia, as well as three persisters, echoed the experience providing insight into the ease with which students participating in this targeted support program could build close peer relationships.

Seymour and Hewitt (1997) found that all URM students who persisted in STEM identified a support program as a key to their decision to remain in the major. This study echoed the research in that persisters commonly identified the targeted support they received through the Center for Engineering Diversity as an important factor in their transition into engineering and into college. Though female URM leavers ultimately left the discipline, the impact of these support programs was still largely evident as they indicated that the friends they made through these programs remained their primary social connections even after changing majors. If these support programs did not exist, the number of female URM leavers may in fact increase, particularly given the distinction these students made in their description of the overall engineering climate in comparison. This distinction is explored in the following section.

Perceptions of School Climate. While female URM leavers and persisters both spoke of the impact the Center for Engineering Diversity and its summer bridge program had on their

ability to connect with their peers, only female URM leaver went on to say that those strong connections did not occur in the classroom, citing a competitive academic environment as a primary reason. After describing the very positive experience she had making friends through the summer bridge program, Jamilah shared a different perception of the school's climate outside of the support program. She stated, "I think the environment was more competitive than what I expected in some ways because I've always learned about engineering as being a collaborative." By contrast, persisters noted the competition inside the classroom but spoke of it more as an expected, at times necessary, part of the engineering discipline that did not adversely affect them. Thus, while leavers described their positive involvement in targeted support programs, the perceived competitiveness in the day-to-day engineering experience negatively impacted their perceptions of the academic environment overall.

Stemming from the perceived differences between experiences within targeted support programs and the actual engineering classroom environment, this study also found that while diversity is perceived school-wide, a lack of diversity is felt inside the classroom. This finding was once again echoed between both female URM leavers and persisters. Jamilah explained, "Separate outside of class, [CED] helps you kind of realize that there was a community of minority students" while within the classroom she was "clearly one of the only...one of [her] kind." Therefore, while targeted support programs successfully created the diverse environment that female URM leavers sought, the experience did not extend into the classroom.

URM Identity and Other Group Orientation. Leavers and persisters who highlighted differences between perceived diversity in and outside of the classroom responded to the reality in very different ways. Leavers elaborated on the difficulty they experienced in building strong connections in the classroom, or as Lydia described as "shock," revealing the added challenge of

not seeing another female URM student in the classroom. Conversely, some female URM persisters highlighted the pride they felt being one of few minority women in their classes. While increased student interactions and the building of peer networks have been found to have a positive effect on STEM retention (French et al., 2003; Hurtado et al., 2007; Perna et al., 2009; Seymour & Hewitt, 1997), students in the gender/racial minority face challenges if their perceived connections are limited to only other minority students. From this study, a student's other-group orientation played an important role in her engineering persistence. Those who expressed difficulty in creating connections with students outside of their identity group were more likely to leave the discipline.

Students' perceptions of racial climates can be real or perceived and may also be influenced by their prior exposure to similar environments (Chang et al., 2011; Fleming et al., 1995). Three persisters highlighted this notion when talking about their navigation through the lack of diversity in their academic environments. After noting the lack of diversity in the classroom, these persisters emphasized that the experience was not new to them, implying that they have accepted the reality and were capable of moving through it. One student admitted that it is no longer "much of a shock to [her]" when she is one of few minority students in an academic environment. None of the three leavers who described the lack of diversity shared this experience.

Notably, conversations about diversity and identification with an underrepresented minority group in engineering rarely intersected race and gender. Of the leavers, Lydia was the only one to speak of being both a racial and gender minority. Jamilah and Alexis primarily spoke of being a racial minority and Anna, in response to being asked about whether or not she

identified with an underrepresented group explained, “I mean I guess I could say women, but really there’s a decent amount of girls here so no.”

These distinctions in underrepresented identity also appeared in the responses of female URM persisters. Five persisters identified as either a racial minority or a gender minority separately: three as URM and two attributing it to their gender. Only two persisters spoke of both their racial and gender identity as underrepresented. While students were not explicitly asked about their thoughts on the intersection of race and gender on their experience as a female URM student in engineering, the interview protocol allowed space for a discussion of that intersection to emerge if the students brought it to light. As a result, the intersection of race and gender minority identity did not appear to be largely relevant for most participants, as students aligned more closely with what seemed to be their more prominent identity or with the identity that they perceived to be more of a minority in the engineering program.

Outcome Expectations. Non-URM students appeared more certain and confident of their decision to leave engineering with many indicating they were never truly interested in engineering and, as a result, were able to easily identify another specific academic pursuit. Female URM leavers described their process differently. All, with the exception of Paige, expressed uncertainty about which discipline to pursue and indicated that the decision to leave was not as simple as it seemed to be for others. What they were certain of, however, was that engineering was not for them. Lydia and Jamilah cited negative perceptions of their own success in the discipline, and Paige, Alexis and Anna identified that the content was not a good fit for them. However, it is possible that these sentiments are influenced by their desire to rationalize their decision to switch out of the major.

As previously discussed, direct relationships between self-efficacy and outcome expectations have been found as they relate to STEM goals, and this relationship is stronger for those who perceive favorable conditions in their environments (Byars-Winston et al., 2010; Lent et al., 2003). Lydia and Jamilah in particular did not perceive favorable conditions in their academic environment and felt that they were limited in what they could do to be successful in the discipline. Female URM students seemed to have pursued engineering due to a more dedicated interest in the field while non-URM students emphasized that they were never fully invested in the discipline. Consequently, their decision to pursue another major did not entail as much consideration as it did for their female URM counterparts. Three male URM students echoed Lydia and Jamilah's lack of perceived future success in engineering as the impetus for leaving.

Both male URM leavers and female URM leavers were more likely to be uncertain about their future professional outcomes compared to non-URM students who opted to leave engineering. Female URM leavers were more likely to indicate doubt in their academic preparation, were less likely to view themselves as an academic resource, and did not feel like they were able to connect their coursework to their professional goals while in engineering. These students' academic experience in the major was often marred with uncertainty in many forms, whether it be in their own abilities or in seeing those connections between coursework and goals. It appears that these elements of doubt continued to manifest themselves in the present as many female URM leavers were clearly still trying to find their footing academically and professionally.

Engineering versus Second-elected Major

The second research question sought to explore the differences between engineering and a second-elected major as described by female URM leavers. In this study, female URM leavers largely discussed the dissipation of the academic barriers that they encountered in engineering once they changed their major. No longer did they experience a heavy and compacted course load, which enabled them to now pursue multiple interests. Alexis spoke in detail of the added room she now had in her course schedule in international relations, explaining, “I wanted to be fluent by the time I graduated in a second language. And I personally didn’t have room, pursuing the BME major.” Most students also highlighted that they could now make clear connections between the material and its application. Students would attribute the closer connection between the material and its application to either the nature of the content or the methods of teaching that the professor implemented.

Lydia and Jamilah, who had discussed their perceived academic deficits in engineering, highlighted that they are thriving in their current majors and the content is tailored more to their individual strengths. As discussed in the previous chapter, Lydia switched her major to business administration because she wanted to utilize her strength and interest in math. Being in an academic environment that promoted her strengths changed her college experience. She explained, “I just really, really felt as a different person, more myself at [the school of business].”

While these noted differences in the academic experience are important in understanding female URM leavers’ perceptions of their second-elected major, their comments come with limitations that prevent these differences from being a core finding to this study. Participants may have responded positively when comparing their new major to engineering in an effort to

feel that they have made the right decision. Many of the positive aspects of the second-elected major may very well exist; however, it is not surprising that leavers perceived the environment as largely positive. Therefore, what is most important to this study is that these students indicated that their second-elected majors allowed them the flexibility to explore various interests, to connect course content to real-world applications, and to feel more academically confident in their abilities—all factors that they highlighted engineering did not provide.

Faculty Perceptions

In response to research question #4, faculty often corroborated the experiences of female URM engineering students in their descriptions of the academic environment and perceptions of the unique experiences of students in the racial and gender minority. Engineering professors largely agreed that the discipline is very demanding, describing it as “tougher” and “much more difficult” than other majors and consisting of “crowded curriculum.” Faculty spoke of their desire and attempts to make their courses more interactive, acknowledging the limited levels of engagement possible given the highly technical content. Faculty provided a perspective of the same environment the students described but from another angle, adding insight to the challenges professors face in meeting the content requirements while also trying to remain engaging and make real world connections. This sentiment rang particularly true for those professors teaching introductory courses who were required to cover an extensive amount of foundational material, adding further context to what female URM leavers experienced in their introductory classes. Professors also supported students’ sentiment of the limited flexibility in the curriculum, citing this as one of the potential reasons students of any background ultimately leave.

Early validation from faculty is important (Rendon, 1994; Terenzini, 1994), and STEM retention research has highlighted the positive role faculty can play on student persistence (Cole

& Espinoza, 2008; Gasiewski et al., 2012; Herrera & Hurtado, 2011; Kim & Sax, 2011; Maton et al., 2000; Perna et al., 2009). When a faculty member exhibits genuine concern for student learning and creates a comfortable environment in the classroom for students to actively participate, students are more engaged and consequently become more committed to the material and field (Gasiewski et al., 2012). Faculty in this study seemed to adopt these perspectives in their support of students and female URM students in particular. Faculty realized that they play a role in the academic experience for students and respond to that role by being accessible when support is needed and honest about what the engineering discipline entails.

Female URM leavers largely reported very positive experiences with their engineering faculty and, with the exception of Jamilah, did feel that professors were supportive and approachable. However, once again, even with this positive support from faculty, these students still ultimately left the discipline, suggesting that this support was not enough to encourage them to persist. As a point of comparison between female URM leavers and persisters, those that continued to pursue their engineering degree largely identified faculty as a core component of their support system. Leavers identified professors as supportive but did not identify them explicitly as one of their sources of support when facing challenges. There is an opportunity for future research to explore why URM women who consider faculty as supportive nonetheless seek out that support less often.

Four professors highlighted that female URM students in particular need role models they can identify with, supporting the research of Newman (2011) who found that students in his study noted the lack of same-race faculty as a missing component of their engineering experience. In this particular study, faculty diversity was not as important to students as it has been found in other research and as was perceived by the faculty participants. When

asked about the climate of diversity in the school of engineering, only one male URM leaver noted a lack of diversity among his professors while all others, including female URM leavers, focused more closely on the level of diversity they experienced within the student population explicitly. What seemed to emerge most saliently for female URM students and others was the diversity felt among their peers rather than a desire for more same-race and same-gender faculty.

Study Limitations

The purpose of this study was to probe more deeply into the perceptions and experiences of a specific student population have primarily been aggregated into other groups in prior research. As discussed in previous chapters, research on female URM retention in engineering has been limited with most studies either: A) combining all URM students together, B) combining all female students together, or C) aggregating engineering into STEM retention more generally. One goal of this study was to unmask the unique experiences of a group that is both a gender and racial minority in the field of engineering in an attempt to understand the intricacies that race and gender play in the experience, if any. Given the very specific purpose of this research, there are limitations to generalizability due to the small sample size. This study and its findings are limited to the study participants' experiences and may not necessarily reflect the experiences of all female URM engineering students nationwide. Nonetheless, the findings from this study do provide reader generalizability and the opportunity for future research that explores the potential larger trends stemming from what students in this study described.

Additionally, this study was limited in scope given the research timeframe, leaving the opportunity for more extended research to continue to explore engineering student experiences and their influence on attrition. I was unable to conduct a cross-case analysis with other students who matriculated into another STEM major yet also subsequently left as a point of comparison

with engineering. Therefore, considering engineering as a unique environment remains an assumption only to be substantiated by Paige and Anna changing majors into another STEM field, specifically biology, and their descriptions of the differences they perceived. Without a cross-case analysis, this study also is limited in exposing any unique characteristics of female URM students who enter engineering as compared to the female URM students who enter another STEM field and whether or not those characteristics play a role in their decisions to leave the disciplines. Additionally, this study asked students to reflect on their experiences in engineering while currently persisting successfully in another major. This may have affected students' perceptions of their earlier experiences in the engineering discipline. However, study participants appeared to speak openly about the positive and negative aspects of their experiences in both engineering and their 2nd-elected majors suggesting that a bias towards their new major was not overly prevalent to discount the findings of this research. This study qualitatively reveals some of the nuances evident in prior quantitative and aggregated studies while also leaving the opportunity for future research to further explore these findings more explicitly.

Implications for Future Research

As qualitative research is limited in the realm of STEM retention studies, this study promotes future qualitative research in this field as a method of understanding the unique experiences of different student populations. As revealed through some of the data in this study, at times students corroborated the findings of prior research, yet also uncovered other layers to those findings. As an example, both female URM leavers and persisters identified a targeted support program as important in their success, a finding that echoes the research. However, the qualitative research design in this study exposed the specific differences between leavers and

persists in how large of a role that targeted support program played in their connections with other students. From this research, it appears that the more a student viewed the support program as their sole source of peer connections, the less likely they were to persist.

As previously discussed, this study focused closely on the unique experiences of female URM students as compared to other student populations. However, findings have emerged in other student populations and were only presented on a limited basis as necessary to highlight the experiences of the target population. These emerging findings from other student populations, particularly male URM and female non-URM students, indicate that more research is needed to continue to understand the complexities of different racial and gender groups in how they perceive their engineering academic environments. If the engineering field is to respond to the very limited existence of racial and gender minority representation in the field, qualitative research on targeted populations needs to continue.

The intersection between race and gender was not explicitly explored in the interview protocols for female URM students but rather allowed to emerge naturally if a student identified the intersection. Participants discussed this intersection between being a racial and gender minority on a limited basis, with the majority of participants aligning with either one or the other. Future research may explore the intersection of race and gender more explicitly; however, from this study it appears that students largely elected one of their underrepresented identities with which they more closely identified. This may indicate that the intersection of race and gender may give way to one's primary identity in an environment or even by their perceived level of underrepresentation of one of their identities. It is an area that would benefit from future study to gain further understanding.

Recommendations for Practice

It is evident from the data that WPU acknowledges the need for added support mechanisms for students from underrepresented backgrounds and actively pursues strategies to promote their success. These factors were part of the reason why WPU was selected as the research site, as the question remained of why female URM students still continued to leave the discipline at higher rates than any other student population, even with the added supports. Based on the research findings, and utilizing the ideas of both student and faculty participants, the following are a few recommendations for practice.

Targeted support programs for female URM students must be expanded beyond summer bridge programs to fortify their impact on these students' success in engineering.

The majority of female URM students, both those persisting and those who left, discussed the role the Center for Engineering Diversity played in their positive experience at the school. Whether through the summer bridge program, the center's staff, or the strong connections made with other students, female URM students emphasized that the center was a key component of their transition into college and into engineering specifically. While the female URM students who left seemed to need more support outside of what the center could provide, it may be true that if the Center of Engineering Diversity and its summer bridge program did not exist, there may be more students who would end up choosing another discipline because they did not have that initial source of support from which to spring.

There exists an opportunity to further extend the arm of the Center for Engineering Diversity and leverage the impact this targeted support has on female URM students. Expanding the summer program into a year-round, cohort-based model would expand the support of female URM students as they begin to encounter the day-to-day engineering academic experience.

Creating a more structured and extensive support program will more deliberately connect female URM students struggling with the transition and with the in-class experience to those that are successfully navigating the environment.

Those structured connections could promote discussions on the various academic resources needed to tackle obstacles that persisters seemed to instinctively access. They could also include direct conversations on students' shared experiences being a racial and gender minority in the classroom and how to persevere through the perceived peer dynamics that can occur as result. I suggest that programs through the Center for Engineering Diversity serve as a consistent home base for female URM students rather than just a springboard of support prior to their freshmen year.

Connect lower-division classroom experiences with real-world applications more explicitly, allowing student ideas to fuel group projects. Research has found that the ability to connect classroom content with future goals and tangible applications is important to the retention of women of color in engineering (Espinosa, 2011). This finding also emerged in this study. A moment in the research process that really resonated with me was Lydia's story about her hopes of applying what she would learn in civil engineering to fixing a real problem in her mother's hometown in Mexico. It was disheartening to hear Lydia speak passionately about wanting to make a difference where it was really needed but then go on to describe the challenges she faced very early on in the classroom and ultimately deciding to leave. A lack of connection between the classroom experience and students' current interests and future goals was mentioned repeatedly among the other female URM leavers as well. As Johnson (2007) found, the lack of connection that students felt between themselves and the class content as well

as how science is commonly decontextualized was found to be discouraging to women of color, particularly if they were entering the field to have a societal impact.

While I acknowledge some lack of connection may be due to an incorrect perception of what engineering entails when students enter the field of study, it is possible that these students would have been more likely to remain committed to the discipline if they were to be exposed to some of the experiences persisters described from their upper-division coursework.

Understandably, and as professors noted, there is limited application one can do without having reviewed the foundational principles, but the professors teaching introductory courses highlighted their interest in moving in that direction by flipping the classroom. One of the writing professors more specifically noted the idea of “flipping the pyramid” of the engineering curriculum. He described the concept further as:

Flipping the pyramid in a way so that the first year they're exposed to the types of projects that they're going to be doing as working engineers as opposed to now where they're suffocated with math and physics and all the stuff that they need to know.

I argue that in addition to “flipping the pyramid” and bringing more applications to lower-division courses, students should be encouraged to identify their own projects within the framework of an assignment. This would encourage students like Lydia, as well as Paige and Alexis, to directly connect what they are learning to their original goals that inspired them to pursue engineering. It would also preserve the voices of diverse students who may be entering the engineering field for reasons unique to them. As female URM students entered engineering largely due to an interest or strength in the subject area, as opposed to male non-URM students who entered for the job prospects, female URM students should be afforded the space to fulfill their interests in the classroom, potentially preserving their commitment to the major.

Incorporating student input in crafting their own engineering projects also may alleviate some of the discomfort of in-class participation in the larger classroom environment.

Encourage students to consider themselves as one of many academic resources available to them while in engineering. Findings from this study echoed the conclusions of prior research in that female students in engineering are less confident in their own abilities than male students (Besterfield-Sacre, et al., 2001; Leslie, McClure, & Oaxaca, 1998). However, this study expanded on previous studies as self-doubt was more common for URM women than women in the racial majority. WPU, and likely many engineering programs across the country, succeed in providing targeted resources to URM and women in engineering, as well as extensive academic support services to all students given the rigorous nature of the content. As a result of this study, I recommend that schools supplement their support of female URM students with direct discussions and guidance on how they can utilize their own strengths and expertise to succeed in engineering as other students appeared to assume that strategy more innately. The support services will always be present, and these students do access these resources. However, female URM students may need added encouragement to know that they too are capable of determining how to best address the challenging workload and that it is not solely a matter of relying on external assistance. This recommendation can take many forms, whether through direct and facilitated discussions during the summer bridge program or through the advice of upperclassmen that have refined their self-directed learning strategies over time. The opportunity for this additional mentorship is discussed in the following recommendation.

Incorporate more student-centered techniques that rely on group work and class discussions to curtail the existence of competition in the classroom. As evident in prior research, schools where faculty employed student-centered pedagogy had higher rates of STEM

persistence of students overall (Hurtado et al., 2012). Two introductory course professors discussed implementing the flipped classroom model in an effort to increase engagement among their students. In this model, students watch the professor's lecture via online video at home and the class period is dedicated to working on homework problems, often in groups and coupled with the professor's facilitation. While the introductory course professors considered flipped classrooms as an engagement strategy, I argue that this model, along with other student-centered pedagogical practices, will also promote a more collaborative and supportive working environment for all students. When students have the opportunity to collaborate with peers in class, it has been found to increase their commitment to the discipline (Gasiewski et al. 2012).

This safer space will likely allow students like Lydia, Jamilah, and Alexis the room to ask questions either in their smaller peer working groups or to the professor as he moves about the room. As female URM students and professors echoed, introductory courses in particular move quickly through a lot of material and are primarily didactic with the professor lecturing for the majority of the time. With research finding that STEM attrition largely occurs within the first two years of school, the teaching structures of those introductory courses are all the more important (Chang et al., 2008; Chang et al., 2011; Gainen, 1995; Gasiewski et al., 2012; Reichert & Absher, 1997). A large, didactic class structure minimizes the opportunity for student interaction and can leave students to fend for themselves academically, fueling the competitive environment that the female URM students in this study described. Those more confident and comfortable are able to push past the competition, forging academic relationships through peer study groups. Others, like Lydia and Jamilah in particular, are left on the outside of that peer support, consequently experiencing the isolation that student competition can create. Group work and in-class discussions can minimize the existence of competition within the engineering

classroom and help to create a more supportive academic experience for female URM students to succeed.

Conclusion

The stories of Paige, Lydia, Jamilah, Alexis, and Anna describe the distinct experience of being a racial and gender minority in engineering. Engineering is a rigorous discipline whose academic challenges are felt by all students regardless of background. However, female URM students, whether persisting in engineering or in another major, shared similarities in their perceptions of the environment that were only at times shared by other URM or other female students. Within those perceptions shared among female URM leavers and persisters, however, existed differences in how each population navigated through their environments, beginning to expose some of the factors that encourage persisters to continue in the discipline while others decide to leave. As researchers, our role is to bring to light the voices of those that are navigating certain educational realities that those in the majority are not. Quantitative methods excel at pinpointing instances of larger trends and issues, but I argue that allowing underrepresented student populations to speak of their experience themselves allows for a rich interplay in STEM retention research data. My hope is that this research study adds to that interplay and promotes the utilization of students' stories to expose and explain these persistent issues in engineering attrition.

Appendix A

Biographical Questionnaire

1. Gender

- ☐ Female
- ☐ Male

2. Ethnicity

- ☐ Hispanic or Latino
- ☐ Not Hispanic or Latino

3. Race

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

4. Year in School

- ☐ Freshman
- ☐ Sophomore
- ☐ Junior
- ☐ Senior

5. What is your current major?

6. If you have changed your major, what was your initial major?

7. What is the highest level of education your parent(s)/guardian(s) have completed?

Mother/Guardian

- ☐ Some high school
- ☐ High school diploma or GED
- ☐ Associate's Degree
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctorate

Father/Guardian

- ☐ Some high school
- ☐ High school diploma or GED
- ☐ Associate's Degree
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctorate

8. Are one or both of your parents/guardians engineers?

- ☐ Yes, one parent
- ☐ Yes, two parents
- ☐ None

Appendix B

Interview Protocol—Students Who Have Exited Engineering

The goal of this interview is to gather data on the perceptions and beliefs of students that have matriculated into engineering but have since changed majors. Questions revolve around their reasons for leaving the engineering major and the differences and similarities they have experienced in their current major. This protocol explores students' perceptions of barriers and supports, academic climate, faculty and peer interactions, co-curricular opportunities, and these factors' potential impact on their academic self-concept.

- 1. How did you come to the decision of initially majoring in _____ engineering?**
 - a. What or who influenced your decision, if at all?
 - b. What were your expectations of the major? Did your experiences align with your expectations?
 - c. What were your expectations of the school? Did your experiences align with your expectations?
- 2. How would you describe your interactions with students and faculty while in the engineering program?**
 - a. How did you connect with other students? Faculty?
 - b. Who were your main sources of support while in engineering?
 - c. How would you describe the overall sense of community within the program?
 - d. Did you participate in any out-of-class activities or organizations at the engineering school?
- 3. How would you describe your academic experiences while in engineering?**
 - a. Did you have any academic challenges? Were the classes as challenging as you expected them to be?
 - b. Tell me about how you tried to overcome these challenges? What resources, if any, did you access or attempt to access?
- 4. What does a typical engineering course look like?**
 - a. What strategies did the professor use to present content (i.e., lecture, group work, student presentations)?
 - b. What did you think of these methods?
 - c. How often did you participate in class? Attend office hours?
 - d. Do you feel your instructors are strong teachers?
 - e. Tell me about your interactions with faculty in your engineering courses.
- 5. How would you describe the climate of diversity in the engineering school?**
 - a. Would you describe the engineering school as diverse?
 - b. Would you identify with a group that you feel is underrepresented in the school of engineering?
 - c. If so, has being a part of an underrepresented group had an impact on your experience in engineering?

- 6. Can you talk about your decision to switch out of engineering?**
 - a. What factors contributed to this decision?
 - b. Thinking back to this decision, would you have done anything differently knowing what you know now?
- 7. How would you describe your academic experiences in your current major?**
 - a. How are you connecting with current students and faculty?
 - b. Have you had any academic challenges?
 - c. Tell me about how you tried to overcome these challenges? What resources, if any, did you access or attempt to access?
- 8. What differences have you noticed in your courses in your new major compared with your engineering courses?**
 - a. Are they structured differently – more/less lecture?
 - b. How are students interacting with faculty?
 - c. Are these differences what you expected?
- 9. How would you describe your interactions with your peers?**
 - a. How did you meet most of your college friends? Through class? Through your dorm? Through a student organization? At a party? Etc.
 - b. How would you describe your experience making friends here?
 - c. How often do you share a class with friends?
 - d. What out-of-class activities and organizations are you currently involved in?
 - e. Have you stayed friends with anyone that you met during your time in the engineering school?
- 10. How would you describe the climate of diversity in your current major?**
 - a. Would you describe the _____ school as diverse?
 - b. Would you identify with a group that you feel is underrepresented in the major?
 - c. If so, has being a part of an underrepresented group had an impact on your experience in your current major?
- 11. What are your educational and career goal(s) both immediate and long term?**
 - a. What are the obstacles or barriers, if any, that might affect your immediate and long term career goals (e.g., family concerns, time to degree, financial rewards, etc.)?
- 12. Is there anything else you would like to share about your experience as you reflect on your time as an engineering student and now in the ____ major?**

Appendix C

Interview Protocol—Undergraduate Engineering Students

The goal of this interview protocol is to gather data on the perceptions and beliefs of female URM students that have matriculated into and are persisting in an engineering major. Questions revolve around their thoughts regarding their academic environments, exploring students' perceptions of barriers and supports, academic climate, faculty and peer interactions, co-curricular opportunities, and these factors' potential impact on their academic self-concept.

- 1. How did you come to the decision of majoring in _____ engineering?**
 - a. What or who influenced your decision, if at all?
 - b. What are your expectations of the major? Did your experiences align with your expectations?
 - c. What are your expectations of the school? Did your experiences align with your expectations?
- 2. How would you describe your interactions with students and faculty in the engineering program?**
 - a. How do you connect with other students? Faculty?
 - b. Who are your main sources of support while in engineering?
 - c. How would you describe the overall sense of community within the program?
 - d. Do you participate in any out-of-class activities or organizations at the engineering school?
- 3. How would you describe your academic experiences in your engineering major?**
 - a. Do you have any academic challenges? Are the classes as challenging as you expected them to be?
 - b. Tell me about how you've tried to overcome these challenges? What resources, if any, do you access or attempt to access?
- 4. What does a typical engineering course look like?**
 - a. What strategies does the professor use to present content (i.e., lecture, group work, student presentations)?
 - b. What do you think of these methods?
 - c. Do you feel your instructors are strong teachers?
 - d. Tell me about your interactions with faculty in your engineering courses.
- 5. How would you describe your interactions with your peers?**
 - f. How did you meet most of your college friends? Through class? Through your dorm? Through a student organization? At a party? Etc.
 - g. How would you describe your experience making friends here?
 - h. How often do you share a class with friends?
 - i. What out-of-class activities and organizations are you currently involved in?
 - j. Have you stayed friends with anyone that you met during your time in the engineering school?

- 6. How would you describe the climate of diversity in the engineering school?**
- a.** Would you describe the engineering school as diverse?
 - b.** Would you identify with a group that you feel is underrepresented in the school of engineering?
 - c.** If so, has being a part of an underrepresented group had an impact on your experience in engineering?
- 7. What are your educational and career goal(s) both immediate and long term?**
- d.** What are the obstacles or barriers, if any, that might affect your immediate and long term career goals (e.g., family concerns, time to degree, financial rewards, etc.)?
- 8. Is there anything else you would like to share about your experience as an engineering student here?**

Appendix D

Interview Protocol—Engineering Undergraduate Faculty

The goal of this interview protocol is to gather data on the perceptions and beliefs that engineering faculty members hold on the reasons for attrition among the female, URM population in the school.

1. Introductory Questions

- a. What would you describe is your primary role at the school of engineering?
- b. How often do you interact with engineering students and in what capacity?
- c. How long have you worked at the school of engineering? How long have you worked in the field?

2. What kind of environment do you promote in your classroom?

- a. How do you structure your engineering courses?
- b. To what extent do you encourage student interaction?
- c. In what ways do you structure your course to promote an inclusive environment?
- d. What strategies have you found most effective to engage students in their learning?

3. How would you describe the climate at the engineering school?

- a. How would you describe the students here? What characteristics do they have in common? How do they differ?
- b. How is the engineering environment unique as compared to other schools at the university, if at all?
- c. Would you say there are some students that are more active in your classes than others? Please expand.
- d. How would you describe the climate of diversity?

4. What are the biggest challenges that engineering students face as they pursue their degree?

- a. Under-preparation, academic dishonesty, learning disabilities, extreme competition?
- b. What do you or the institution do to address these issues?
- c. How does the academic experience in the engineering school differ from that at other schools at the university, if at all?
- d. How are the experiences of URM students or female students in engineering unique from those of non-URM or male students?
- e. What do you believe is the primary reason(s) engineering students elect to change majors into other colleges at the university? Please expand.

5. When thinking of female, underrepresented racial minority students in particular, how would you perceive their experience in the school of engineering?

- a. How do you think being a gender minority affects their experience in engineering, if at all?

- b. How do you think being a racial minority affects their experience in engineering, if at all?
 - c. Thinking of the female, underrepresented minority students that you've had in your classes, do you feel they:
 - i. Participated in classroom discussions and asked questions more, less, or at the same rate as other students in the class?
 - ii. Visited your office hours more, less, or at the same rate as other students in the class?
 - iii. Achieved grades higher, lower, or approximately the same as other students in the class?
 - d. What do you believe are the primary reason(s) female, underrepresented minority students elect to change majors into other colleges at the university? Please expand.
- 6. As an undergraduate professor, what role do you have in contributing to the retention of engineering majors?**
- a. What impact, if any, do you feel you have on student retention?
 - b. What do you think engineering students need in order to be retained and what should the school provide in an effort to meet those needs? What support should professors provide?
 - c. What do you think female, underrepresented minority engineering students need in order to be retained and what should the school provide in an effort to meet those needs? What support should professors provide?
- 7. Is there anything else you would like to share about your experience working with engineering students or specifically with female, underrepresented minority students here?**

Appendix D

Data Analysis Matrix

Pre-College Influences		
SLT (Female URM Leaver)	SL (Other Student Leaver)	SP (Female URM Persister)
SLT1: <u>I was in high school. I was really good at math and science. When you're really good at math and science, they shift you to engineering.</u> That was basically it. <u>I took an auto class in high school and I thought cars were pretty cool and how they designed them</u> and I thought, that's what I want to do. I want to design cars. And aerospace was the closest thing to that. <u>It's also top of the list so might as well pick one to start out.</u> ... My dad. <u>My dad was like oh you're going to be an engineer.</u> I have friends who are engineers. It's a great profession. I want to be one. You should do it, you'll be amazing.	MALE/URM: Well in high school and just as a kid in general I've always liked cars, so what I wanted to do was <u>study something that would help me work with cars</u> in the future and also in high school we had, our high school was kind of split up into different mini academies sort of and <u>I was in the engineering and design academy</u> so in that academy I took some college courses that had to do with engineering so <u>I was introduced into engineering</u> with that so I wanted to continue engineering in college and I chose mechanical engineering. <u>I'm not sure if it was really any particular person.</u> I think it was just my interest in the field	SP1: <u>In high school, I was really good at chemistry and biology and math.</u> I hate english, I hate history, I'm really bad at writing. So I knew I couldn't do anything...I had to something math or science based. And I was doing research and was thinking mathematician and I really considered the economy, so I'm like kinda of paranoid. <u>So I was like I need something that was going to get me a job after school so I though engineering would do that.</u> And I just researched the different ones and chemical engineering sounded the most interesting. <u>I went to a really small school so there were a lot of people to help me.</u> My physics and chemistry teacher was like "oh that'd be awesome, that would be so good for you." My mom is a social worker so she's like, she had no idea what that even was. She was like "whatever makes you happy." So I kind of just decided to do it.

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