UNDERREPRESENTED ENGINEERING STUDENTS, FAMILY
CHARACTERISTICS, MAJOR SELECTION, AND ACADEMIC PERSISTENCE

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Reina Teresa Gonzalez

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UNDERREPRESENTED ENGINEERING STUDENTS, FAMILY CHARACTERISTICS, MAJOR SELECTION, AND ACADEMIC PERSISTENCE

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by

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Department of Educational Leadership and Policy Studies
Abstract

of

UNDERREPRESENTED ENGINEERING STUDENTS, FAMILY CHARACTERISTICS, MAJOR SELECTION, AND ACADEMIC PERSISTENCE

by

Reina Teresa Gonzalez

Brief Literature Review

Female students and students from underrepresented ethnic groups (UEGs), including Latinos, African Americans, and Native Americans, are underrepresented in the academic and occupational setting of engineering. Females tend to receive messages from society regarding lower expectations of interest and performance in math and science, which can be discouragement from studying engineering. Being a student from a UEG decreases the chance a student knows an engineer in their personal life and increases the chance the student has received poor preparation for studying engineering. These previously mentioned factors result in decreased likelihood that these students will choose to study engineering in postsecondary education.

Family members play an important role in the development of a student’s academic self-concept, and affect the types of cultural and social capital students possess. The types of support families provide to their students can make a positive impact on
students’ overall well-being and academic experiences. Alternatively, families can be a source of responsibility competing with a student’s studies.

Statement of Problem

The purpose of this study was to identify 1) family characteristics of underrepresented engineering students and 2) these students’ perceptions of their family’s influence on major selection, academic performance, and persistence to degree completion.

Methodology

A mixed-method, anonymous, online survey was distributed to current undergraduates and a few recent graduates in two large engineering departments at Northern State University\(^1\). Data was filtered and analyzed by the following subgroups: female and male and UEG, White, and Asian American. Responses were analyzed through the use of descriptive statistics for quantitative data and systematic review for qualitative data.

Conclusions and Recommendations

The results of this study were generally consistent with the literature review. The underrepresented students reported coming from families of lower socioeconomic status more so compared to their counterparts. Additionally, the underrepresented students cited lower rates of family members who were influential in their (the students) decisions

\(^1\) Name of university is a pseudonym.
to study engineering. Also, underrepresented students reported later development of engineering identities. Although perceived familial emotional and motivational support was high, perceived parental disappointment varied between females and UEGs, indicating other social influences at play.

__________________________, Committee Chair
José Chávez, Ed.D.

__________________________
Date
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Chapter 1
INTRODUCTION

The academic and occupational field of engineering is an area lacking a considerable amount of diversity in its students and labor force, especially when compared to the current United States population and projected growth of the population. In 2009, 70% of the students enrolled in engineering programs were White and 82% of the students were male (National Science Foundation [NSF], 2012). According to the National Action Council for Minorities in Engineering (NACME), in 2009, only 12% of engineering bachelor’s degrees were earned by students from underrepresented ethnic (UEG) groups, including Latino, African American, and Native American students, although these ethnic populations comprised 28% of the U.S. population (Frehill, 2010). In 2008, women earned only 18% of engineering bachelor’s degrees, but comprised slightly over half of the U.S. population (NSF, 2011). This phenomenon of low rates of female engineering graduates is especially noteworthy due to the stark difference between the overall numbers of women completing any bachelor’s degree, which in 2008 was 57% (NSF National Center for Science and Engineering Statistics [NCSES], 2011). While this lack of representation is an issue for women of every ethnicity, it is amplified for female engineering students of underrepresented ethnicities, who face the challenges of being a minority in both their ethnicity and gender (Castillo, Conoley, & Brossart, 2004).
It is common knowledge students from underrepresented ethnic groups generally have a harder time accessing higher education compared to students from the majority, but they can also have a more difficult time accessing the science, technology, engineering, and mathematics (STEM) pipeline (Anderson-Rowland, 1999). When it comes to achievement in math and science, the challenges underrepresented students face are multifaceted and include socio-psychological barriers and issues in our current educational system (Gilmartin, Li, & Aschbacher, 2006). Furthermore, students from underrepresented ethnic groups tend to be more influenced by their family interactions and environment than non-minority students, especially in terms of cultural adaptation (Orbe, 2008). College recruitment and admission processes and campus communities tend to gravitate toward the norms and values of the dominant culture, which include independence from the family and a competitive nature (Castillo et al., 2004). While the transition from secondary education to college can be challenging for students of any background, minority students transitioning to university life are at an increased level of disadvantage because they have a steeper learning curve and lower level of cultural congruity compared to the students already familiar and comfortable with dominant cultural norms (Gloria & Robinson-Kurpius, 1996).

What factors contribute to the recruitment, retention, and academic performance of students from underrepresented ethnic groups in the field of engineering? Many studies (Adams, Womack, Shatzer, & Caldarella, 2010; Rogers, Theule, Ryan, Adams, & Keating, 2009; Spera, 2005; Tan & Goldberg, 2009) have looked into the role of the
parental and family influence in the academic persistence and success of students, but few studies have focused on the family influence factors affecting engineering students of underrepresented ethnic groups. In addition, many studies on family influence on college students have approached this issue from a middle-class, traditional, American family perspective (Sclafani, 2004). These findings cannot necessarily be directly applied to varying dynamics of multicultural families from lower socio-economic classes with less access to quality K-12 education.

Several studies (Brown, 2008; Goodman et al., 2002; Lord et al., 2009; Trenor, Yu, Wright, Zerda, & Sha, 2008; Wentling & Camacho, 2008) in the last decade have addressed the issue of underrepresentation of women in engineering; however, female engineer recruitment and graduation rates have not significantly improved in recent years. In 1978, only 7% of the engineers graduating with bachelor’s degrees were women and this proportion increased to 15% by 1988. Another 10 years later, in 1998, the graduation rate for women rose slightly to 18%, but the 1998 proportion is the same as that of 2008 (NCSES, 2011), indicating stagnation in recruitment. Compared to male engineering students, a higher proportion of female engineering students report having an engineer in the family. Also, female college students who do not have prior contact with engineering tend to select engineering as a major later in their academic careers than males, which can affect their preparation and time to degree (Mannon & Schreuders, 2007).
Statement of the Problem

The purpose of this study was to identify characteristics and perceptions of underrepresented engineering students in regard to their family’s potential influence on major selection, academic performance, and persistence to degree completion. In this study, underrepresented engineering students include both ethnic minorities and females. Specific questions to be addressed are:

1. What are the family factors and characteristics of female students and students of underrepresented ethnic groups who decide to pursue an undergraduate engineering education?

2. As they relate to their academic persistence, how do underrepresented engineering students perceive familial support and expectations, and which, if any, family responsibilities do students perceive as challenges to their academic studies?

Definition of Terms

Academic Performance

Academic performance is measured based on grade point average (GPA) and completion of attempted coursework. Another measurement is academic standing, including probation and dismissal.
Engineering Identity

Engineering identity consists of one’s understanding of and abilities within engineering, in addition to internal and external recognition of being an engineer (Carlone & Johnson, 2007).

Extended Family

Extended family includes one’s immediate family, plus other relatives and generations, such as grandparents, aunts, uncles, cousins, nieces, and nephews (Starbuck, 2006). In addition to “in-law” family members, extended family can include other non-blood members, also referred to as fictive kin (Hays & Erford, 2010), who have close relations to the group.

Family Social Support

For this research, three types of social support are relevant. The first, emotional support, relates to caring, concern, and intimacy. Motivational support, which can also be referred to as appraisal support, concerns the sharing of information, feedback, and encouragement. Finally, financial support, also referred to as instrumental support, is the assistance of money or other provisions (Gilbert, Fiske, & Lindzey, 1998; Perlman & Rook, 1987).

Financial Need

This term refers to the monetary need a student has with regard to paying the cost of higher education.
First-generation College Student

A student whose parents or guardians have not completed a bachelor’s degree. The parents may have attended some college and earned an associate’s degree. The student may or may not have siblings who have attended college (National Archives and Records Administration, 2010).

Immediate Family

For this research, the terminology “nuclear family” will not be used to recognize that many students grow up in family structures that do not fit into the nuclear family definition of married, heterosexual parents. Instead, immediate family will be used in reference to a student’s family of origin, the family with which they grew up. Some students may have more than one immediate family (Galvin, Bylund, & Brommel, 2004).

Major Selection

Selection of an academic major is a process influenced by a number of factors including, but not limited to: type of information received regarding the major, internal desire to study and complete the major, external motivations, and environmental reasons to select a major (Matusovich, Streveler, & Miller, 2010).

Persistence

Persistence is marked by completion of degree requirements with the intention of earning a degree. Some students who do not persist switch to other majors, while
other students leave the university, either because they choose to leave or are required to leave (Lichtenstein, McCormick, Sheppard, & Puma, 2010).

Self-efficacy
Self-efficacy is the internal belief about one’s ability to successfully complete a given task. Self-efficacy has close ties to motivation and persistence (Sclafini, 2004).

Socioeconomic Status (SES)
This term can be applied to an individual or a family based on income, education, and occupation. It is based on the individual’s or family’s relational position in the given society. Low socioeconomic status falls below the categories of middle SES and high SES. Due to access to resources, including medical resources, SES can be predictive of one’s general health and well-being (Hays & Erford, 2010).

STEM Field
The areas of science, technology, engineering, and mathematics. Typically, the term is used in the context of education and occupations.

Underrepresented Ethnic Groups (UEG)
In this paper, the term “underrepresented ethnic group” refers to students of one or more of the following descents: Latino, African-American, Native American, or Alaskan American. Many, but not all, of these students are also first-generation college students and may have considerable to significant financial
Asian American students are not considered underrepresented in engineering education (Lord et al., 2009).

Limitations of the Study

This study was limited to a local setting within Northern California and focused on a public, master’s granting university. This study did not include students at the community college level who intended to pursue an engineering degree, but included students who had transferred from community colleges and other institutions. Due to the challenges UEGs have accessing higher education, there may be higher proportions of these students at the community college level.

Also, this study intended to focus on three broad ethnic groups fitting into the term “underrepresented ethnic group,” which include: 1) Latino, 2) African American, 3) Native American and Alaskan American. Unfortunately, there were very few responses in the data collection from African American and Native American students due to their lower attendance rates in engineering in general and at this institution. The study also collected data from engineering students of other ethnic groups, including the two dominant ethnicities in this field, which are White and Asian American. The researcher recognized the challenge that ethnic groups are not monolithic in nature. Individuals tend to affiliate with more than one social identity, but this study primarily focused on ethnicity and gender, and secondarily on socioeconomic status (SES).
Significance/Importance of the Study

This topic of study is of significance because students and professors from the majority culture have dominated the workforce and academic field of engineering. The historical origins of higher education include beginnings when mostly men participated in academe (Scott, 2006). Additionally, engineering origins are closely linked to the military, another male-dominated arena (Hacker, 1989). As the overall demographic of higher education has shifted, both women and ethnic minorities remain underrepresented in engineering and the broader STEM field. This is in part due to the societal and educational challenges these students face with regard to accessing the STEM pipeline in their K-12 years.

As highlighted in seminal work by Seymour and Hewitt (1997), even if a course of study is started at the college level in engineering, it can be difficult for students to complete the rigorous degree requirements, paired with a cultural environment that can be less than welcoming to UEGs and women. The barriers students perceive while in pursuit of an engineering education can vary by their ethnicity and their parents’ educational level (Trenor et al., 2008). Many underrepresented students have reported sensing the effects of “imposter syndrome,” in which their self-confidence is hurt by the internalized idea that they somehow made it into engineering by luck or accident and do not believe they truly belong (Goodman et al., 2002). For students of underrepresented ethnicities who do make it to graduation, it typically takes them a longer period of time to complete the degree than White and Asian-American students (Ohland et al., 2008).
Increasing diversity in the engineering workforce and academia is imperative (Bandura, 1997). As the U.S. population continues to grow as projected in the next few decades, the majority of the country will consist of various minority groups. The growing underrepresented populations are now being referred to as the “emerging majority” (Sullivan, Mwangi, Miller, Muhammad, & Harris, 2012), and for the first time in the history of our country, Whites will no longer constitute the majority of the population (Passel & Cohn, 2008). The highest growth rate is within the Latino community, and it is projected this ethnicity will comprise at least a quarter of the country’s population by 2050 (U.S. Census, 2006). If the country wants to maintain a high position in the global economy, it is essential our population possess the jobs skills and education necessary to fill jobs in all needed areas; however, STEM jobs are especially crucial for maintaining global competiveness. The country needs to increase access to this field so the engineering workforce, educators, and students are diverse and representative of the U.S. It is not only important for the country as a whole, but also important for the well-being of underrepresented ethnic groups and as a means to combat the growing socioeconomic gap that is widening today.

The income gap between men and women has slowly shrunk over time, but as of 2010, on average, women still only made 77 cents for every dollar earned by men, and the gap is wider for those of African-American and Hispanic/Latino descent (American Association of University Women, 2010). While the gender income gap is somewhat smaller in engineering professions, this gap still exists. In 2006, the median income for
men working in engineering with a bachelor’s degree was $76,000, while the median income for women was $65,000. This equates to female engineers earning about 86 cents for every dollar earned by a male engineer, which is the same proportion for female and male engineers with master’s degrees (National Science Foundation, Division of Science Resources Statistics, 2011).

Another crucial issue hindering recruitment of underrepresented groups into engineering is the phenomenon of the vanishing minority male in higher education (Oguntoyinbo, 2009; Sáenz & Ponjuan, 2011). Latina, African American, and Native American women are more likely to go to college and complete a degree but are less likely than their vanishing male counterparts to study engineering. Higher education pipeline issues start early. In K-12 education, Latino and African American boys are overrepresented in special, remedial, and vocational education and have lower graduation rates than their female counterparts (Oguntoyinbo, 2009). African American men outnumber all other races in the correctional system, and Latino men also constitute a significant portion of this population (Quality Education for Minorities, 2010). If a major shift in policy and practice is not made, the trajectory for minority males in higher education will continue downward. Suggestions for improving rates of college attending Latinos include improving family relations in the student’s educational experiences (Oguntoyinbo, 2009; Sáenz, & Ponjuan, 2011).

Although the topic of this study will focus primarily on the experiences of undergraduate engineering students, the make-up of graduate students in engineering is of
noteworthy consideration. At first glance of female engineering graduate students, it appears the rates of women earning doctorates has been steadily increasing; however, it turns out this is only due to an increase of foreign-born females. Rates of domestic women earning doctorate degrees have not changed (Ferreira, 2009). In 2005, a little less than half of master’s degrees and a little more than half of doctorate degrees were earned temporary residents, while UEGs earned less than 15% of master’s degrees and less than 10% of doctorates (Frehill, Di Fabio, & Hill, 2008). Recent master’s and doctoral graduates are likely to become the next generation of leaders in the engineering faculty and workforce, but only a small fraction are representative of the population needing to be recruited for domestic advantages in engineering. It is not only important to improve underrepresented numbers at the bachelor’s level, but once recruited into the engineering pipeline, these students also need to gain experience that will prepare them for success in graduate studies and beyond. It has been shown that it helps underrepresented students to have mentors of similar gender and ethnic backgrounds, but a critical mass of these leaders and mentors has yet to be achieved (Tsui, 2010).

Ideally, the results of this study will shed light on the experiences of UEGs and women in engineering, including their precollege and undergraduate years, and the how the students perceive their family interactions in relation to their academics. This research is framed through social capital theory, and self-efficacy and self-concept theories. The goal of the study was to gather information to present to educational leaders that will impact the body of knowledge and possibly serve as data to change the
current state of how student services are offered to this population, and inspire alternative methods of family and parent outreach and recruitment programs and orientations.

Organization of the Remainder of the Study

The remainder of this study is presented in the following four chapters. Chapter 2 reviews related literature regarding undergraduate engineering education, relevant frameworks, and family influences on students with an emphasis on families of underrepresented ethnic groups. Chapter 3 includes descriptions of the setting, population, sample, and design of the study. Chapter 4 provides a summary and analysis of the findings of the study. Lastly, in Chapter 5, the researcher provides suggestions for best practices for underrepresented engineering students and families, as well as suggestions for future possible research.
Chapter 2
REVIEW OF RELATED LITERATURE

Introduction

This literature review focuses on the experiences of undergraduate engineering students, emphasizing students from underrepresented ethnic groups (UEGs) and female students, and their families’ characteristics and influences as they relate to the students’ pursuit of an engineering education. This review begins by describing characteristics of and perceptions regarding engineering education at the undergraduate level and characteristics of both female students and students from UEGs. Next, the review discusses relevant frameworks, including but not limited to social capital, self-efficacy theory, and engineering identity. Lastly, the review focuses on family characteristics and influences and how these affect students from UEGs and women in terms of education experiences and decisions leading up to and while in college.

Characteristics of Undergraduate Engineering Education and Female and URM Students

Engineering is the application of science to innovate and create solutions to existing problems. The undergraduate experience of students studying engineering is notoriously rigorous and requires strong academic preparation in K-12, especially in math and science. The number of technical units required for the undergraduate degree is the highest of all of the fields: much higher than the humanities and social sciences, and
higher than that of other sciences. Males and Caucasians dominate the undergraduate student and faculty population of engineering, while Asian Americans are also well represented (Su, 2010). Temporary residents, those who were born outside the country, account for about half the graduate students in engineering (Freihill et al., 2008). The general culture of American higher education is reflective of the dominant society and rewards students who are independent, competitive, and individualistic (Sue & Sue, 2008). Compared to other academic fields, engineering programs are less diverse, and hence, its culture is less welcoming to those who are underrepresented, including women and ethnic minorities; at times, the climate has been described as “chilly” (Seymour & Hewitt, 1997, p. 13).

Although all four years of engineering undergraduate curriculum are challenging, the first year or two can be an especially difficult transition period for students. The engineering curriculum begins with many prerequisite level courses in mathematics, physics, and chemistry, often taught outside the engineering department (Tsui, 2010). In some instances, a student might not take a course taught by an engineering professor until the later part of the second year or even the third year. Additionally, these prerequisite courses can be very large, and as such, considered impersonal and competitive. The grading practices (e.g., grading on the curve) can be confusing for students as they transition from high school to college. The grading practices can also be harmful to the self-confidence of students who are unsure if they belong in an engineering major, such as women and UEGs (Tsui, 2010). Even if it is not the intention of the engineering
department to utilize these courses as so-called weed-out courses, students report perceiving the introductory coursework in this manner (Seymour & Hewitt, 1997). If students do not have an opportunity to take an introductory engineering course, it can be hard for them to learn what engineering really is until they have completed over half the degree requirements. It can also be difficult for them to appreciate the necessity of the prerequisite coursework. All these factors can contribute to attrition in engineering, whether the student chooses to leave to another major or leaves the university due to poor academic performance.

To the chagrin of those who wish to reform engineering recruitment and education, the academic and professional setting of engineering is not as well understood across society as other popular fields, such as law or medicine (National Research Council, 2005). Engineering is not a requirement in K-12 public education curriculum, so youth are not exposed to it in school unless they have a teacher who goes out of their way to introduce the topic (Goodman et al., 2002), or if they personally know an engineer. Professional engineers and engineering academics are well aware of what their day-to-day work looks like and how it contributes to the advancement and betterment of society and technology, but the general public does not exactly share this perspective and understanding. Prime time television shows do not glamorize the life of engineers as is done with the multitudes of entertainment and literature involving fictional doctors, lawyers, and detectives of both genders (Kemper & Sanders, 2001; Landis, 1995; Wentling & Camacho, 2008). Furthermore, there is a wide array of diversity within the
sub-disciplines of engineering and rapidly developing technologies in each, which are other factors contributing to the general population’s low understanding of the field (Kemper & Sanders, 2001)

Much of what is known about engineering in the public eye is that it is challenging and time consuming, not only while pursuing it in school, but also at the professional level. In a 1998 survey titled “American Perspectives on Engineers and Engineering,” commissioned by the American Association of Engineering Societies, 45% of respondents stated that they were “not very well informed about engineering and engineers,” while another 16% stated that they were “not at all well informed about engineering and engineers” (as cited in Kemper & Sanders, 2001, p. 7). Interestingly, in the same survey, parents were asked on a scale of 1-10, where 1 was extremely displeased and 10 was extremely pleased, how pleased they would be if their child became an engineer, and the parents reported a mean response of 9 (Kemper & Sanders, 2001). So, although engineering may not always be well understood, there seems to be a general sense that the accomplishment of being an engineer is worth significant value, at least among parents. At the same time, some have the perception that engineering is inaccessible and requires too many sacrifices. A survey among college students, both engineering and non-engineering, revealed students “generally believe that engineering benefits society, but that it takes too much effort to earn a degree and the resulting careers are very demanding” (Matusovich et al., 2010, p. 291).
Suggestions for improving engineering recruitment tend to include the necessity for deconstructing the image of what it means to be an engineer, highlighting how engineering is highly relevant to society and targeting not only students, but also getting these messages to their families (National Research Council, 2005; Hoffman, St. Louis, & Hoffman, 2010). One cause for the lack of transparency issue is engineers in the workforce do not largely interact with the general public. There is a common perception that engineering is a “male-dominated field of so-called ‘nerds’” (Hoffman et al., 2010, p. 253). Another issue is the notion engineering deals mostly with things and little with people. Many aspects of engineering, such as improvement of quality of life and environmental protections, contribute to the betterment of society and fit into the characteristics of altruistic or helping professions (Kemper & Sanders, 2001), but female students start college less aware of this quality than their male peers (Tsui, 2010). Since women and students from UEGs tend to place more value on helping and social professions, it would be advantageous to move beyond the general perception of this field as just a high paying profession requiring talent in math and science and emphasize how truly dynamic engineering can be (Amelink & Meszaros, 2010).

Given the negative perceptions about the difficulty of earning an engineering degree, one might assume persistence is low for students who matriculate into engineering. Given the low proportions of female engineers, another assumption is women engineering students persist at lower rates than men, but it appears the more relevant issue for women in engineering is their low rates of matriculation into the major
Analysis of the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), which included over 75,000 engineering students who matriculated to four-year universities between 1988 and 1998, showed persistence in engineering was actually higher than other majors (Ohland et al., 2008). Further analysis of MIDFIELD highlighted that women of all races, with the exception of Native American women, persisted in engineering at rates comparable to men. Women who left engineering were more likely to switch to another major, while men who left engineering were more likely to leave the university (Lord et al., 2009; Ohland et al., 2011; Seymour & Hewitt, 1997).

Lichtenstein et al. (2010), who reviewed longitudinal data from 12,000 students of various majors in the National Survey of Student Engagement (NSSE), found engineering students who persisted in the major spent more time studying, less time caring for dependents, and less time working off campus for pay. The demands of the engineering curriculum can force students to forego extracurricular experiences, whether the activities are on campus or off campus. As such, students who placed a higher value on being involved in extracurricular activities or working while in school might avoid engineering because of perceived poor fit between competing priorities. In this population, being a female engineering student decreased the odds of persisting in the major by 35%. For those who entered the engineering pipeline at the college level, persistence was not tied to capacity, and low grades were typically not the cause of leaving in the first year.
Students who needed to spend a good deal of time working off campus to pay for school were at risk for not completing the degree (Lichtenstein et al., 2010).

Although overall persistence in engineering appears to be similar to other majors, a more interesting picture is revealed when looking at subgroups of who is persisting in engineering. The Center for Advancement on Engineering Education (CAEE) (as cited in Atman et al., 2010) found the students most likely to leave engineering were from underrepresented groups and students who were first-generation, meaning the students who persisted were more likely to be male, white, and have older family members who attended college. Additionally, CAEE found that students who switched out of engineering were more likely to cite parental influence as a reason for initially studying in engineering. Lower confidence in math and science was also a reason cited for switching out of engineering (Atman et al., 2010). The students who selected engineering because they felt as if their identity aligned with aspects of the field were more likely to persist to degree completion.

Being a student from an underrepresented ethnic group is highly correlated with two other characteristics: being a first-generation college student and coming from a lower socioeconomic status (University of California, 2011). Students who fall into these categories are less likely to receive quality academic preparation in their K-12 years compared to students from the dominant culture, students who have at least one parent who went to college, and students from middle to high social economic statuses. The primary and secondary schools students from UEGs attend tend to have instructors with
fewer qualifications or less experience, less advanced placement coursework, and fewer resources in general. This, in part, is contributing to the result that only 4% of students from UEGs are graduating from high school as “engineering eligible” for colleges and universities. As a result of these socioeconomic and educational factors, students from UEGs were more likely to start their post-secondary education at community colleges, where engineering courses can be harder to find (Frehill et al., 2008). Also, the pathway to transferring to a four-year engineering program can be more difficult to navigate compared to transferring in a social sciences or humanities program or entering an engineering program as a freshman at a four-year university.

Students from underrepresented ethnic minorities tend to have less knowledge than other students regarding what engineers are and what engineers do in their careers (Trenor et al., 2008). If only 4% of students from UEGs are graduating engineering eligible, it is safe to assume an even smaller proportion of this population is actually interested in studying engineering and able to go to college right out of high school. Similar to females, students from UEGs have fewer examples of educational and occupational successes in engineering from their own demographic to reference (Kemper & Sanders, 2001). Additionally, women of all ethnicities have been historically socialized to believe they are less adept than men in math and science and are less likely to even have the interest to learn more about engineering (Wentling & Camacho, 2008).
Student Gender Attitudes Toward STEM

High school course selection and performance in advanced math and science classes can predict the likelihood of students selecting STEM majors and can also predict their academic performance in college (Cole & Espinoza, 2009). A review of the literature brought forth conflicting information on course selection between males and females in high school. On one end, Eccles (2009) stated that because of gender socialization and stereotypes, fewer females are taking advanced math classes in high school, while others (Mannon & Schreuders, 2007; Wentling & Camacho, 2008) argued the proportion of females and males in advanced math classes has evened out over time. According to Wentling and Camacho (2008), female students are keeping up academically with their male peers in math and science courses. It has been noted that an increase of females in the K-12 math and science pipeline should result in an increase of females who select STEM majors in college (Mannon & Schreuders, 2007).

Unfortunately, the expected increase in female student matriculation into STEM has yet to become a reality, suggesting other influential factors are stopping them from entering these fields.

Male students are less likely to be discouraged to pursue engineering because of grades or ethnic identity, likely explained by the gender socialization they receive during childhood and adolescent development about being well suited for math and science. Female students struggle more with their identities and how they fit into the engineering realm (Gilmartin et al., 2006). While males from UEGs lack engineering role models of
a similar ethnic background, they can at least identify with the other males in the field. Females from UEGs lack role models of both a similar ethnic background and gender. If family members and teachers can influence females to think more about how they can fit and do fit into engineering and science, while also increasing awareness of the altruistic and helping aspects of engineering, then females’ self-perceptions may shift more toward a sense of belonging.

While researching segregation of gender and ethnicity in science, Mullen and Jane’s (2008) discovery that the most selective and top-tier universities were also the schools tending to offer the most programs in engineering was exposed. This is an unfortunate occurrence due to the fact that women, Latino, and African American students are underrepresented at these institutions and are more likely to attend universities having less rigorous admission standards. At the less selective schools, where the overall female to male ratio is higher, males display a stronger representation in science and engineering. Mullen and Jane (2008) noted this occurrence might be the result of males feeling external pressures to choose a major aligning with more masculine traits.

Theoretical Frameworks

This framework section is organized into umbrella topics. The first topic reviewed is the theory of intersectionality as it relates to identities. Next, is the discussion of cultural and social capital, which looks at how the individuals function
within communities and society based on their knowledge and relationships. The next topic is the perception of self students possess and how it influences their motivations and decision-making processes. Next, the concept of engineering identity is discussed. Lastly, the model of Subjective Task Value (STV) is reviewed, along with a direct application to studying engineering. After covering these theories, models, and concepts the review moves into the next subtopic, family influence. The final subtopic will include how families shape and influence their students’ capital (social and cultural) and students’ self-perception.

Theory of Intersectionality

Because women of all ethnicities are underrepresented in engineering, the theory of intersectionality is relevant to this study and this literature review. The theory of intersectionality refers to how the different pieces of an individual’s identity do not exist in separate silos, but instead can be challenging, or even impossible, to separate (Lord et al., 2009). Some of the major social constructs of identity relevant for college students include gender, race, ethnicity, religion, sexual orientation, and social class. The importance of each of these pieces of identity can vary based on environmental context (Organista, Marin, & Chun, 2010). All engineering students from UEGs may feel the effects of discrimination and social inequalities, but when the identity of gender is added to the equation, the effects may be compounded for women (Gilmartin et al., 2006; Lord et al., 2009).
**Theories of Cultural and Social Capital**

Two closely related forms of capital affecting students’ educational experiences are social capital and cultural capital. The first, social capital refers to the social relationships possessed by an individual or group contributing to access of knowledge and resources (Moschetti & Hudley, 2008; Stanton-Salazar & Dornbusch, 1995). Theorist James Coleman expressed specific interest in how social capital can assist with social mobility and the relationship between inequality and education (Dwyer, Modood, Sanghera, Shah, & Thapar-Bjorket, 2006). Students from working-class families tend to have less social capital than other students (Stanton-Salazar & Dornbusch, 1995), which is related to their lower levels of knowledge regarding college admissions and occupational opportunities. Students with family members who went to college have higher levels of social capital regarding higher education. These family members teach students in both direct and indirect ways about what is required to gain admission to college, what to expect once there, and how to navigate the bureaucratic system of higher education (Moschetti & Hudley, 2008).

Cultural capital, according to theorist Pierre Bourdieu, relates to knowledge of the dominant culture allowing one to gain social mobility (Sullivan, 2001). Under Bourdieu’s theory, children from higher socioeconomic status (SES) families have more exposure to cultural capital because these families are better acquainted with the dominant culture. This stronger acquaintance also allows these children to achieve higher educational levels than children from lower SES families (Sullivan, 2001). For
youth, both social capital and cultural capital are heavily influenced by family context and educational environments, which can vary significantly according to ethnicity, gender, culture, and SES status. It is commonly believed there are higher rates of social mobility in the U.S. compared to other global regions; however, statistics show the SES of one’s family of origin is the most accurate predictor of an individual’s SES later in life (Hays & Erford, 2010). Students who have parents or other close connections to engineers may benefit from transmission of specific engineering educational and occupational knowledge.

When students arrive on university campuses, their experiences can vary greatly based on their levels of social and cultural capital. Students with higher levels of congruity between their personal self and the institution feel more connected and secure, allowing for a greater sense of well-being (Camacho & Lord, 2011; Castellanos & Gloria, 2007). When a student perceives her culture is not validated on a campus or within a specific academic program, it can lead to negative feelings, such as isolation and depression.

College students who successfully overcome the challenges of low cultural congruity do so by “playing the game” (Shehab et al., 2007, p. 17). In a qualitative study examining ethnic identity and persistence of engineering students of UEGs, Shehab et al. (2007) argues that educational systems reward students from the dominant culture, while disadvantaging other students simply because of their lower levels of capital. Generally, the dominant cultural, in this case the university, does not think it is its responsibility to
teach the minority the rules of the system (Shehab et al., 2007). To learn the rules, students must take the risk of exposing their lack of knowledge (Sullivan, 2001), which might be an uncomfortable or even frightening experience, depending on the student.

*Perception of Self*

For the purposes on this research, the first important type of student perception of self is academic self-concept. Academic self-concept is the way that students view their intelligence and ability to be academically successful in comparison to their peers’ (Espinosa, 2008). For students from UEGs in college, the measurement of academic self-concept is a better predictor of later success than standardized test scores (Espinosa, 2008). Academic self-concept forms during students’ K-12 years, but continues to develop and change as they enter the university environment. Findings on STEM students of UEGs indicate both male and female college students experience a drop in their academic abilities, drive to achieve, and math ability but an increase in their intellectual self-confidence (Espinosa, 2008). The second type of relevant self-perception is self-efficacy. Eccles’ (2009) model of self-efficacy predicts individuals select activities for themselves they believe will result in success due to their own beliefs about their abilities to perform well. The beliefs individuals use to judge their self-efficacy are formed by a combination of both internal and external factors. Through communicating with and observing their environments, students can figure out which tasks seem easier for them than others and which are more difficult. These opinions are also shaped by the
external messages they receive from their families, communities, and cultural environments (Eccles, 2009).

The amount of self-efficacy a student perceives they possess in terms of specific academic topics can influence the decision of what major to select in college. During college, self-efficacy and academic self-concept influence student beliefs regarding their ability to successfully persist to degree attainment. As described by Bussey and Bandura (1999):

- Perceived personal efficacy influences the choices people make, their aspiration, how much effort they mobilize in a given endeavor, how long they persevere in the face of difficulties and setbacks, whether their thought patterns are self hindering or self aiding, the amount of anxiety and stress they experience in coping with taxing and threatening environments, their vulnerability to depression and their resilience to adversity. (p. 692)

Furthermore, challenges and failures are attributed differently for students with high self-efficacy versus low self-efficacy. Those who perceive higher levels of self-efficacy tend to associate setbacks to situational or external factors, while those with lower levels of self-efficacy ascribe setbacks to personal inadequacies (Bussey & Bandura, 1999). Given the previous information that engineering is an academic field requiring a considerable amount of effort and one that can cause high levels of anxiety and stress in less than welcoming environments, higher levels of self-efficacy and
academic self-concept could potentially help mitigate the formerly mentioned challenges and contribute to higher levels of student success.

Self-efficacy is important in both cultures valuing individualism and cultures valuing collectivism because high self-efficacy can contribute to both an individual’s or a group’s success (Bandura, 2001). The way in which self-efficacy beliefs form in individuals can vary based on the values of one’s culture. Regardless of the differences in values, people feel most efficacious and accomplished when the system in which they are operating emphasizes the same values as their dominant culture (Bandura, 2001). For example, Camacho and Lord (2011) noted Hispanic Serving Institutions (HSIs) are graduating the highest rates of Latino engineering students, and Eagan, Hurtado, and Chang (2010) noted the highest graduation numbers of African American STEM students are from Historically Black Colleges and Universities (HBCUs). This may be due, in part, to the fact the overall culture at HSIs and HBCUs more closely matches the culture of their student populations, helping the students feel more self-efficacious and persist to degree completion (Camacho & Lord, 2011).

*Engineering Identity*

As suggested by theorists, strong positive self-efficacy and academic self-concept can increase students’ chances for success. Specific to students in STEM, the development of an emerging science identity is also an important part of success, especially for underrepresented students (Carlone & Johnson, 2007). According to Carlone and Johnson (2007), science identity is influenced by three factors: one’s
performance and one’s competence in a given science field as well as recognition of self and by others that the individual is a “science person.” For the purposes of this research, the term science identity will be narrowed to engineering identity. Of the three factors influencing engineering identity, recognition of an individual as an engineering person is the most important influential component to highlight for this research. The ways in which students recognize their own qualities and characteristics that align with an engineering identity are influenced by the culture and environment in which they live, including direct and indirect family influences. Also, to recognize personal similarities or differences with engineering, students must have a perception of what engineering is. The students’ environments also influence the amount and types of information they possess regarding engineering. The more clear or accurate the student’s perception of engineering, the easier they will be able to develop a secure engineering identity.

Subjective Task Value

Eccles’ (2009) Subjective Task Value (STV) model examines and predicts individuals’ motivations and outcomes. The likelihood of an individual to select and complete a task is influenced by the perception of any combination of four types of values associated with the task. The first value is interest value, or how much an individual expects to enjoy doing a task. Attainment value deals with how much performing a task will affirm or agree with the individual’s self-concept. Utility value relates to the future usefulness of the task, but does not directly relate to self-concept. Finally, cost value deals with how much effort a task might require and take away from
the ability to engage in other tasks. Cost value also includes potential psychological impacts, such as stress and anxiety (Eccles, 2009; Matusovich et al., 2010).

In a study on engineering students, Matusovich et al. (2010) used Subjective Task Value (STV) to look at why students selected engineering as a major. The study displayed the importance of attainment value for not only the selection of engineering as a major, but also for student persistence in engineering. It is not always enough for a student to like a topic (i.e., interest value), but when the topic is in harmony with the student’s identity (i.e., attainment value), a stronger bond is created. This finding affirms the importance of students needing to possess an understanding of what engineering is to more accurately determine if it aligns with their identity. It also suggests students who select engineering as a major because of the goal to get a well-paying job after graduation, which is a utility value, are more likely to succeed if they also associate a high attainment value with the field, and are less likely to persist if a high cost value is perceived.

The Matusovich et al. (2010) study and other studies have highlighted the effects of various combinations of values. Matusovich et al. (2010) confirmed the negative effect of low attainment value in engineering students can be mitigated by the presence of high levels of other values. When students displayed low attainment value, but matched it with high utility value, they were more likely to persist. Seymour and Hewitt (1997) also showed that low interest value can be mediated by other values to support persistence. Both studies show high cost value in combination with low attainment,
interest, and/or utility is a situation in which students’ persistence can be greatly challenged. Since underrepresented engineering students, both ethnic minorities and women, are less likely to possess a thoroughly developed understanding of the field, they could be less likely to place high attainment value on this field. Recruitment and retention services should first focus on trying to increase student attainment value, and second, promote the interest and utility value of engineering.

Family Characteristics and Influences

The definition of family can vary from culture to culture and even within cultures, but it is generally thought the family is one of the most, if not the most, important social network people possess (Schoebi, Wang, Ababkov, & Perrez, 2010). “Family members provide information, opportunities, and experiences for their children that shape students sense of possibility in school and beyond” (Gilmartin et al., 2006, p. 186). In this regard, family members are an extremely crucial component in the development of a student’s academic self-concept and affect the types of cultural and social capital students possess. The types of support families provide to their students can make a positive impact on their overall well-being and academic experiences. Likewise, families may place certain expectations or responsibilities on their student children, or the students may place these on themselves, impacting the student in both positive and negative ways.

Although many are familiar with the image of the stereotypical American family, the nuclear family, consisting of a married, heterosexual couple and one child or more, it
is not the most common family form and, in the last four decades, has proportionally decreased (Galvin et al., 2004; Segrin & Flora, 2005). While some families of UEGs do consist of a nuclear structure, there are also many variations of single-parent families, multigenerational families, families headed by grandparents, and more (Organista et al., 2010). Furthermore, family structures are not static, and, as individuals develop, their roles within their family can transform.

**Limitation of Generalizations**

A challenge in studying students of UEGs and their families is that these and all cultural groups are not monolithic; it is a mistake to assume all individuals from one group are the same. However, Uba (as cited in Sue & Sue, 2008) does note, “it appears that almost all minority groups place greater values on families, historical lineage (reverence of ancestors), interdependence among family members and submergence of self for the good of the family” (p. 194) when compared to the family structure of the dominant culture. The following sections are an attempt to highlight similar characteristics within very large, diverse ethnic groups, but are not intended to stereotype any ethnic culture or claim that people who identify with the following ethnic cultures also have the exact qualities listed.

**General Characteristics of African American Families**

Within available literature on African American family structures, it is clear perspectives of this culture vary. When compared with White, middle-class family structures, outsiders have described African American families to be “disorganized” or
“dysfunctional,” although those with a more in-depth view see this family structure as different, but with a strong ability to adapt and solid interpersonal ties among extended family members and non-blood relatives (Buchanan & Selmon, 2008; Logan, 2001).

African American families tend to value extended family structures across many generations. The extended family is especially important in terms of caring for and raising children (Logan, 2001; Sue & Sue 2008). Older children, both male and female, are often considered part of the extended family in terms of childcare and other household responsibilities (Hays & Erford, 2010; Logan, 2001). Older family members teach younger generations to be assertive and proud of who they are, including their ethnic identity, as well as that respect toward elders is important (Logan, 2001).

African American families lower in social economic status tend to be matriarchal and over 70% of these families are headed by women (Sue & Sue, 2008). Approximately half of African American families do not have a father living with the family (Logan, 2001). Compared to White women, African American women are less likely to depend on men for economic survival and are also less likely to be married (Buchanan & Selmon, 2008). Men are more comfortable with tasks considered to be women’s roles by other cultures (Sue & Sue, 2008). These family factors contribute to less traditional gender attitudes than those of white families (Buchanan & Selmon, 2008).

Graduation rates of African Americans are slowly increasing and the gap between this minority and the majority is not as wide as before, but academic performance issues are still considerable (Frehill et al., 2008). Numbers of African Americans in higher
education have a long way to come. Regardless of economic status, it appears it is more important to families for African American students to earn any degree, rather than persist in a STEM field, if that was their original intention (White, Altschuld, & Lee, 2006). Also, males who grow up in households led by women are likely to have career goals influenced by their mothers’ occupations (Mannon & Schreuders, 2007). The above educational and occupational factors contribute to the lower numbers of African-American engineering students.

*General Characteristics of Latino Families*

The Latino population is comprised of many different heritages, including, but not limited to people from the following descents: Mexican, Puerto-Rican, Cuban, and South and Central Americans. Across the board, there are many shared characteristics, including the Spanish language, but there are also many variances, or heterogeneity (Hays & Erford, 2010). This review focuses on the similarities in terms of family and educational characteristics. The Latino family unit tends to include extended family members and non-blood relatives. *Familismo*, or familism, which includes family unity, loyalty, cooperation, obligation, and a willingness to sacrifice for others, is central to this culture (Castellanos & Gloria, 2007; Cooper, Baker, Polichar, & Welsh, 1993). If there is a problem needing resolution, the family is conferred first. Depending on the group or issue, outside help may or may not be pursued, but only after help of family is exhausted (Sue & Sue, 2008). In some cases, the response to a problem is to accept and adapt to it, rather than come to resolution (Avila & Avila, 1995).
The sex role expectations in Latino families are clear and distinct. Males are the providers and protectors while women are responsible for the care of the home and family. A commonly used term, *machismo*, refers to being masculine and displaying manhood. This gender characteristic is sometimes viewed in a chauvinistic manner. On the other end of the spectrum, *marianismo*, a female gender role, relates to being submissive to men, raising children, and having other homemaking qualities (Hays & Erford, 2010; Starbuck, 2006). Additionally, children of both genders are expected to be obedient, and the male head of the household typically makes decisions (Avila & Avila, 1995).

Among the youth, being successful at school is perceived as acting “white” or “nerdy.” Mexican American college students expressed that their pursuit of higher education could alienate them from their ethnic group (Phinney, Dennis, & Osorio, 2006). High school dropout and pregnancy rates are high among Latino teenagers and the educational gap between Latino and White students appears to be widening (Mather & Foxen, 2010). Also, the relationships between the families and schools can be strained due to poor communication and trust. Schools may perceive traits of *familismo* as apathy (Sue & Sue, 2008). Lastly, Latinos are well represented in the work force, but are more likely to work in blue-collar occupations. Youth who do not complete high school or do not go to college often decide to enter the workforce to help support their families (Starbuck, 2006).
General Characteristics of Native American and Alaskan Natives Families

It is hard to describe a typical family of Native Americans and Alaskan Natives because there is great diversity among a large number of tribes. In the U.S., Native Americans and Alaskan natives make up about 1% of the population, but within this small fraction, there are hundreds of tribes. It has been said these tribes represent 50% of the entire nation’s diversity (Hodgkinson, 1990). There are also distinct differences between those who live on the reservation, where tribal values may be stronger, versus those who do not live on reservations. A similarity across tribes is that extended family is usually the basic unit, which includes both non-blood relatives and distant family members (Sue & Sue, 2008). Collectivism is a key component of these family structures and shared group experiences are also valued (Trimble & Thurman, 2002). Individuals often make decisions based on how the tribe will be affected and value harmony and interconnectedness with their tribes (Anderson & Ellis, 1995; Hays & Erford, 2010).

Access to higher education is a challenge for Native Americans. Only 52% of these students graduate from high school. Seventeen percent attend college, but only 4% of Native Americans persist to the completion of a bachelor’s degree (Hays & Erford, 2010). The values and beliefs of Native Americans, centered on collectivism, are not congruent, and some may even argue in direct opposition, with the individualistic culture of American higher education. Leaving the tribe to attend college may even be viewed as the student rejecting their cultural values (Anderson & Ellis, 1995).
**Biculturalism**

Students who grow up in their own family’s culture and a different culture at school, which is typically the dominant culture, experience the effects of biculturism. The dominant culture of the United States is achievement-oriented and individualism is an essential component. In this culture, it is widely thought that individuals should make their own decisions, set their own goals, and control their own lives. When an individual is successful according to the standards of this dominant culture, merit is typically attributed to the individual, not the contributions and sacrifices of others (Gilbert et al., 1998; Sue & Sue, 2008). Sometimes, the younger generations of the family are more influenced or more drawn into the dominant culture and identify more with these values as opposed to the values of their family of origin, which can lead to intergenerational conflict (Sue & Sue, 2008). Cultural dissonance between family members can be more commonly found between first-generation and second-generation populations. Additionally, the more generations a family has been in the U.S., the further from traditional cultural values the family may be (Hays & Erford, 2010).

**Parental Gender Attitudes and Expectations**

Across the board, research has emphasized parents have different beliefs and attitudes about their children based on their gender (Eccles, 2009; Gilmartin et al., 2006; Hanson, 2000; Mannon & Schreuders, 2007; Wentling & Camacho, 2008). The messages children receive from their parents are then incorporated into the child’s beliefs about their own abilities and self-concept. Males tend to receive cues reinforcing
behavior that is aggressive, inquisitive, and independent, while females tend to receive cues encouraging passiveness, caring, and dependability (Hanson, 2000). Another relevant parental influence is the attitude differential with regard to math and science. Parents tend to believe these topics are easier for boys to comprehend than for girls. They also tend to believe boys enjoy learning math and science more than girls do. 

These parental beliefs channel into broader, stereotypical gender role messages children receive from both their families and society at large. Females are discouraged from being interested in science and engineering at many developmental stages, including very early stages in their lives. They receive signals about future expectations to raise and care for family members, which do not always align with expectations of individuals in science and engineering careers (Gilmartin et al., 2006). “A critical element in the culture of science occupations involves ideas about having to be wedded to one’s work – making it difficult for women with families (spouses and/or children), but not men with families, to succeed” (Hanson, 2000, p. 170). This problem is further exacerbated in the STEM field by the assumption that every woman, whether or not they currently have a family, has the potential of starting a family at any given point in time, which could result in less dedication from said woman (Hanson, 2000).

Occupational Inheritance

“One of the best ways to influence a student to choose engineering as their major field is for them to have a family member or know a friend who is or was an engineer” (Anderson-Rowland, 1996, p. 373). Occupational inheritance is a sociological
phenomenon in which students gravitate toward the educational and career interests of their parents and other family members (Mannon & Schreuders, 2007). This may be of particular interest to the recruitment of women engineers because males, regardless of their ethnicity, are more likely to learn of engineering and be encouraged to pursue it by role models outside the family, such as high school teachers and counselors. Mannon and Schreuders (2007) conducted the first research specifically on the occupational inheritance as it relates to engineering and found that the pathway for the selection of engineering as a major was significantly different for males versus females. In their findings, males displayed a tendency to select engineering prior to starting college, whereas females were more likely to switch into engineering after starting college. The females who selected engineering prior to college were much more likely to have known an engineer in their family (Mannon & Schreuders, 2007).

In another study on female engineering students, 44% of participants reported having an engineer in the family, but over twice as many of the family engineers were males rather than females, reiterating the lack of female engineering role models (Wentling & Camacho, 2008). The strong effect of knowing an engineer in the family may be problematic for the recruitment of UEG students because being a student from UEGs is significantly related to not knowing an engineer (Trenor et al., 2008). Furthermore, in a qualitative study on influences of engineering parents on the majors selected by their daughters, it was deduced that some engineering parents actively discouraged their daughters from going into engineering, a phenomenon directly opposed
to occupational inheritance (Hoffman et al., 2010). It is suggested this occupational avoidance is due to the anticipation that women in engineering may face several obstacles and the desire of parents and their daughter’s to select an educational and career path that is not as rocky (Hoffman et al., 2010).

**Attending College to Help One’s Family**

In a study on reasons to attend college, Phinney et al. (2006) focused on diverse students and uncovered an educational motivation not previously identified: to help one’s family. The study, conducted on Latino, Asian American, African American, and White students, and controlled for SES, showed that all minority students considered helping one’s family to be a motivation for attending college. Latino and Asian American students reported this reason at a slightly higher rate than African American students, which can be explained by the collectivist quality of the former.

Family interdependence may be associated with a desire to do well educationally, to repay their parents for sacrifices they made in immigrating to the US…

Students with strong interdependence who are encouraged by others (extrinsic motivations) to go to college are more likely to do so. (Phinney et al., 2006, p. 350)

All minority students reported attending college to help family as significantly more important than White students did (Phinney et al., 2006).

In another study with Latino, Asian American, African American, and White students, Trenor et al.’s (2008) finding indicated only Latino students speak very
specifically about choosing engineering as a way of helping their families after college. All the Latino students interviewed mentioned they planned to look for a job right after college rather than go to graduate school. This intention to head directly into the workforce may be a factor affecting the low numbers of students of UEGs in postgraduate engineering education.

Independent of one’s ethnic or cultural background, students from low-income families are also more likely to go to college with the goal of helping their families (Phinney et al., 2006). Low SES students are also more likely to choose majors in applied fields of study, such as engineering, while high SES students tend to study humanities and social sciences (Mullen & Jane, 2008). With the goal of helping family members in mind, lower SES students feel the pressure of needing to earn a degree that will help them acquire a dependable job and paycheck once they have completed school.

In a separate study, also on Latino, Asian American, African American, and White students, researchers examined the relationship between family science support and science and engineering career aspirations (Gilmartin et al., 2006). The relationship between families and careers was slightly stronger for Latino and Asian Americans compared to White and African American students. The differences imply the possibility that Latino and Asian American students receive more direct input from family members on their feelings regarding science and engineering. The findings also suggest Latino family members should be targeted more in recruitment efforts to increase the numbers of Latinos studying science and engineering (Gilmartin et al., 2006).
Parent Expectations for Students Attending College

Parents’ expectations for their children to earn at least a bachelor’s degree can vary on a number of different demographics. On one end, parents with higher household incomes report higher rates of expectation for their children to go to college. On the other end, parents who do not speak English as the main language at home and parents born outside the United States report higher rates of expectation for their children to go to college compared to English speaking parents and parents born in the United States (Lippman et al., 2008). The finding related to high SES may be explained by parents’ higher levels of social and cultural capital as they relate to higher education, while the findings on language and generational status may be explained by beliefs regarding the impact of educational attainment on social mobility.

Student Well-being

The state of well-being decreases stress, and thus increases the likelihood students will be able to feel secure and are able to perform successfully (Perlman & Rook, 1987). Family members can be great sources of various types of social support for their students, which in turn, can also increase student well-being. Emotional support relates to caring, concern, and intimacy. Motivational support concerns the sharing of information, feedback, and encouragement, and financial support is the assistance with money or other provisions (Gilbert et al., 1998). People are more likely to help and support their own families compared to helping strangers, especially in more extreme situations. In terms of measuring support between families, observable support is not the only important type,
but perceived support in relationships also has a strong impact on individuals (Gilbert et al., 1998).

The importance of family has been identified as a key factor in “life satisfaction,” or an overall state of well-being for Mexican American adolescents (Edwards & Lopez, 2006). More specifically, the youth indicated the support received from their families contributed to their well-being. Applying these results to Latino college students indicates a need for students to perceive they are receiving family support to increase their overall satisfaction and well-being, which in turn, will ideally poise them to be academically successful.

*Double Bind*

According to Vasquez (as cited in Castillo et al., 2004), once students find themselves at the university level, especially students of Latino descent, they can find themselves caught in a “double bind” (p. 151). The double-bind situation is characterized by the family’s desire for the student to be successful at school along with a desire for the student to maintain core cultural values, including closeness with the family (Vasquez as cited in Castillo et al., 2004). College campuses, which tend to reflect the values of White American culture, promote individualistic values including competition, independence, autonomy, and self-reliance, which is in direct opposition to qualities of *familismo* (Sue & Sue, 2008). The disconnect and conflicting nature between the double bind can leave students feeling alienated, marginalized, and distressed in their campus environments (Castillo et al., 2004; Gonzalez, 1999). Additionally, when students are
pulled toward their families and away from their studies, educators and peers from other cultural backgrounds, mostly the dominant culture, have a harder time relating to and understanding why family is so important to the student. This misunderstanding can lead to negative stereotypes being made about the students and their culture and questioning of the students’ commitment to their educational pursuits (Castellanos et al., 2007).

In general, first-generation college students, not just Latino students, see their families as vital sources for their success in college (Orbe, 2004). However, it is not uncommon for these students to simultaneously perceive outward support from their families while also sensing an internal resistance regarding their pursuit of higher education. The family resistance can come from a desire for the student to fail so she can return home and contribute to the family, as expected of the younger generations in Mexican-American cultures. Another reason for the resistance is jealousy because older family members did not always have the same opportunities as the younger generation and have made sacrifices for the students to be able to go to college (Orbe, 2008). This duality of support and resistance students perceive can be very confusing and difficult for them to sort through as they are at the same time attempting to navigate complex university systems and their engineering coursework.

The double-bind issue can be intensified for female Latino students because of the additional gender role expectations placed on them, including the expectation that females will be the caretakers of family. However, a study conducted on Mexican American female college students indicated that perceived family support is related to
perceived student distress, where less support equates to increased distress (Castillo et al., 2004). The researchers recommend that on-campus support services continue to develop methods to include the family in the student’s educational experience, given that family support predicts lower levels of student distress, and lower levels of distress allow for greater chances of academic satisfaction and success.

An important decision for students to make regarding college and their families is where to pursue their undergraduate studies. Some families pressure students to stay close to home, which can more readily cause the double-bind issue for Latino students (Kiyama, 2010). The effect of students living close to home can vary greatly. On one end of the spectrum, students with positive family relationships can more easily access and maintain their support systems. On the alternate end, an easy ability to go home and local extracurricular responsibilities can potentially cause distractions from the rigorous demands of a course of study in an engineering curriculum, resulting in lowered academic performance.

*Other Family Factors*

Due to differences in cultural values and points of view, it can appear Mexican American families are not involved in their children’s education because they have a hard time accessing culturally relevant ways to participate with the K-12 system (Kiyama, 2010). Although the families of first-generation college students may not have direct access to information on college, including information in family members’ primary language, they are able to utilize their social capital and network with the larger ethnic
cultural group. Another member of the group who may have firsthand experience can transmit funds of knowledge to the family, effectively developing a strong social support network (Kiyama, 2010). While the transmission of positive and helpful knowledge that can support academic performance is possible, it is also possible negative information discouraging underrepresented students from pursuing higher education will be disseminated. An example of the latter would be sharing information about the cost of tuition without sharing information about the accessibility of financial aid for students who qualify.

Family anxiety regarding the cost and financing of higher education can potentially result in the development of limitations in educational ideologies (Kiyama, 2010). Many of the parents and guardians interviewed in Kiyama’s study (2010), who were also participating in a college outreach program, expressed a willingness to make sacrifices for the child’s higher education. Ultimately, the issue of cost was another hurdle in the confusing maze of the higher education system’s policies and expectations.

Student services programs can improve their knowledge of cost structures and available funding options.

Best Practices

A best practice in theoretical applications for student success with Latinos identifies a psychosociocultural approach, which integrates family relations in some of the suggestions to increase academic achievement (Castellanos & Gloria, 2007). Rather than focusing on the big picture of success for Latino students, it is necessary to target
small steps that can lead to success. One psychological element of success included students “talking with family to provide them daily updates about how they [the student] have managed their coursework” (p. 386), while cultural elements of success included “talking about one’s family with a faculty member over coffee or lunch” and “engaging in a course assignment that requires examination of family and cultural values relative to the curriculum” (p. 387). This psychosociocultural approach focuses on the holistic nature of the student, validating their cultural identity, which for students from underrepresented ethnic groups can mean incorporating the family. Even though two of three suggestions only had the student think about, but not interact with, their family, incorporation of the idea of family in the educational experience can help improve student success. Unfortunately, given the small percentage of non-math, science, and engineering courses, it may be hard to incorporate examination of family and cultural values in an engineering curriculum.

**Rationale for the Study**

Seminal work produced by Seymour and Hewitt (1997) provided great insight into student persistence in STEM undergraduate fields. Over the last decade and a half, researchers have looked more closely at specific persistence issues related to students from underrepresented ethnic groups and women in engineering. This study aims to examine the pre-college- and college-level experiences and perceptions of engineering students with a focus on women and minorities. The experiences and perceptions are
examined under the frames of family characteristics and influences and students’ self-concepts and values, with the goal to increase knowledge regarding recruitment and retention of engineering students.

Summary

Family members and cultural values have a significant impact on students and their development of self, including student’s academic self-concept, self-efficacy beliefs, and their engineering identity. Families also influence the way students view the world and their educational and occupational values, especially in terms of social and cultural capital. According to previous research, two ways to increase underrepresented student attendance and graduation in engineering is to (1) increase pre-college students’ understanding of what engineering is and (2) increase support mechanisms for underrepresented engineering students at the university level. For minority students and women, incorporating family members in culturally sensitive ways may in fact help increase knowledge regarding engineering and persistence in the field.
Chapter 3

METHODOLOGY

Introduction

The purpose of this study is to shed light on the ways in which engineering students are influenced by their family members to choose an engineering major and students’ persistence in the major. This study includes participants from all ethnicities and genders, but has a particular interest in underrepresented engineering students, including females of all ethnicities and students from underrepresented ethnic groups (UEGs). This information is sought to provide suggestions for recruitment and retention of underrepresented students in engineering.

1. What are the family factors and characteristics of female students and students of underrepresented ethnic groups who decide to pursue an undergraduate engineering education?

2. As they relate to their academic persistence, how do underrepresented engineering students perceive familial support and expectations, and which, if any, family responsibilities do students perceive as challenges to their academic studies?
Research Design

The design of this study was an online survey aimed to collect mostly quantitative data and some qualitative data in an attempt to conduct phenomenological research. Data was collected from the point of view of the student and was analyzed from the same point of view. The study focused on students’ family demographics and on how students perceive or feel about the experiences of their academic studies and their family interactions and influences. The researcher created the data collection instrument from information highlighted in the literature review. Survey questions were refined and clarified based on the advice and feedback of colleagues and a more experienced researcher.

Setting of the Study

The site of this research study was a large public university in the northern region of California, which from here on is referred to as Northern State University (NSU). NSU is, for the most part, a master’s granting institution, with the exception of a few doctorate programs. The doctorate programs are administered jointly with other universities; however, none of these programs are within engineering. The university has about 27,000 students, with approximately 23,000 students at undergraduate level students (Northern State University, n.d.). The campus is mostly non-residential, although on-campus housing has increased in the last few years. The campus has about 41% male students and 59% female students (Northern State, n.d.). The overall student
population of the campus is 7% African American, 1% Native American, 16% Latino/Latina, 43% White, 20% Asian/Pacific, 2% International, and 11% other.

As of Fall 2010, about 2,100 undergraduates were enrolled in engineering programs on the campus (American Society for Engineering Education [ASEE], 2011). At the time, the male population in engineering was 89% and the female population was very low at 11%. The overall student population of engineering majors is 4% African American, 1% Native American, 18% Latino, 40% White, 22% Asian/Pacific, 2% international, and 13% other (ASEE, 2011). The student ethnicity statistics for engineering are relatively similar to the overall campus population, although considerably lower for the African American population. The gender statistics of engineering compared to the overall campus population are extremely different.

Population and Sample

Population. The population of this study included all undergraduate engineering students with an emphasis on underrepresented students, including both ethnic and gender minorities. For the purposes of this research, UEGs in engineering education were Latino, African American, and Native American/Alaskan Indian. Asian American students are not underrepresented in this academic discipline. Women of all ethnicities are also underrepresented in engineering. Undergraduates of all levels were included in this population. Freshmen and sophomores may not have had as much experience on campus, but their data is valuable in terms of their family characteristics and pre-college motivations for selecting engineering.
Sample. The sampling procedure used for this study was convenience sampling, a type of non-random sampling of available students who could be accessed (Bui, 2009), from two of the larger engineering departments at the university. The sample of this study was comprised of 106 undergraduate students declared in engineering majors at NSU and three recent alumni. The undergraduate students included five freshmen, 12 sophomores, 46 juniors, and 42 seniors. Fifty-four percent of participants transferred to NSU from a community college. Data from students who intended to change their major from engineering were omitted from the study ($N=1$). Data from subjects who started, but did not complete the survey were also omitted ($N=11$).

Data Collection

The researcher was unable to obtain contact information of engineering undergraduates, so the researcher contacted two department chairs in engineering departments at the institution. The chairs agreed to forward a link to the survey and the informed consent letter (see Appendix A) to the undergraduate students in their departments. An e-mail message was sent to approximately 1,200 students, including students of a broad range of ethnicities and students of both genders. Students self-selected if they wished to participate in the study. In the e-mail message, participants were provided with a consent letter and could decide to continue with the survey or opt out. Data were collected over a period of two weeks.
**Instrumentation**

An online survey tool, www.surveymonkey.com, was used to collect data for this survey. The nature of the online survey allowed for data to be collected anonymously. Data collected from the survey was kept anonymous and respondents were not asked any identifier information such as name or student identification number.

The questionnaire (see Appendix B) consisted of multiple components, starting with a section on demographic characteristics and both quantifiable and absolute (i.e., yes or no) questions regarding academics. In the next section, multiple choice, ranking, and Likert-type scale questions focused on several different themes. First, items surveyed pre-college experiences and perceived family influences. Second, questions focused on the experiences of students during college. Next, a portion of questions regarding student motivation and self-efficacy beliefs as they related to studying engineering were asked. This section included questions aimed at gauging students’ Subjective Task Values (STV) regarding engineering. Lastly, a brief section of open-ended questions gave participants the opportunity to further elaborate on any perceived family support received, influences and motivations for pursuing engineering education, and family responsibilities that may take time away from studies. Participants were allowed to choose to skip individual items if they did not feel comfortable responding to an item. Surveys started but not completed through the last page were omitted from data analysis.
Data Analysis Procedures

Analysis of quantitative data of close-ended questions was largely processed through descriptive statistics. The response data was filtered by male and female participants and also by underrepresented ethnic group (UEG) and White and Asian American participants. The filters were used to compare differences between response segments. The researcher sorted the relevant survey items based on themes as they related to the research questions. Open-ended responses were systematically analyzed, starting with a thorough, but general review. After the initial review, emergent themes in the qualitative data were identified, and the data were revisited and coded according to the themes.
Chapter 4
DATA ANALYSIS AND FINDINGS

Introduction

In this study, the researcher’s purpose was to understand the following questions:

1. What are the family factors and characteristics of female students and students of underrepresented ethnic groups who decide to pursue an undergraduate engineering education?

2. As they relate to their academic persistence, how do underrepresented engineering students perceive familial support and expectations, and which, if any, family responsibilities do students perceive as challenges to their academic studies?

The first section of this data analysis describes the subgroups filtered for discussion of the descriptive statistics. Then, the survey instrument items and responses are presented in several themes, in a chronological order of pre-college experiences to experiences during college. The themes include demographics and family characteristics of the respondents, and respondents’ reported perceptions or feelings about various family and academic characteristics. In the last section of this chapter, the discussion of the findings and the themes are organized and reviewed according to the two research questions listed above.
Presentation of the Findings

Demographics of Filtered Subgroups

The researcher chose to filter the data based on the subgroups from selected categories of gender and ethnicity. The gender filters included categories of male and female. The ethnicity filters included three categories: White, Asian American, and lastly, underrepresented ethnic groups (UEGs), which is an umbrella term for Latino, African American, and Native American or Native Alaskan. The data are mostly presented in percentages of response rates from these filtered subgroups. Table 1 shows the total number (N) of respondents and percentages (%) from each of the filtered subgroups.

Table 1
Survey Respondents Included in Data Analysis Filters by Gender and Ethnicity

<table>
<thead>
<tr>
<th>Gender Filters</th>
<th>Ethnicity Filters</th>
<th>Non-UEG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Underrepresented Ethnic Group (UEG)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Female</td>
<td>Latino</td>
</tr>
<tr>
<td>N</td>
<td>81</td>
<td>25</td>
</tr>
<tr>
<td>%</td>
<td>75%</td>
<td>23.10%</td>
</tr>
</tbody>
</table>

Notes:
Omitted from Gender filters: Decline to State (N=2)
Omitted from Ethnicity filters: Native Hawaiian or Pacific Islander (N=1), Decline to State (N=4), Other (N=7)

Due to low response rates from African Americans and Native Americans, all respondents from underrepresented ethnic groups (UEGs) were grouped into one category, which is referred to from here on as UEGs. These low response rates were
expected due to low proportions of these ethnicities in engineering departments and higher education in general. Due to variability in their responses, respondents who identified their ethnicity as White or Asian American were separated into different filters for the purposes of this data analysis.

The gender breakdown of each ethnic filter is shown in Table 2.

Table 2

Gender Breakdown of Ethnicity Filters

<table>
<thead>
<tr>
<th></th>
<th>UEG</th>
<th>White</th>
<th>Asian American</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>N</td>
<td>19</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>76%</td>
<td>80.80%</td>
</tr>
<tr>
<td>Female</td>
<td>N</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>24%</td>
<td>19.20%</td>
</tr>
</tbody>
</table>

The highest proportion of females was from the Asian American filter, while the highest proportion of males was from the White filter. Additional collected demographics included the respondents’ year in school and age, as shown in Tables 3 and Table 4.
Table 3

All Respondents - Year in School

<table>
<thead>
<tr>
<th></th>
<th>Freshmen</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
<th>Graduated/ Alumni</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>5</td>
<td>12</td>
<td>46</td>
<td>42</td>
<td>3</td>
</tr>
<tr>
<td>%</td>
<td>4.6%</td>
<td>11.1%</td>
<td>42.6%</td>
<td>38.9%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

Table 4

All Respondents - Age

<table>
<thead>
<tr>
<th></th>
<th>17 or younger</th>
<th>18-20</th>
<th>21-24</th>
<th>25-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60 or older</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0</td>
<td>23</td>
<td>52</td>
<td>18</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>%</td>
<td>0.0%</td>
<td>21.3%</td>
<td>48.1%</td>
<td>16.7%</td>
<td>7.4%</td>
<td>6.5%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

The majority of respondents indicated they were in their junior or senior year. The higher proportion of juniors and seniors is partially explained by the fact that 52.2% (N=58) of respondents transferred to the university from a community college. UEGs were the least likely to have transferred from a community college and the least likely to be over age 29. Whites were most likely to have transferred from a community college and be over age 29. Two females reported being between 30 and 39 years old, but none of the females reported being over 39 years old. Seven males reported being between 40 and 49 years old, but none of the males reported being over 49 years old.
Parents/Guardians of Respondents

In acknowledgement that not all families are structured in a nuclear style, and to move away from the assumption that people are mostly raised by their biological parents, the researcher wanted to gauge who the guardians of the respondents were. Respondents were allowed to select all persons who played a guardian role in their upbringing based on the following definition: “A "guardian" can be a parent(s) or any person(s) who played a significant role caring for you and raising you as a minor.” The responses of each filtered subgroup were fairly similar, as shown in Table 5.

Table 5
Parents/Guardians of Respondents

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>UEG</th>
<th>White</th>
<th>Asian American</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td>96.3%</td>
<td>96.0%</td>
<td>96.0%</td>
<td>96.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Father</td>
<td>77.5%</td>
<td>76.0%</td>
<td>76.0%</td>
<td>82.4%</td>
<td>72.2%</td>
</tr>
<tr>
<td>Grandparent(s)</td>
<td>10.0%</td>
<td>4.0%</td>
<td>8.0%</td>
<td>5.9%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Stepparent(s)</td>
<td>6.3%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>5.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Aunt(s)/Uncle(s)</td>
<td>2.5%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>0.0%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Sibling(s)</td>
<td>2.5%</td>
<td>4.0%</td>
<td>8.0%</td>
<td>0.0%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

“Mother” was the most frequent response at 96% or above for all filtered groups, followed by “father” at a range of 72.2%-82.4% for all filtered groups. The researcher did not assume the “mother” and “father” were married or cohabitated, but acknowledged that either relationship status was possible. Rates of stepparents cited as guardians were
low, so if parents were separated, it seemed rates of remarriage were low. Regarding guardians who were not “mother” or “father,” males identified higher proportions of other family members as guardians compared to females. Also, UEGs and Asian Americans reported higher proportions of other family members as guardians compared to Whites.

*Socioeconomic Status of Parents/Guardians*

The socioeconomic status of the respondents’ guardians has a potential impact on the amount of social and cultural capital respondents may have been exposed to while growing up under the care of their family (Moschetti & Hudley, 2008; Stanon-Salazar & Dornbush, 1995; Sullivan, 2001). The socioeconomic status of the respondents’ guardians was gauged by collecting information regarding highest level of education completed by any guardian as well as guardians’ household incomes. Table 6 shows responses to the item regarding highest level of education attained by any guardian resulted in considerable variance between filtered subgroups.
Whites reported the lowest percentage of having guardians who did not complete high school and reported the highest percentage of guardians who completed a bachelor’s or postgraduate degree. UEGs reported a majority of “did not complete high school” as their guardians’ highest completed level of education and reported having at least one guardian who completed postgraduate school at the lowest percentage. Females reported having a guardian who completed a postgraduate degree at the highest percentage. Similar to Whites, a majority of males also indicated that at least one guardian had completed a bachelor’s degree or postgraduate degree.

For the most part, a follow-up question asking respondents if they were a first-generation college student or not, agreed with the responses of the previous item regarding highest level of education completed by any guardian. The definition of first-generation college student used for this study and provided in the questionnaire was the
following: “First-generation college students include any student whose parent(s)/guardian(s) did not complete a bachelor’s degree. The parents of first-generation college students may have attended some college, or even completed an associate's degree.” Responses between the two items matched exactly for males and UEGs. A range of 4%-8% of female, White, and Asian Americans that fell into the above definition of the first-generation student category did not self-identify as a first-generation college student.

In addition to looking at the guardian’s educational level, the survey also collected information regarding the guardian’s annual household income in an attempt to further gauge the socioeconomic status of the respondent’s family. Table 7 displays the annual income of the respondents’ guardians.

Table 7
Annual Household Income of Respondents’ Parents/Guardians

<table>
<thead>
<tr>
<th>Income Interval</th>
<th>Male</th>
<th>Female</th>
<th>UEG</th>
<th>White</th>
<th>Asian American</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $25,000</td>
<td>15.6%</td>
<td>33.3%</td>
<td>29.2%</td>
<td>10.2%</td>
<td>33.3%</td>
</tr>
<tr>
<td>$25,000-$34,999</td>
<td>9.1%</td>
<td>8.3%</td>
<td>20.8%</td>
<td>4.1%</td>
<td>11.1%</td>
</tr>
<tr>
<td>$35,000-$49,999</td>
<td>9.1%</td>
<td>4.2%</td>
<td>16.7%</td>
<td>8.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>$50,000-$74,999</td>
<td>9.1%</td>
<td>8.3%</td>
<td>12.5%</td>
<td>10.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>$75,000-$99,999</td>
<td>14.3%</td>
<td>16.7%</td>
<td>12.5%</td>
<td>14.3%</td>
<td>16.7%</td>
</tr>
<tr>
<td>$100,000-$124,999</td>
<td>16.9%</td>
<td>20.8%</td>
<td>8.3%</td>
<td>24.5%</td>
<td>16.7%</td>
</tr>
<tr>
<td>$125,000-$149,000</td>
<td>6.5%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>10.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>$150,000 or more</td>
<td>7.8%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>10.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>I don’t know</td>
<td>11.7%</td>
<td>8.3%</td>
<td>0.0%</td>
<td>8.2%</td>
<td>22.2%</td>
</tr>
</tbody>
</table>
Females, UEGs, and Asian Americans were the most likely to report guardian household income under $25,000 and did not report any incomes over $125,000. Whites and males reported the highest proportions of incomes at $100,000 and above. Some respondents \((N=12)\) did not know their guardian’s household income.

*People Who Were Most Influential in the Decision to Study Engineering*

For the purposes of this research, it was important to find out who, if anyone, played an influential role in the respondents’ decisions to study engineering. Respondents were instructed to choose one or two of the provided options. Nine respondents selected three influential people despite the instructions. All data were included in this analysis because the researcher was unable to ascertain which, if any, extra responses were more important than the other.

Previous research has indicated students are more likely to understand what engineering is if they know an engineer in their family, and female students who choose engineering before college reported having an engineer in the family more than males (Mannon & Schreuders, 2007). Additionally, being a student from a UEG means the student is less likely to know an engineer (Trenor et al., 2008). Figure 1 displays the responses of the gender filters.
In Figure 1, male respondents most often listed “father” to this item and did so significantly more than female respondents. The next responses from males, in order from highest to lowest, were “mother,” followed by “other,” “teacher,” “peer/friend,” and then “none.” In this sample, female respondents listed “teacher” the most. For females, “teachers” was followed by “none,” “father,” and “mother” and “other relative” at the same proportion. Figure 2 displays the responses regarding the most influential people in the decision to study engineering according to the ethnicity filters.
Like females, UEGs listed “teacher” at the highest percentage. “Teacher” was followed by equal response rates of “mother,” “father,” and “none.” Whites and Asian Americans both reported “father” at the highest proportion, but diverged in patterns after “father.” Whites reported both “mother” and “teacher” at the next highest percentage, then “peer/friend,” followed by “none.” After “father,” Asian Americans reported both “none” and “other relative” at the next highest percentage, then “mother” and “peer/friend” at the same level.

Overall, the selections “college recruiter” and “sibling” were reported at the lowest percentages. Females and UEGs were the only filtered subgroups to select “college recruiter.” All groups reported “sibling” at a low level, with the exception for Asian Americans, who reported it almost twice as high as any other group. Figure 3 summarizes if any of the influential people from Figures 1 and 2 were engineers.
Given that UEGs reported “teacher” at the highest percentage in the previous item, it was not surprising to see that this filtered subgroup was most likely to report the people most influential in their decision to study engineering were not engineers themselves. Asian Americans reported their influential person was an engineer at the highest percentage, followed by Whites. Males reported their influential person was an engineer at a higher percentage than females.

**K-12 Educational Interactions with Parents/Guardians**

Educational interactions between the respondents and their guardians during the respondents’ K-12 years can also have an impact on students’ social capital regarding college and studying engineering. As shown for the gender filters in Figure 4 and the ethnicity filters in Figure 5, respondents were asked to list which of the following activities students experienced with their parents/guardians during their K-12 education.
Each filtered subgroup responded to “encouraged me to get good grades” at the highest percentage (range 68% to 88.9%). The statement with the next highest
percentage of responses was “talked to me about the importance of attending college.” With the exception of UEGs, all filtered subgroups responded to this item in a range from 60%-83.3%. The UEG response rate was markedly lower at 40%. Next, a majority of most groups responded affirmatively to the statement “discussed school related matters with me,” but UEGs also responded to this item at a lower percentage of 40%. Whites reported the previous statement at the highest percentage of 72.5%. Next, the statement “were actively involved in my college application and selection process” had a much lower response from all filtered subgroups, with UEGs responses to the previous statement again being lower than all others. Finally, the statement “none of the above” had the highest response rate from UEGs over the other filtered populations.

Motivations for Studying Engineering - Open Ended

In an effort to collect illustrative data regarding the respondents’ motivations for studying engineering, respondents were given the opportunity to provide an open-ended response to the following question: “Please discuss your motivations for studying engineering and if any of these reasons relate to your family.”

Of the 68 respondents who answered the question, only four, all males, indicated a direct relationship between their motivation to study engineering and their family, including statements that their families advised, encouraged, or told them to be an engineer or study engineering. Of the 68 respondents, 31 made references to various indirect relationships between their motivation for studying engineering and their families. Themes in these responses including the following:
• The respondents wanted to make their families proud, including younger generations.

• Because of their family members’ experiences, including older generations, in blue collar work, the respondents wanted to work smarter, not harder, or to use their mind, not their body (i.e., physical labor).

• The respondents shared certain traits, characteristics, or behaviors with their families, which they believed made them apt to study engineering.

• The respondents’ families helped them identify and cultivate their strengths relating to engineering.

• Families encouraged the respondents to pursue higher education, but specifically engineering.

• Some respondents cited there were engineers in their families, but the families did not directly push them to study engineering. In other instances, the engineering work of various family members was inspiring or motivational.

Thirty-one respondents cited a personal interest in math, science, and engineering as their motivation for studying engineering. Of this group, six respondents explicitly stated their motivations were not related to their families. The following are selected illustrative responses from the previously mentioned themes:

    My father's father died years before I was born, but he was a self-taught electrical engineer. When I learned this information, (close after I changed my major to engineering from business) I suddenly felt more confident, like I must have an
innate knack for engineering and science. Since then, I've grown more and more confident in my abilities and my grades are the best they've ever been (just barely missed a 4.0 last semester). I guess realizing that engineering is something in my family, really helped me feel reassured of my decision and abilities. Female, White, age 21-24

I am tired of being broke all the time. I want to be able to provide a better lifestyle for my family Male, White, age 40-49

Engineering is a challenging field that suits certain individuals. I seem to fit the category of 'engineer;' my personality, characteristics, interests and capabilities. I am often compared to my grandfather and great-grandfather in mechanical awareness. This match of traits assisted in motivating me to follow through with the pursuit of an engineering degree. Male, White, age 21-24

To give back to my parents for all the hard work, money, and sacrifice they have provided me in order to live a good life and go to school. They did not have the same opportunities as I have now when they were growing up. Male, Asian American, age 21-24
Motivations are being a good role model for my female relatives in my family

*Female, Latino, age 30-39*

I have been motivated by the members of my family who are well off. All that went to school and got a degree with a specific career goal attached to that degree have been very successful. I long for that kind of success and to influence others to strive for the same. I want to be well off, and be able to be a role model for my son. I want to be able to help others in my family achieve a similar feat. *Male, Latino, age 25-29*

My motivation to [study] engineering is due in large part to my belief that this field of study is essential to our everyday lives. The machines and structures we use in our everyday lives were crafted and designed by engineering geniuses, and I wish to be a part of that group to serve this society to the best of my abilities. I learned this importance through my uncle who is also an engineer. *Male, Latino, age 25-29*

I find pleasure in building and designing things. My family is crafty and pays attention to details. My father was a carpenter and I assisted for many years. I admire his mathematical and problem solving skills. *Male, Latino, age 25-29*
I like space, planes, and green energy. I want to make a difference in the world and engineering was the most interesting/rewarding major for me. My family never really guided me towards it because most have not finished high school or have little knowledge in science and math. It can be frustrating when there is no one to relate and talk to about school. **Female, Native American, age 21-24**

My parents always told me I should be an Engineer since I was in grade school. But I didn't fully understand what Engineering was until I got to college. Even now the idea I have of what an Engineer does is still evolving, though at a much slower pace. I think I have a strong desire to affect other people in a positive way and in no other field would I be able to do that in such an efficient and stimulating way. I also have acquired a deep-seated fear of not making the most of myself. **Male, Latino, age 21-24**

I have known I wanted to be a Civil Engineer since I was 8, when I was inspired by the Golden Gate Bridge. My parents encouraged me but let me figure out what was involved for myself cause at that time I had no interest in math or science, it wasn't til high school that I actually started being challenged enough to enjoy. **Male, Latino, age 21-24**
My motivation in the beginning was to be an architect because my cousin is an architect and she introduced me to all the amazing projects that she does. I have found motivation in civil engineering because it was allowing me to create bridges and make the big decision on how the structure will come out. Female, Asian-American, age 21-24

Academic Self-Confidence, Self-Efficacy and Engineering Identity

Grade point average (GPA) is a quantitative measure of a student’s academic performance evaluated from coursework. When students earn low GPAs, or perform poorly in their coursework, their academic standing can slip into academic probation (AP), which is a warning period that can lead to dismissal if performance does not improve. Self-reported GPA ranges of all filtered subgroups are shown in Figure 6.
In this sample, female respondents reported the highest levels of GPA and the lowest percentages of ever being on Academic Probation (AP), with 92% of females reporting they had never been on AP. After females, Asian Americans reported the next highest percentages of GPAs at 3.1 or above (70.6%), then 61.5% White students at 3.1 or above. Males reported GPAs 3.1 and above at 51.9%, and, finally, UEGs reported the lowest GPA percentages with 48% at 3.1 or above. After females, Asian Americans and UEGs reported being on AP at the lowest percentages, only 8% of females ever on AP, 11.1% of Asian Americans ever on AP, 12% of UEGs ever on AP, and 17.3% of Whites ever on AP. Males were the most likely to have been on AP at 21%.

Possessing a thorough understanding of what the field of engineering is and what it means to be an engineer can help students strengthen their engineering identity (Carlone & Johnson, 2007). Of the respondents surveyed, males (34.1%), Whites
(31.3%), and Asian Americans (38.9%) were more likely than females (16%) and UEG students (20%) to report they felt they developed a good understanding of engineering in high school or earlier. In each subgroup, the majority felt they developed their understanding of engineering while in college, but females (16%) and UEGs (12%) were more likely to report they still did not have a good understanding of engineering compared to males (7.6%), Whites (9.8%), and Asian Americans (5.6%).

UEGs (64%) and females (52%) were the most likely to report they had occasionally or frequently thought about changing their major, while males (42%) and Whites (36.5%) were less likely to report this. Fifty percent of Asian Americans reported they occasionally thought of changing their major, but none of them thought about it frequently.

Overall, this sample of respondents was fairly confident of their abilities to complete their engineering degree. Only one respondent disagreed with the following statement: “I believe that I will complete a bachelor's degree in engineering” and none of the respondents strongly disagreed or indicated neutrality. Three respondents selected “N/A” because they had already completed their degree. In addition to being confident in their abilities to complete the degree, 89.8% of the total sample indicated they agreed or strongly agreed to the following statement: “I selected engineering as a major because I am confident in my abilities to do well in this academic field.” Additionally, 92.5% of the sample agreed or strongly agreed with the statement “I am content with the idea of
working in a career in engineering,” while only 7.5% indicated neutrality. None of the respondents disagreed with the previous statement.

**Perceived Social Support from Family**

Respondents were asked to rank their perception of support received from their families in the three following social support categories: financial support, emotional support, and motivational support. Respondents received the following instructions: “If support is received, rank amount/quality of support from 1-5, where 1 is low and 5 is high, or select 0 if you don't receive the type of support.” Figure 7 shows the responses to the financial support category.

**Figure 7  Perceived Financial Support from Family**

With the exception of Asian Americans, all filtered subgroups reported a majority of none to low (rank of 0-2) financial support from their families. Males, Whites, and Asian Americans reported the highest percentages (rank of 4 or 5) with males at 32%,
Whites at 29.7%, and Asian Americans at 40%. Both underrepresented student groups reported lower rates of high financial support (rank of 4 or 5) with UEGs at 16.7% and females at 15%. Figure 8 shows the responses to the emotional support category.

Figure 8 Perceived Emotional Support from Family

With the exception of Asian Americans, all filtered subgroups reported a majority of high emotional support from their families (rank of 4 or 5). Both underrepresented student groups did report these higher scores at a higher percentage than the other subgroups (females 68.4%, UEGs 68.2%). Figure 9 shows the responses to the motivational support category.
Overall, all subgroups ranked motivational support as the greatest type of support received from their families. Females were the most likely to rank motivational support from their families at the highest score of 5 (37.5%, White 29.5%, UEG 23.8%, male 23.1%, Asian American 21.4%). With the exception of Asian Americans, a range of 75%-85% of each filtered subgroup ranked motivational support as moderate to high (score of 3, 4, or 5). Fifty percent of Asian Americans reported high levels of motivational support, and 50% reported in the range of 0-2, with 28.6% reporting 2.

Overall, the majority of each population reported they agreed or strongly agree with the following statement: “My family is involved or interested in my higher education experience” (agree or strongly agree: female 76%, White 71.1%, male 67.9%, UEG 64%, Asian American 55.5%). Asian American respondents reported disagree or strongly disagree the most to the previous statement (22.3%), while males (9.8%), Whites
(9.6%), and females (8%) reported at the next level. UEGs were the least likely to disagree with the statement at 4%. UEGs were also the most likely to cite a neutral stance to this statement (32%) and reported the lowest percentage of strongly agree (20% versus 32-38% range of other groups).

Students’ Educational Finances

Students’ educational finances can affect students’ decisions of how they spend their time while pursuing an engineering degree. Time spent working, stress related to funding school, or even family financial responsibilities, can distract from studies and can lower the well-being of the student. It was shown students who needed to work while studying engineering were at higher risk for not finishing the degree (Lichtenstein et al., 2010). Educational finances responses are shown for gender filters in Figure 10 and ethnicity filters in Figure 11, and work status responses are shown for gender filters in Figure 12 and ethnicity filters in Figure 13.
Figure 10  Financial Support for Educational Expenses – Gender

![Bar chart showing financial support for educational expenses by gender.](chart10)

Figure 11  Financial Support for Educational Expenses – Ethnicity

![Bar chart showing financial support for educational expenses by ethnicity.](chart11)
Responses in Figure 10 from males and females regarding full financial aid were fairly similar, with the most respondents stating they received financial aid that covered
the majority of or all educational expenses. Compared to females, males received more financial aid for some of their expenses, and more family financial support that covered the majority or all of their expenses. The finding that males reported more financial aid or support is consistent with the part of Figure 13 where females reported they had to work to support themselves at a higher rate than males. In Figure 11, UEGs and Asian Americans reported receiving financial aid to cover most or all of their educational expenses four or five times more than Whites. Compared to UEGs, Whites and Asian Americans reported family financial support that covered the majority of or all education expenses at least five times as much. Compared to Whites and UEGs, Asian American were less likely to work, worked part-time at a lower percentage, did not report working full-time at all, and were much less likely to report having to work to support themselves or their families.

**Students’ Educational Perceptions & Perceived Family Expectations**

Overall, all filtered subgroups agreed or strongly agreed to the following item:

“Studying engineering is significantly more demanding of my time and energy compared to majoring a non-engineering field.” Across subgroups, rates of agree or strongly agree ranged from 83.4% to 92%. Females and UEGs agreed or strongly agreed in the highest percentages (92% each, males 85.2%, White 86.6%, Asian American, 83.4%). Additionally, 93.5% of all respondents agreed or strongly agreed to the following statement: “An engineering degree can provide the opportunity for social and economic mobility.” Only 6.5% of respondents indicated neutrality, and none disagreed or strongly
disagreed. Respondents’ beliefs regarding education differed more on an item comparing the financial cost and time commitment of going to college to various categories of majors, as shown in Figure 14.

Figure 14   Worth of Financial Costs and Time Commitment of Majors

UEGs and Asian American students were the most polarized between the options of college cost and time commitments being worth it for “any major” or “only engineering,” with low proportional responses regarding “other non-engineering STEM majors.” After UEGs and Asian Americans, males also showed some polarization between the two options of “any major” or “only engineering.” Females responded with the highest percentage to the costs of college being worth it for “any major” and
responded at near equal percentages to “other non-engineering STEM majors” and “only engineering.”

Respondents were asked to report on their beliefs regarding their parents'/guardians’ educational expectations for them. A majority of males, females, and Whites either strongly disagreed, disagreed, or were neutral to the following statement: “My parents/guardians expect me to complete a degree in engineering so I can get a well-paying job and support my parent/guardians and other dependents.” Of those respondents who agreed or strongly agreed, there was a marked difference between males (agree 14.8%, strongly agree 21.0%) and females (agree 16%, strongly agree 8%), especially in the “strongly agree” category. UEGs were split equally on either side of neutral: strongly disagree (16%) and disagree (20%) and agree (16%) or strongly agree (20%). Asian Americans showed a stark contrast to the other groups by reporting agree 27.8% of the time and strongly agree 38.9% of the time.

Only 13% (N=14) of all respondents agreed or strongly agreed with the following statement: “I feel that the educational and occupational expectations that my parents/guardians have for me are influenced by my gender.” Of the respondents who agreed or strongly agreed, 11 were males and three were females, and the ethnicities varied.

Figures 15 and 16 display the differences in respondents’ perceptions of if their parents or guardians would be let down if they did not complete any degree compared to if they decided to major in a field outside of STEM.
Figure 15  Parents Let Down If No Degree Completed or Change to Degree Outside of STEM – Gender

Figure 16  Parents/Guardians Let Down If No Degree Completed or Change to Degree Outside of STEM – Ethnicity
The majority of all subgroups reported agree or strongly agree to the following statement: “My parents/guardians would be let down if I did not complete a bachelor’s degree.” UEGs (52%), Asian Americans (50%), and males (48.1%) reported strongly agree at the highest rates (females 32%, Whites 36.5%). Females reported the lowest percentage of agree or strongly agree at 64%, and reported the highest proportion of strongly disagree or disagree at 24%.

All filtered subgroups, with the exception of Asian Americans, reported a majority of disagree or strongly disagree to the following statement: “My parents/guardians would be let down if I chose to pursue a bachelor’s degree outside of STEM (science, technology, engineering, math).” UEGs were the most likely to report agree or strongly agree at 24%, followed closely by Asian Americans at 22.3%, and then males at 16.1%. Females reported only agree at 12% and Whites reported the combination at 5.7%.

Family Responsibilities - Open Ended

A total of 60 respondents replied to the following question: “Do you currently or have you ever had family responsibilities that compete with your academic studies? If yes, please describe those responsibilities and how they impact you as a student.”

Of the respondents, 24 indicated they did not, at the time of the survey, or had never had family responsibilities compete with their studies. Of these 24, 19 were males, including 11 White males. None of the five female respondents in this category were from UEGs. One Latino male indicated that if his family interactions were different, his
response might also be different, “I have never had to choose between family and studies. I think if I interacted more with my extended family, who are all in Mexico, I might be singing a different tune.” An Asian American female reported, “No. My family allows me to submerge myself in my studies so that I can receive the best education possible.”

Ten of the respondents to this item indicated or referred to some type of responsibility that competed with their academic studies, but did not specify if or how it was related to their family.

Twenty-six respondents indicated they did have or had had family responsibilities during their studies. Upon systematic review, six themes of responsibility emerged from the data. Two Asian Americans stated they helped their parents with translation because they did not speak English. Eight respondents, of which seven were males, discussed responsibilities of being a parent, spouse, or both. Three respondents indicated they helped take care of siblings. Four respondents mentioned issues of parents’/guardians’ finances. Six referenced issues of parents’/guardians’ health, including navigation of the healthcare system. Lastly, five made references to generally needing to help parents.

The following are selected illustrative responses from the previously mentioned themes:

There were several times in which I decided to stop my education because of my parents financial problems and help instead. Male, Latino, age 21-24, parent finances
My mother lost her job last year and I couldn't go to school because I couldn't afford to not work because I was supporting both of us at the time. *Female, White, age 25-29, parent finances*

Both my parents have suffered from long time drug use which have taken a toll on their physical and mental health. My mom is often in the hospital for congestive heart failure and I have missed school a few times to deal with my dad's drug induced psychosis episodes. Although they are not perfect (I think drug addiction is a disease) my parents still support me as best as they can and that motivates me more than them paying for my education. I have learned to be independent and I enjoy taking care of my family. I currently pay for my dad's phone bill and my sister pays for my mom's phone bill so we can stay in contact. *Female, White, age 21-24, parent health and finances*

I am the oldest member of my family, so I do bear the responsibility of being home to look after my younger siblings, and with that it often competes with my time studying while taking care for them while my parents are at work. This includes helping them with their homework, and providing food for them when I can. It is difficult to manage the time to fully study while helping them. *Male, Latino, age 25-29, care for siblings*
I am required to provide all financial resources for my family. That requires a great deal of effort and time working. I also have responsibilities as a father and husband that require a lot of time. Perhaps the greatest distraction is dealing with my wife's mental illness. I must spend several hours a week helping her. Male, White, age 40-49, spouse and children

One responsibility is the after school day care of my daughter and her dropping off and picking up from school. Female, Latino, age 30-39, children

I constantly am struggling with balancing my role as a father and sole provider in my house with my academic responsibilities. It is very difficult to study with a child begging for your attention that you are too stressed to give because you have more homework than you can handle (while knowing that taking a smaller load only means that I'd have to do this longer). Male, Latino, age 25-29, children

Discussion of Findings

The findings of the study are discussed from the perspectives of the respondents, who were current students or recent graduates generally in good academic standing and confident of their abilities to complete their engineering degree. The findings are also discussed in the context of the setting of the study, which was a master’s granting, lower research-level public university.
**Research Question #1.** What are the family factors and characteristics of female students and students of underrepresented ethnic groups who decide to pursue an undergraduate engineering education?

Overall, the parent/guardian composition of the various groups was similar with UEGs reporting only slightly lower rates of “father” and most respondents reporting their parents as their guardians, rather than extended family members. Greater differences in the data arose in the factors contributing to guardians’ socioeconomic status, including education and income. The highest percentages of responses in educational levels of females’ guardians were split between either no high school or college degrees completed, or completed bachelors and postgraduate degrees. The majority of UEGs reported having guardians who did not complete high school. Of all the filtered subgroups, females had the highest percentage of guardians who completed postgraduate degrees, but males had the highest percentages of guardians with either bachelor’s or postgraduate degrees, in general. Whites reported guardians with college degrees more than twice as much as UEGs and nearly twice as much as Asian Americans. Overall, both females and UEGs reported guardian incomes lower than that of males and Whites, but UEGs reported lower incomes than females. In sum, UEGs reported guardians of lower socio-economic status, including education and income, compared to all the other filtered subgroups, while females reported guardians of lower socio-economic status more than males, with the exception of the percentage of guardians who completed graduate degrees.
In this study, both underrepresented groups in engineering reported being motivated to study engineering more by teachers than by their parents or family. Females reported a higher percentage of “none” in regard to who was influential in their decision to study engineering compared to citing their family members and also reported their spouses as sources of influence under the “other” option. The responses from females and UEG were in stark contrast to responses from males, Whites, and Asian Americans, who all cited their fathers most often in this survey item. Males, Whites, and Asian Americans reported that at least one of the individuals who was influential in their decision to study engineering was also an engineer much more often than the underrepresented groups. The UEG results for this item were consistent with previous research that cites UEGs are less likely to know engineers (Trenor et al., 2008). The female results did not align with previous studies in which female engineering students more often reported knowing an engineer than male engineering students (Mannon & Schreuders, 2007). One possibility is females influenced by their parents and by engineers may be at more selective institutions that also have higher percentages of female engineering students. Additionally, females influenced by parent engineers may be more likely to start their college education at a four-year institution, whereas a considerable portion of this study’s sample was made up of students who transferred from two-year institutions.

Overall, during their K-12 years, the majority of respondents experienced positive motivation from their parents and guardians in regard to their education, but differences
appeared in the subgroups. Females were the highest of all subgroups to report encouragement to get good grades, while UEGs reported this the lowest. Compared to males, higher proportions of females heard from their guardians about the importance of attending college, but experienced less involvement in the application and selection process than males. UEGs were far less likely to have guardians who discussed the importance of attending college and were the most likely to report they did not experience the specific K-12 interactions with their guardians listed as options in this survey.

**Research Question #2.** As they relate to their academic persistence, how do underrepresented engineering students perceive familial support and expectations, and which, if any, family responsibilities do students perceive as challenges to their academic studies?

In terms of expectations from parents/guardians regarding higher education, all groups generally reported they thought their parents/guardians would be let down if they did not finish any degree, but that their guardians would not be nearly as let down if the degree completed was outside of STEM. Upon closer analysis, females were less likely than males to believe their families would be disappointed if they did not complete a degree, which is noteworthy given guardians’ educational levels reported by females, the higher rates of postgraduate degrees, and higher response rates to “my parents talked to me about the importance of attending college.” Also, UEGs were more likely than Whites to believe their families would be disappointed if no degree were completed, even
though UEGs reported lower levels of guardians’ education and fewer responses to “my parents talked to me about the importance of attending college.” Males were slightly more likely than females to expect guardian disappointment if they pursued a degree outside of STEM, and UEGs and Asian Americans expected guardian disappointment much more than Whites if the degree was outside of STEM.

The respondents in this study were similar in that they overall reported high levels of self-efficacy and self-confidence as they relate to studying engineering and completing their degree. This finding was not a surprise, given the majority of respondents had successfully made it to their junior or senior year. Also, the respondents almost all reported they felt their engineering major required more time and energy compared to non-engineering majors.

The subgroups showed more differences in their academic performance, engineering identities, and perceptions of worth of various majors given the financial and time commitments of college. Females reported higher GPAs than males and were on AP the least of all subgroups, while UEGs reported the lowest GPAs of all the subgroups. Compared to males, Whites, and Asian Americans, both underrepresented groups reported their development of understanding what engineering is happened later in their education and they thought about changing their major outside of engineering more often than the other subgroups. These findings were consistent with the literature review and were expected, due in part to the reported lower levels of influential people who were engineers in the lives. Although females displayed the highest academic performance,
their higher reported thoughts about changing majors more than males is consistent with the literature review in that females tend to doubt their abilities or fit within engineering more than males, given the social cues they have received regarding their math and science abilities and expected interest levels (Hanson, 2000; Gilmartin et al., 2006; Seymour & Hewitt, 1997; Wentling & Camacho, 2008). Lastly, UEGs were mostly split between stating the time commitment and financial costs of going to college are “worth it for any major” or are “only worth it for engineering.” On this item, females reported “worth it for any major” the most, but were fairly split between “only worth it for engineering” and “worth it for any STEM major.” This finding on females is consistent with previous studies identifying high rates of females in biological sciences and other pre-health profession majors (Mullen & Jane, 2008; Seymour & Hewitt, 1997).

The amount of support students perceive they receive from their families was looked at in terms of financial support, emotional support, and motivational support. Perceived family financial support is discussed in consideration of collected information on family SES and financial aid. All subgroups reported a majority of low financial support, but compared to males, Whites and Asian Americans, both females and UEGs, perceived even less financial support from their families. This finding was expected given the lower guardian incomes reported by females and UEGs. A higher percentage of females reported they received financial support from their families that covered the majority of their educational expenses, while almost none of the UEGs reported this. Compared to females, higher percentages of UEGs reported receiving financial aid that
covered the majority or some of their educational expenses. Financial aid can help mitigate the potential negative effects of not receiving financial support from families. Females and UEGs reported working both part-time and full-time at similar rates and slightly more than their counterparts. Females and UEGs also reported the need to work to support themselves at similar, low rates, but UEGs and males reported the need to work to support their families at slightly higher rates. In sum, although respondents reported low financial support from families, it appears that in this sample, almost all the UEGs, and a majority of females, were able to fund their education through aid, and if needed, supplement with mostly part-time work.

Emotional support relates to caring, concern, and intimacy, and motivational support is the sharing of information, feedback, and encouragement (Gilbert et al., 1998; Perlman & Rook, 1987). Both of these items can help increase overall student well-being and reduce stress. In general, most of the respondents felt they received moderate to high emotional support and motivational support from their families, but females and UEGs ranked both of these items higher than any of the other subgroups. Although specific examples of motivational support were not collected for this study, an interesting future study could investigate the types and quality of school-related feedback transmitted between parents and first-generation students, and with parents without a background in engineering and engineering students.

The second part of the second research question is mostly analyzed through illustrative data from an open-ended, qualitative survey item. A little over half the
sample provided an open-ended response regarding family responsibilities and their studies. Of the 60 who provided a response, a little over half the respondents to this specific item said they did not and had never had family responsibilities that interfered with studies, or did not indicate responsibilities related to their family. The majority of respondents without responsibilities were males not from UEGs, and the few females in this category were also not from UEGs.

Six themes emerged from the 26 respondents who indicated they had family responsibilities that competed with their academic studies which included 1) being a parent, spouse, or both, 2) their guardians’ health, 3) their guardians’ finances, 4) helping care for siblings, 5) helping guardians with translation, and lastly 6) helping guardians with general needs. Because the literature on college students tends to focus on students of traditional age, who are likely to be single and do not have children of their own, this study’s finding on students with spouses and children was the most unexpected family responsibility. White males cited this theme most frequently; however, one Latino male and one Latina female also cited their own children as responsibilities.

Summary

At Northern State, females are by far a minority in engineering, even more so when compared to other four-year institutions. Although the females in this sample reported the highest emotional and motivational support from their families and highest GPAs, they still reported thinking about leaving engineering more often and that their
families’ expectations for them to finish a degree or finish a degree in STEM are still somewhat lower compared to males. This is all despite the higher reported levels of encouragement to be academically successful during the K-12 years and guardians’ levels of education. The findings of this study are consistent with the indications of previous research. It appears the females in this study, even though the majority persisted to their third or fourth year in engineering, still perceived some level of social messaging regarding studying and working in the realm of math, science, and engineering. Specifically, these females reported perceiving less pressure to complete their degrees in engineering and to be the main providers for their families.

The percentage of UEG engineering undergraduates enrolled at Northern State is slightly higher than the national percentage of UEGs earning engineering bachelor’s degrees. The UEGs in this sample reported high emotional and motivational support from families, but they also reported lower GPAs and that they thought of leaving engineering more than students of other ethnicities. UEGs also reported lower levels of guardian income and education and lower levels of interactions with their guardians in their K-12 years that might promote higher education and studying engineering. Despite the previously mentioned lower levels of guardian education and educational interactions, the respondents reported they thought they would let their parents down if they did not complete a degree or a degree in STEM at rates higher than Whites. It appears that, as consistent with literature review, there may be other sociocultural factors at play requiring further examination. Also, due to differences in culture, it may seem to
outsiders that UEG families are not as engaged in the education of their children.

However, the bigger issue seems to be providing UEG families with ways to engage in their children’s education that are culturally relevant.
Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Although rates of female students and students from underrepresented ethnic groups (UEGs) earning engineering degrees have improved over the last few decades, students from both of these groups are still significantly underrepresented in engineering, especially when compared to their overall rates in the U.S. population. When compared specifically to their rates of study in other majors, females are significantly underrepresented in engineering, and on most college campus are now outnumbering male students. UEGs, especially African Americans and Native Americans, are generally underrepresented in all areas of higher education, including engineering (Su, 2010).

Through the collection of information regarding engineering students’ family characteristics and students’ perceptions regarding family interactions and academic experiences, this study was able to compare information about female and UEG engineering students’ experiences to the experiences of their counterparts, which included male, White, and Asian American students. Relevant family characteristics and experiences included the socioeconomic status of their parents, interaction with parents during their K-12 years, the role their families did or did not play in influencing their decision to study engineering, perceived levels of family support, perceived expectations by parents to complete a degree, and any family responsibilities competing with
academics. Data was collected from current engineering undergraduates and small numbers of recent graduates through a voluntary, anonymous online survey, which mostly collected quantitative data and provided the opportunity for respondents to provide open-ended, qualitative, responses to the broader themes of the study.

Conclusions

The findings of this study were generally consistent with the literature review. Both underrepresented groups were more likely to report that the people most influential in their decisions to study engineering were their teachers as opposed to their family members. Additionally, both underrepresented groups were less likely than their counterparts to indicate that these influential people were engineers. Consistent with this last finding and compared to their counterparts, both underrepresented groups were more likely to indicate their understanding of what engineering is, which contributes to their engineering identity, developed later in their academic careers, or still had not fully developed.

Family Characteristics of Underrepresented Engineering Students

The findings of this study suggest the linear predictions of family occupational inheritance and social and cultural capital do not necessarily directly apply to underrepresented students who have decided to study engineering. Many of the underrepresented students indicated their families of origin had completed less education compared to their counterparts, and the females, despite some having guardians with
postgraduate degrees, were not sensing familial academic expectations as much as their male counterparts. The underrepresented students in this sample did report they perceived high levels of support from their families, which may have played an influential role in the fact that so many of these students have persisted to their junior and senior years. Their successes aside, these underrepresented students are still a minority in their academic discipline and could be considered the exception to the norm. It appears other factors are at play for these underrepresented students in this study who have chosen to study engineering.

Family Support and Perceived Family Expectations

Rates of various types of perceived support from families were reviewed against other academic and family experiences. While all student groups, including well-represented groups, reported moderate to high rates of motivational and emotional support from their families, both underrepresented groups reported even higher rates of both types of support. Despite the highest reported rates of K-12 interactions with parents that promote academics and higher education, females reported lower rates of anticipated disappointment of parents if they did not complete either any degree or a degree in STEM. As referenced in the literature review, this occurrence may be caused by societal norms and cues regarding females’ expected interest and performance levels in STEM education and the family roles females, especially UEGs, are expected to fulfill. Furthermore, although UEGs reported fewer K-12 parental interactions contributing to the promotion of academics and higher education, UEGs reported a stronger sense of
anticipated disappointment from parents if they did not finish any degree and if they did not complete a degree in STEM. This finding may be explained in part by the cultural disconnect between the educational system and UEG families, and previous findings that one of the more recently uncovered motivations for UEGs to attend college is to help their families (Phinney et al., 2006). Lastly, even though financial support from underrepresented students’ families was low, financial aid and some employment helped mitigate the issue of funding education.

Recommendations

Recruitment of Underrepresented Engineering Students

This study did highlight the need for improved recruitment strategies of females and UEGs into engineering. The underrepresented students in this sample were consistent with the larger underrepresented engineering population in that the actors in their lives who influenced their decisions to study engineering were less likely to be engineers when compared to their counterparts. Given the greater proportion of males, Whites, and Asian Americans in engineering, and their indication of family members playing an influential role in their decision to study engineering, it appears their family played a considerable role in getting students into this field. While the underrepresented respondents in this sample may have been brave enough to study engineering with less exposure to and comprehension of what they were embarking on, it is likely other females and UEGs have not been as willing to take that risk, as marked by their low rates in engineering. A higher proportion of females are already pursuing higher education and
are graduating high school engineering eligible, so these students should be targeted for redirection in the field. The ability to recruit more UEGs into engineering will largely depend on improving the academic circumstances and experiences of UEGs in K-12 education.

If these underrepresented students are not learning about engineering from their families or mass media, they need to learn about it, and learn earlier in their academic experiences, from engineers and other educational professionals and teachers. Recruitment practices should be increased and specific improvements should include the previously cited suggestions of re-packaging and marketing of engineering to both females and UEGs by highlighting the human side and altruism of the profession (Amelink & Meszaros, 2010; Kemper & Sanders, 2001). Recruitment strategies should also include increased exposure to engineering during K-12 years as a way for students to develop appreciation of the everyday usefulness of math and science concepts when applied to real-world, quality-of-life problems. Additionally, family members should be incorporated into recruitment practices as much as possible, so students and their family members can side by side develop an understanding of engineering and its societal benefits. Helping the entire family develop an understanding of engineering will prepare them to be able to provide more specific and higher quality support to their students as it relates to studying engineering.
Proposed Future Research

While this study did not directly identify the ways in which families influence underrepresented engineering students, further qualitative studies, including studies that collect data from both students and their family members, may be more effective in illustrating this information, including students’ motivations for this field and the ways in which they develop their engineering identities. Other qualitative studies may want to examine types and quality of family support in greater detail. While most any family member can be capable of providing emotional support, the types and quality of motivational support received from family members may greatly vary. For example, an engineering parent can give much more specific feedback on college and engineering experiences and challenges because they have first-hand similar experiences, whereas a parent who did not complete high school may have little knowledge of the experiences of being a college student. All the respondents reported high emotional and motivational support, but more details on specific support received could be useful illustrative information, especially for educators who conduct family orientations and programs on college campuses. Also, the researcher suggests a multi-campus, longitudinal study, similar in format to the work done by Seymour and Hewitt (1997), but with a focus specifically on engineering students, their families, and their precollege experiences, in addition to their experiences once they matriculate to institutions of higher education.

The theme of non-traditional students in engineering, in terms of age and marital and parental status, was an unexpected finding in this study given the lack of previous
research identified in the literature review. The mostly male respondents discussed strong motivations for degree completion to ultimately be able to provide better lifestyles for their spouses, children, or both. The researcher suggests further studies into the unique circumstances and needs of this non-traditional engineering population who are largely influenced by their dependents.

The status quo in engineering recruitment and education must be challenged if the goal of gender and ethnic diversity proportional to the overall workforce is to ever be achieved. This study has not focused on the experiences of engineering students inside the classroom, but rather has been an examination of family factors and perceptions that have lead them to enter and continue in engineering programs. Getting underrepresented students through the door has been, and will continue to be, a great challenge. For underrepresented students, especially UEGs, increasing the engineering awareness of families may help students not only take the first step toward a degree in this field, but also in developing stronger self-efficacy and engineering identities, which will assist with persistence to completed degrees, and eventually, careers in engineering.
APPENDICES
APPENDIX A

Informed Consent Letter

Dear Engineering Undergraduate Student,

You are invited to participate in a research study to investigate influences of family members on the recruitment and retention of engineering students. The study is being conducted by Reina Gonzalez, a graduate student in the Department of Educational Leadership and Policy Studies at California State University, Sacramento.

You will be asked to answer a series of questions in an online survey. Some of the questions will ask you about your perceptions of your relationship with your family and how they have influenced your educational experiences and decisions. The responses that you provide will then be collected and analyzed. You can skip any questions you do not wish to answer.

You may not personally benefit from this research; however, it is hoped that the results of the research will help campuses improve recruitment and support services for engineering students, including students from underrepresented populations, and their families.

By clicking the survey link below, you are indicating you have read this page and consent to participate in the research. Your responses will be kept confidential to the degree permitted by the technology used. However, no absolute guarantees can be given for the confidentiality of electronic data. Because this survey is anonymous, once the
survey is submitted, the researcher will not be able to remove your results from the database should you wish to remove your responses.

Here is a link to the survey: https://www.surveymonkey.com/s/HLQ5KVQ. Estimated time to complete the survey is 10 minutes.

If you have any questions about this research, you may contact Reina Gonzalez at rg2348@saclink.csus.eu or rtgonzalez@ucdavis.edu.

Thank you for your participation!
APPENDIX B

Data Collection Instrument – Survey

ENGINEERING STUDENTS AND FAMILY INFLUENCES SURVEY
SPRING SEMESTER 2012

1. Are you majoring in an engineering field?
   ___Yes
   ___Yes, but I intend to switch to a major outside of engineering.
   ___No
   ___No, but I intend to declare engineering as a major.

2. What is your year in school?
   ___Freshmen
   ___Senior
   ___Sophomore
   ___Graduated/Alumni
   ___Junior

3. Which category below includes your age?
   ___17 or younger
   ___30-39
   ___18-20
   ___40-49
   ___21-24
   ___50-59
   ___25-29
   ___60 or older

4. What is your GPA?
   ___3.6 – 4.0
   ___3.1 – 3.5
   ___2.6 – 3.0
   ___2.1 – 2.5
   ___2.0 or below

5. Have you ever been on academic probation?
   ___Yes
   ___No

6. Did you transfer to Northern State University from a community college?
   ___Yes
   ___No
7. Gender:
___Male
___Female
___Decline to Respond

8. Ethnicity:
___White
___Decline to State
___African-American
___Other (please specify) ________
___Hispanic/Latino
___Asian-American
___American Indian or Native Alaskan

9. Who was your main guardian(s) as a minor? (check all that apply)
A "guardian" can be a parent(s) or any person(s) who played a significant role caring for you and raising you as a minor.
___Mother
___Aunt(s)/Uncle(s)
___Father
___Sibling(s)
___Grandparent(s)
___Other (please specify) ________
___Stepparent(s)

10. What is the annual income of your primary guardian's household:
___Less than $25,000
___$25,000-$34,999
___$35,000-$49,999
___$50,000-$74,999
___$75,000-$99,999
___$100,000-$124,999
___$125,000-$149,000
___$150,000 or more
___I don’t know

11. What is the highest educational level completed by any of your parents/guardians?
___Did not complete high school
___Graduated high school or equivalent
___Some college, no degree
___Associate’s degree
___Bachelor's degree
___Post-graduate degree

12. Are you a first generation college student?
First generation college students include any students whose parent(s)/guardian(s) did not complete a bachelor's degree. The parents of first generation college students may have attended some college, or even completed an associate's degree.
___Yes
___No
13. Do you currently live with your family?
   ___Yes (If Yes, skip questions 14 and 15)
   ___No

14. If you don't live with your family, what is the distance between you and your family?
   ___0-50 miles
   ___50-100 miles
   ___100-200 miles
   ___200-500 miles
   ___50-100 miles
   ___50-100 miles
   ___+500 miles
   ___100-200 miles

15. If you do not live with your family, how often do you go home to spend time with your family?
   ___weekly
   ___only during academic breaks
   ___once or twice a month
   ___rarely or never
   ___once or twice per academic term

16. The two people who were most influential in my decision to study engineering were (choose one or two):
   ___Mother
   ___Father
   ___Sibling
   ___Teacher
   ___Peer/Friend
   ___College Recruiter
   ___Other relative
   ___None
   ___Other (please specify)

17. Are either of the people selected in the question above an engineer?
   ___Yes
   ___No
   ___N/A

18. Please select the most accurate response:
   ___Most of my family interactions are within my immediate family. Extended family members are interacted with rarely or occasionally.
   ___Most of my family interactions include my immediate family, and sometimes include extended family.
   ___Most of my family interactions include my immediate family and many extended family members and non-blood relatives.

19. During my K-12 education, my parents/family (check all that apply):
   ___Discussed school related matters with me.
   ___Encouraged me to get good grades.
   ___Talked to me about the importance of attending college.
   ___Were actively involved in my college application and selection process.
   ___None of the above
20. In regards to financial support for educational expenses (check all that apply):
   ___I receive financial aid that covers the majority or all of my expenses.
   ___I receive financial aid that covers some of my expenses.
   ___I receive financial support from my family to cover the majority or all my expenses.
   ___I receive financial support from my family to cover some of my expenses.
   ___None of the above

21. In regards to studying engineering, I receive the following types of support from my family (If support is received rank amount/quality of support from 1-5, where 1 is low and 5 is high, or select 0 if you don't receive the type of support)
   Financial Support  0  1  2  3  4  5
   Emotional Support  0  1  2  3  4  5
   Motivational Support  0  1  2  3  4  5

22. While I am in college (check all that apply):
   ___I don't work.
   ___I work part-time (less than 32 hours a week).
   ___I work full-time (32 hours a week or more).
   ___I have to work to support myself.
   ___I have to work to support my family.

23. I consult with my family on important educational decisions.
   ___Never                      ___Often
   ___Rarely                    ___All of the time
   ___Sometimes

24. My education decisions are strongly influenced by my parents/guardians expectations.
   ___Never                      ___Often
   ___Rarely                    ___All of the time
   ___Sometimes

25. I feel I developed a good understanding of the field of engineering:
   ___Before high school.
   ___During high school, but before college.
   ___In college.
   ___I am in college, but I do not feel I have developed a good understanding of the field of engineering yet.
26. The financial costs and time commitment of going to college
___ Would be worth it for any major in any discipline.
___ Would be worth if I were majoring outside of engineering, but in another
    science, math or technology major.
___ Are only worth it because I am majoring in engineering.

27. I have thought about changing my major to something outside of engineering:
___ Never
___ Occasionally
___ Frequently
___ I am currently in the process of changing to a non-engineering major.

Please rank the following from 1-5, where 1 = strongly disagree, 2 = disagree, 3 =
neutral, 4 = agree, 5 = strongly agree

28. My parents/guardians expect me to complete a degree in engineering so I can get a
    well-paying job and support my parent/guardians and other dependents.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

29. My parents/guardians would be let down if I did not complete a bachelor's degree.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

30. My parents/guardians would be let down if I chose to pursue a bachelor's degree
    outside of STEM (science, technology, engineering, math).
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

31. I feel that the educational and occupational expectations that my parents/guardians
    have for me are influenced by my gender.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

32. I feel that it is important for me to do well in college so I can become a positive role
    model for my family.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

33. My family is involved or interested in my higher education experience.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

34. I feel there is a cultural disconnect between the norms of my family and norms of
    being an engineering student.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A

35. I chose to major in engineering because I enjoy challenges and solving problems.
___ 1 strongly disagree  ___ 2 disagree  ___ 3 neutral  ___ 4 agree  ___ 5 strongly agree  ___ N/A
36. An engineering degree can provide the opportunity for social and economic mobility.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

37. My interest in my engineering major is low, but I continue with it because I believe
   the pay-off of an engineering degree to be high.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

38. I am content with the idea of working in a career in engineering.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

39. I feel that majoring in engineering is significantly more demanding of my time and
   energy compared to majoring in a non-engineering field.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

40. I feel that my engineering major is competitive and rewards individual efforts more
   than group efforts.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

41. When I am confused in a class or not clear on an academic policy, I feel comfortable
   asking a faculty member or university staff for help.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

42. I believe that I will complete a bachelor's degree in engineering.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

43. I selected engineering as a major because I am confident in my abilities to do well in
   this academic field.
   ___1 strongly disagree ___2 disagree ___3 neutral ___4 agree ___5 strongly agree ___N/A

44. According to your perspective, how accessible is engineering to students of
   underrepresented ethnic minorities (Hispanic/Latino, African-American/Black, American
   Indian/Alaskan Indian)?
      ___Very accessible
      ___Accessible
      ___Somewhat Accessible
      ___Not Accessible

45. According to your perspective, how accessible is engineering to female students?
   ___Very accessible
   ___Accessible
   ___Somewhat Accessible
   ___Not Accessible
46. Do you feel that the culture of your ethnicity has affected or currently affects your decision to study engineering?
   ___No
   ___Somewhat
   ___Yes

47. Please comment on the types of support you receive from your family and how that has helped you as a student. Types of support can be, but are not limited to, financial support, emotional support, and motivational support.

48. Please discuss your motivations for studying engineering and if any of these reasons relate to your family.

49. Do you currently or have you ever had family responsibilities that compete with your academic studies? If yes, please describe those responsibilities and how they impact you as a student.

Thank for you completing this survey! Please hit the "Done" button below.
REFERENCES


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