HOW SOCIAL NETWORKS INFLUENCE FEMALE STUDENTS' CHOICES TO MAJOR IN ENGINEERING

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CHAPTER I

INTRODUCTION TO STUDY

Women are grossly underrepresented in engineering versus science, technology, and math. Examining female enrollment across all disciplines, 58% of all bachelor's degrees have been awarded to women since 2002 (NSF 2010), and women are well represented in most fields other than engineering. In 2009, women earned 55.6% of all bachelors' degrees in *All Sciences* and 43% in *Mathematics and Statistics.* Contrasted with the fact that women only earned 18.1% of all bachelor's degrees in *Engineering*, there is a chasm between engineering and other science fields (NSF 2009). Additionally, while enrollment of males in undergraduate engineering programs increased by 11.5% from 1995 to 2007, enrollment of women in engineering only increased by 3% during that same time frame (NSF 2007).

This data indicates several trends: First, women are well represented in most university majors, as evidenced by the fact that 58% of all bachelors' degrees have been awarded to women since 2002. Second, female students are well represented in science, technology, and math, but are still underrepresented in engineering specifically. Although a student's educational experience can be bolstered by interactions with people from varying backgrounds and different interests (Antonio, Chang, Hakuta, Kenny, Levin, & Milem, 2004; Gurin, Dey, & Gurin, 2003), engineering is still lagging behind in terms of gender diversity. Based on this recent data, there are differences between female enrollment in engineering and female enrollment in science, technology, and math (STEM). Since diversity is beneficial to not only students studying engineering particularly, but also the educational experience as a whole, we need to know why engineering fields do not share the gender diversity of other fields such as science, technology, and math.

The underrepresentation of female students in STEM fields could be because female students do not have an accurate perception of STEM fields from the beginning of their primary education, meaning that they do not understand the full scope of careers in STEM fields and specifically engineering. Female students also must achieve success in an environment that is not welcoming to females (Hall & Sandler, 1982; The Chilly Collective, 1995; Opportunity 2000, 1996), which has a hand in driving down female enrollment in STEM fields. When examining only the environment in which female students learn science and math, the issue narrows down to how female students' social networks influence her perceptions of herself, her educational environment, and the STEM fields. Specifically, the decision to major in a STEM field could be highly influenced by how female students' relationships influence her perception of the field, the environment in which she learns science and math, and the people in her life that may or may not encourage her to enter into a STEM field.

An understanding of key terms is essential before delving any father into this topic. For the purpose of this study, diversity will focus on the aspect of gender (i.e., male or female) and not race or ethnicity. Specifically, this study will focus only on female students and will not take race or ethnicity into consideration. STEM refers to the fields of science, technology, engineering, and mathematics. This study will place engineering students into one group; science, technology and math students will be placed into another group for the purposes of statistical data analysis. The social network refers to the peers, parents, high school teachers, and high school counselors that a female college freshman has in her life. The social network includes only those people with whom the female student has interacted on a firsthand basis. However, just because a female student has interacted with someone in her social network, this not does necessarily guarantee that they have had a significant impact upon her life.

Purpose of the Study and Research Question

We need to know more about how social influence plays a part in female students' choices of college major. Social influence may show itself through peers, family members, and teachers and may encompass resources under the umbrella of social capital. The purpose of this study is to examine how female students' social networks, through the lens of social capital, influence her major choice of whether or not to study engineering. The research question is as follows:

1. Do female freshmen who major in engineering at four-year, research universities report higher amounts of social network support than female freshmen who major in science, technology and math?

Research Hypotheses

1. Female engineering students will report higher levels of peer support for studying math and science in high school when compared to female students in science, technology, and math.
2. Female engineering students will report higher levels of parental support for studying math and science in high school when compared to female students in science, technology, and math.
3. Female engineering students will report higher levels of counselor/teacher support for studying math and science in high school when compared to female students in science, technology, and math.
4. Female engineering students will be more likely to have one or both parents as an engineer when compared to female students in science, technology, and math.
5. Female engineering students will be more likely to perceive engineering as a helping profession when compared to female students in science, technology, and math.

Significance of the Study

This study is significant for many reasons. First, there are many benefits associated with diversity in engineering, including cognitive skills, increased quality of the educational experience, an increased ability to solve complex problems in new and creative ways, more innovative and improved ideas, being better equipped to meet the needs of a more diverse world, better outcomes for solutions and more creativity for team members, and a variety of perspectives leads to a higher quality of problem solving for all (Antonio, Chang, Hakuta, Kenny, Levin, & Milem, 2004; Gurin, Dey, & Gurin, 2003). Increased diversity in engineering teams is also needed in order to match the increasing diversity of the general population of the United States. More diverse engineering teams are better able to address the more complex issues that engineers face on a daily basis, and there is a need for engineers to better relate to a changing population.

Results of this study could be used to inform recruitment strategies of female students into the engineering field. The study could also be used by K-12 teachers and administrators in understanding their influence on the decision process by their female students. Additionally, many earlier studies have focused on STEM versus non-STEM research and very few have focused on the differences between STEM majors. This study will contribute new knowledge to the field because it is one of the first studies to examine female enrollment within the STEM majors and not just STEM versus non-STEM.

Overview of Methodology

The variables of peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background will be addressed in a 52 question, Likert scale survey. This survey has been modified from an instrument previously used by Reyer (2007) at Bradley University. Data collection will be completed using the Dillman (2009) tailored design model. Responses will be grouped into four main scales grouped around the dependent variables of social influence, encouragement, perceptions of engineering and career motivation. A factor analysis will be completed on the four factors as a whole, and individual questions will not be analyzed. Chronbach's Alpha will test the reliability of the scales, and all responses will be graphically checked for normality.

Limitations

The sample will draw from female students who are in their freshmen year at a four-year university. Therefore, this study is not designed to address college choice or college access, because participants will already be enrolled in college. This study will also not address female students who are enrolled in fields other than science, technology, engineering, or math. Additionally, since only freshmen will participate in the survey, the study will not address retention issues within science, technology, engineering, and math. This study will also not address a male student's issues in choosing a major in a STEM field, and the differences between males enrolled in engineering versus science, technology, and math.

Summary

Although well represented in science, technology, and math, female students are still underrepresented in engineering specifically. Female students' decisions to major in STEM fields could be highly influenced by how her relationships influence her perception of the field, the environment in which she learns science and math, and the people in her life who may or may not encourage her to enter into a STEM field. The purpose of this study is to examine how female students' social network, through the lens of social capital, influences her career choice of whether or not to study engineering.

CHAPTER II

REVIEW OF THE LITERATURE

Diverse ideas are needed to solve the ever-growing complex problems that engineers face every day. Many benefits, including a gain in cognitive skills, enriched academic environments, and enriched creativity stem from increased diversity (Massachusetts Institute of Technology, 2003; Terenzini, Pascarella, & Bliming, 1999; Terenzini, Springer, Pascarella, & Nora, 1995). For the purpose of this study, gender is the aspect of diversity on which the study will focus (specifically, the underrepresentation of females in engineering). Benefits of diversity in academic environments, benefits of diversity in engineering, and statistical indicators of female enrollment in engineering will be discussed.

Benefits of Diversity

Several educational benefits of diversity have been shown to exist in academic literature. Benefits include enhanced cognitive skills (including problem solving, creative thinking, and interpersonal skills) as well as an improvement in the overall quality of the educational experience.

Cognitive Skills

Many educators believe that diversity is beneficial in classrooms and other academic environments for a variety of reasons. Specifically, increased diversity in academic environments supports an increase in cognitive skills, problem solving and creative thinking. Other outcomes including increased problem solving abilities, critical thinking, and multifaceted cognitive processing are supported in diverse academic environments (Antonio, Chang, Hakuta, Kenny, Levin, & Milem, 2004). Greater diversity has also been linked to "higher levels of intellectual engagement and self-assessed academic skills" (Gurin, Dey, & Gurin, 2003, p. 351). This specific observation was made after analyzing a nationwide sample from the CIRP (Cooperative Institutional Research Program) database. Intellectual engagement scores were based on a student's self assessment of his or her motivation, intellectual self-confidence, and degree aspirations, among other variables. The academic skills ratings were based on a student's self-assessment of his or her ability to change, problem solving abilities, critical thinking skills, and academic ability.

Diverse educational environments, therefore, can lead to students coming in contact with new ideas and people. Students benefit cognitively and personally from increased diversity in academic environments. This could be because both formal and informal interactions with people from different backgrounds provide the opportunity for students to reexamine their own values and beliefs, and think critically about their own deeply held ideas.

These informal interactions with a diverse group of ideas and people support cognitive growth as well. Cognitive growth is associated with a student thinking in different ways, experiencing different viewpoints, and coming in contact with new ideas and people (Terenzini, Pascarella, & Bliming, 1999). College student development is influenced by experiences with diversity, and cognitive development is bolstered by informal interactions with peers (Whitt, Edison, Pascarella, Nora, & Terenzini, 1999). Formal and informal experiences, curricular and non-curricular contact, and out-of-class interactions all have an impact on a student's critical thinking ability (Terenzini, Springer, Pascarella, & Nora, 1995). Problem solving skills and group skills are also related to an increased diverse classroom environment (Terenzini, Cabrera, Colbeck, Bjorklund, & Perente, 2001). This is important because when students experience an increase in cognitive skills, they are able to think more critically about the world around them and could perhaps solve problems more effectively in that multiple viewpoints and needs are considered.

Quality of Educational Experience

The overall quality of a student's educational experience is also bolstered by diversity in a variety of ways. Diversity has also been shown to support student learning, progress civic engagement, encourage retention, increase satisfaction of the student's college experience, improve self-confidence, enhance interpersonal skills and develop leadership (Massachusetts Institute of Technology, 2003). Although this literature review will not address all of these components, it is still helpful to see the broad range of benefits of diversity. More specifically, greater classroom diversity enhances a student's overall college education in that it raises new issues and perspectives, broadens the variety of experiences shared, and exposes students to different perspectives (American Council on Education and Association of University Professors, 2000). Diversity also encourages students to try new ideas, experience change, and overcome challenges in education (Gurin, Dey, Gurin, & Hurtado, 2004). This is due to the fact that students who are in more diverse environments are more likely to interact with other students who come from different backgrounds than their own. Trying new ideas, experiencing change, and overcoming educational challenges is a natural reaction to engaging with other students in a diverse educational environment.

The willingness to try new things and overcome challenges would be particularly useful to teams of engineers working on a complex project. Greater diversity has been linked to higher levels of achievements when members were engaged in teamwork (Kearney, Gebert, & Voelpel, 2009). Diversity alone is not enough to enhance the educational experience. Rather, diversity enhances the academic experience when students are actually interacting with others. Assets such as the college experience, interpersonal skills, and leadership ability are all linked to greater diversity in the academic environment.

Benefits of Diversity in Engineering

There are also many benefits to diversity within the context of engineering teams. Creativity in a group dynamic is influenced by the members of the teams, so engineering teams that are more diverse can benefit creatively from the diversity (Wulf, 1998; Lane, 1999). Engineers can learn from each other, and a variety of perspectives leads to a higher quality of problem solving for all. This could be due to the increased critical thinking skills needed when viewing an issue from multiple viewpoints. Increased diversity in engineering teams is also needed in order to match the increasing diversity of the general population of the United States (Massachusetts Institute of Technology, 2003).

Diversity in engineering teams is important because more diverse engineering teams are better able to address the more complex issues that engineers face on a daily basis. The need for engineers to better relate to a changing population is also evident in the professional engineering workforce, which has lead to a need for a more diverse engineering workplace (Ihsen, 2005). The National Academy of Engineering (2005; 2004) has also underscored the importance of diversity in engineering by making the recruitment of underrepresented populations one of many goals for the profession's future.

Several studies have also investigated the benefits of diversity in engineering environments. The primary reason to support a diverse engineering environment is that a more diverse engineering workforce can contribute to engineers having an increased ability to solve complex problems in new and creative ways (Schafer, 2006; WEPAN, 2009). The thought that diversity leads to more creative and improved ideas is also echoed by the Women in Engineering ProActive Network (WEPAN, 2009). Teams that are more diverse are better equipped to meet the needs of a more diverse world, because the problem solving process is bolstered by the variety of perspectives and ideas that diversity brings.

Current Statistics for Diversity in Engineering

The National Science Foundation (2010) records indicate that female students are earning bachelor's degrees in all fields at a rate of 58%. Given that women earned 55.6% of all bachelors' degrees in *All Sciences* and 43% in *Mathematics and Statistics,* female students are still well represented in science and math fields. In comparison, female students only earned 18.1% of all bachelor's degrees in *Engineering*, and there is a chasm between engineering and other science fields (NSF 2009).

The issue, then, is not that female students are lacking in bachelor's degrees in any fields; the main issue is that while female students are making ground in other fields, they are not gaining momentum in engineering. This is a disservice to all students in engineering, regardless of gender, because a student's educational experience can be bolstered by interactions with people who are from varying backgrounds and different interests. Therefore, the more diverse that engineering becomes, the greater the possibility of an enriched academic environment for all students. Overall, there is still a significant difference between engineering and the fields of science, technology, and math in terms of female enrollment. There are several reasons that engineering fields are not diverse when compared to science, technology, and math.

Pre-College Experiences: The Engineering Pipeline

One reason that engineering fields are not diverse may be due to the engineering pipeline (Blickenstaff, 2005). The environment in which a female student learns may impact her chance of entering the engineering pipeline; the engineering pipeline is the set of resources that enable her to declare a major in engineering. The engineering pipeline for female students can "leak" at various stages throughout her academic career: during high school, when she is applying to colleges, while she is majoring in engineering at a university, or even after college graduation (Blickenstaff, 2005, p. 369). Therefore, the various components of the engineering pipeline are examined, with particular attention paid to the environmental forces at play in female students' lives.

High School Science and Math Preparation

The underrepresentation of female students in engineering does not seem to be caused by a lack of high school science and math preparation. According to the US

Department of Education (2007), both female and male high school students take equal amounts of science and math credits. However, female students take fewer Advanced Placement (AP) classes in STEM subjects, and earn lower scores on the AP tests than males. Several other studies have replicated these results. Adelman (1998) studied the high school transcripts for first year engineering students in college. In high school, both females and males had similar math and science backgrounds in terms of the courses taken and numbers of years enrolled in these courses. Additionally, SAT scores for female students were slightly higher than the scores of male students. Felder, Felder, Mauney, Hamrin, and Dietz (1995) interestingly found no significant differences in either SAT scores or number of AP credits for first year engineering students between males and females. Therefore, male and female students are gaining the same amount of math and science preparation while in high school.

Some studies have even found advantages for female students in high school. Haines, Wallace, and Connon (2001) found that female and male students were equally prepared in math, chemistry, and physics; females were more prepared than males in biology. The fact that there are few significant differences between males and females for science and math preparation could mean that additional, non-quantifiable forces may be at play in the underrepresentation of females in engineering.

The number and types of science and math classes that female students take in high school makes a significant impact on whether or not they decide to major in a STEM field. Trusty (2005) found that female students who took higher level math classes in high school were more likely to major in engineering or science fields in college.

Additionally, the choice of a STEM major is influenced by the amount of preparation that students receive while in high school (U.S. Department of Education, 2004).

Deficits in science and math preparation can also have negative effects on the STEM pipeline and therefore the choice of whether to choose a major in STEM. If a female student is not well prepared in high school in science and math, she is less likely to be retained within a STEM major in college (Malgwi, Howe, & Burnaby, 2005). High school science and math preparation is also important since female students make decisions about their eventual college major while they are still in high school (Downey & Yuan, 2005). Therefore, it is clear that choices made in high school, particularly in regards to science and math preparation, have long-lasting consequences for the engineering pipeline.

Environmental Influences

There are many influences that exist in female students' environment that may impact their decision to major in engineering. These environmental influences include peers, teachers, school officials, the student's own perceptions of engineering, and other various motivating factors.

Influence of Peers. Resources within the peer networks can strongly influence female students' choice of a college major. These peer influences can both positively and negatively impact a student's decision. Peers can actually keep female students from deciding to major in science and engineering before they enter college (Leslie, McClure, & Oaxaca, 1998). This might be because students at the adolescent age see their friends as trustworthy sources, and so they are more willing to accept advice from them

(Crosnoe, Cavanagh, & Elder, 2003). In this regard, friends can serve as a resource within their social capital network and self-identity may be drawn from peers.

Friends do hold power for high school students in not only their choice of major, but in the types of courses that they take. Riegle-Crumb, Farkas, and Muller (2006) exclusively studied how the influence from peers impacts the type and level of science and math courses for female high school students. High grades in science and math classes travel within groups of friends. For example, female students who had friends with high grades in science and math were more likely to take calculus and physics courses. Additionally, female students were more likely to take advanced courses if their friends were academically successful. Crosnoe, Riegle-Crumb, Field, Frank, and Muller (2008) found that achievement within friend groups was strongly associated with students in those groups of friends taking math courses. In other words, peer networks in which members took higher levels of math classes resulted in higher academic success for all students in the group. Achievement within friends was also associated with female students being more likely to take math classes.

Social norms also travel within groups (Crosnoe et al., 2008). Social groups of students have been found to take courses that make their group unique when compared to other groups. If a student group identifies itself as smart, therefore, they are more likely to take academically challenging courses in order to fulfill their identity and make themselves unique among other high school peer groups. Female students in particular are more influenced and responsive to the social norms within their groups (Crosnoe et al., 2008). This then makes individuals within social groups more like one another, but different when compared to others outside of the group. In reference to math courses, female students were more likely to consider the norms among their friends when deciding whether or not to take advanced math classes (Crosnoe et al., 2008). Given that female students identify with their groups of friends and then act accordingly, a great deal of power exists within the peer groups for female high school students.

Social norms can also play a negative role when female students are choosing a college major. For example, female students have shown that they perceived that their male peers did not respect them as equals and that their male peers had an education advantage in engineering programs simply because of gender (Vogt, Hocevar, & Hagedorn, 2007). Female students also participate less in classrooms under certain conditions and can be less assertive than their male counterparts (Crawford & MacLeod, 1990). This means that given the educational environment and support or lack of support of her peers, female students can be negatively impacted by their educational environments.

Personal influences of family, high school teachers, and other adult role models also have a significant impact on whether or not a female student will choose to major in a science, math, or engineering field (Seymour, 1999). In fact, when compared with male students, female students have been shown to be twice as likely to choose a science, math, or engineering major because of a personal connection to someone in their lives. This could mean that the social influences of people in female students' lives, such as family, friends, and teachers, can serve as resources and role models when a female student is deciding on possible career paths to take. Additionally, the advantage of having at least one parent with a career in physical sciences and/or engineering increases the chance that a female student will choose to major in either physical science or engineering herself (Leslie et al., 1998).

The age of a female student also can impact whether or not she will choose to major in engineering. Adolescence is an important developmental stage for female students, and influences in her life during adolescence may determine what career path she chooses (Leslie et al., 1998). Specific developments that occur during adolescence include self-efficacy in math and science, as well as self-concepts related to math and science. Since students decide on their first university major while in high school, key players in the female student's inner circle can influence her self-concept and as a result, can influence her career path in STEM fields.

Influence of Teachers and School Officials. Other explanations of the STEM pipeline have focused on the environment surrounding STEM fields, including the fact that the environment for females in engineering has been reported to be "chilly" (Hall & Sandler, 1982; The Chilly Collective, 1995; Opportunity 2000, 1996). In the original work on the chilly climate, Hall and Sandler (1982) reported that women and men were treated differently in university classrooms. There were many specific ways in which both subtle and overt discrimination against female students takes place, such as female students being called upon in class less frequently and female students being interrupted in class by their male peers when they do speak. Challenges that female students face in traditionally "masculine" professions (p. 13) include the unwelcoming atmosphere and their own possible concern about pursuing a "non traditional" major (p. 14). In addition to the classroom environment as a whole, the teachers leading the classroom also impact the movement of female students through the STEM pipeline.

Female students have also been reported to dislike large classes at universities because the classes are too impersonal (Seymour, 1999). The opportunity to have interactions with the instructor and peers in the class is often reason that female students report preferring smaller classes in STEM fields. Female students also tend to expect high amounts of praise from their teachers, which can lead to extrinsic motivation in STEM fields instead of intrinsic motivation. When the high praise from teachers stops, this may lead to female students questioning their decision to major in STEM fields. Looking for the external motivation can also lead female students to become dependent on teachers for performance validation and a perceived lack of encouragement as an obstacle to major in STEM.

Vogt et al. (2007) found that a student's self-perception can be shaped by either the positive or negative reinforcement of faculty members. This self-perception is also tied in with a student's academic self-regulation and academic achievement. In other words, if a female student perceives that a faculty member endorses her work, she may have a higher self-confidence and achievement than if she perceives that a faculty member is not satisfied with her work.

The hostile climate in university classrooms is also found in high school environments, which has a negative effect on the STEM pipeline. High school teachers in science and math are more likely to be men, which leads to a lack of female role models in science and math (Sadker & Sadker, 1994; Blinkenstaff, 2005). Additionally, female students receive less attention from teachers than the males in the classroom (Sadker & Sadker, 1994; Blinkenstaff, 2005) and female students have had teachers who expect less of them than their male classmates (Warrington & Younger, 2000). All in all, the maledriven educational environment leads to an atmosphere that is not conducive to female students choosing a major in engineering. This underscores the importance of positive role models for females in science and math classes, and shows how much power science and math teachers have in shaping the future of their students.

High school teachers can also strongly influence female students to major in engineering (Seymour, 1995). In fact, both high school teachers and parents heavily influence female students' choice in major, but this can lead to female students choosing to major in engineering without having a clear idea of what an engineering major encompasses. Female students in college also receive praise from their science teachers, but can also be stereotyped for being good in science (Seymour, 1995). The stereotyping by teachers can actually lead to female students doubting themselves for their choice of a path in STEM fields. This is linked with the findings above because the reinforcement from instructors is important. When students receive positive reinforcement, they perceive themselves as being more competent than when receiving negative feedback.

Influence of Students' Perceptions of Engineering. Possible explanations for the underrepresentation of females in STEM fields have also centered around the perception of STEM fields by females. Engineering is seen as a masculine profession by many female students, which leads to a decrease in females who major in engineering (Powell et al., 2009), and female students could also be more likely to choose majors in which they expect to have more interaction with people (Diekman, Brown, Johnston, & Clark, 2010). These perceptions can be influenced by the female student's social environment, and can be positively influenced by encouraging peers, parents, and teachers.

Female engineering students are also influenced by a personal interest in engineering. In fact, personal interested was cited as the number one reason that female students chose a major in engineering, followed by encouragement from teachers and parental encouragement (Silver-Miller, 2003). It is helpful to know that female students are choosing engineering because of their personal interests, but what we really need to understand are the forces that shape and influence a student's personal interest.

Academic Major Choice Motivation

Regardless of the chosen field, the academic major selection process has four main components: Sources of Information and Influence, Job Characteristics, Fit and Interest in Subject, and Characteristics of the Major/Degree (Beggs, Bantham, & Taylor, 2008). The most important stages are whether the major matches with the student's own area of interest, the characteristics of the job, and the attributes of the major (Beggs et al., 2008). The student's area of interest is consistently mentioned in the literature as a factor for influencing a student to major in their chosen field (Malgwi, Howe, & Burnaby, 2005; DeMarie & Aloise-Young, 2003). The initial level of knowledge, without digging any deeper, points to the fact that a student's area of interest guides their choice of a major. However, this does not address how the student's area of interest is shaped through educational experiences.

While many studies have shown why females do not choose majors in engineering, some studies have focused on the reasons that female students do choose to major in engineering. Some female students have expressed an interest in STEM fields in order to make a theoretical contribution to science and to be well off financially (Nichols et al., 2007). This shows that if a female student perceives that an engineering career may let her contribute to science, she may be more likely to choose a major in engineering. A student's perception that engineering leads to financial success may also serve as a motivating factor.

Additional predictors exist when determining whether or not a female student will choose a major in engineering. Leslie et al. (1998), after statistically analyzing variables of first year freshmen in engineering, found many significant predictors. Students who had a parent in physical sciences or engineering were more likely to major in physical sciences or engineering themselves. The authors also found predictors that apply to all STEM fields. Overall, new freshmen in STEM possessed higher high school grade point averages (GPAs) than students in non-STEM fields. Additionally, STEM freshmen had higher scores on the SAT math test and ACT comprehensive test. STEM students also exhibited higher self-rated mathematical ability, academic ability, and intellectual self-confidence. Finally, STEM students indicated that they were in college to obtain training for a specific career, as opposed to non-STEM students. This means that STEM students are better prepared academically overall and more confident in their abilities than non-STEM students.

Theoretical Framework

Social capital theory (Bourdieu, 1986; Portes, 1998; Woolcock & Narayan, 2000; Adler & Kwon, 2002) encompasses resources that are located within relationships, especially power and influence that is located within social networks (Bourdieu, 1986), and this makes social capital theory a useful lens through which to view female enrollment in engineering. Social networks are connected to female students in engineering because the female student's personal relationships (including those with her peers, teachers, parents, and guidance counselors) impact her educational environment and possibly her likelihood of choosing to major in engineering. Bourdieu's definition of social capital focused on the "durable network of more or less institutionalized relationships of mutual acquaintance or recognition" (1986, p. 248), and especially the power that is derived from those relationships. Therefore, social relationships and networks to which people belong are the source of real power, both in economic and social status. Relationships with others are viewed as an exclusive club to join, and decisions made in one's life and opportunities given during one's life stem from the power contained within that individual's social network (Bourdieu, 1986).

Bourdieu's (1986) work on social capital theory focuses on the power gained from one's social network and relationships with other people. Other scholars have used social capital theory to focus on relationships that serve as resources for individuals, and have taken the emphasis away from the raw power found within social networks. Under this new viewpoint of social capital theory, relationships can serve as a source of connections, knowledge, and culture for members of the social networks, which is in contrast to Bourdieu's focus on power within relationships. For the purpose of this study, relationships as a source of connection and culture will be the focus (Portes, 1998; Woolcock & Narayan, 2000; Adler & Kwon, 2002; Granovetter, 1973).

From this perspective, members must also actively invest in their social networks, and simply being a member of a social network is not enough in order to benefit from it (Portes, 1998). Only when members actively invest in their network do they obtain the power and resources located within them. As applied to females in engineering, this means that it is not enough for a female student to simply be surrounded by female role models in engineering or female friends in a math class, for example. She must also interact with them and strive to learn from them in order to gain the full benefits of her social network. The potential benefits gained from the relationships within a student's social network can only be utilized when the student actually interacts with those in her network. Additionally, the benefits from social capital stem from learning from others within the social network, and cannot come from individuals themselves.

Social capital can also come from individuals beyond the immediate family, which broadens and diversifies the person's knowledge and beliefs beyond the immediate family. Relationships within a social network could include the female student's parents, friends, and teachers (Woolcock & Narayan, 2000). Essentially, Woolcock and Narayan expanded on Bourdieu's initial ideas as the resources embedded in individual relationships to resources gained from group membership. Woolcock and Narayan's focus on community allows social capital to focus on the origins of capital and also allows social capital to be viewed in more than one context, specifically within individual relationships and within a group membership.

In addition to possibly discouraging group memberships, social capital can also have negative consequences in that outsiders can be excluded, group members might feel as if they own each other, and individual freedoms are inhibited (Portes, 1998). In fact, female students have reported feeling as if they do not "belong" in engineering programs (Stonyer, 2002, p. 395) and that the masculine culture of engineering is at odds with their own feminine identity (Haraway, 1998). Feeling excluded and as if they do not belong in engineering could make female students less likely to choose majors in engineering, driving female engineering enrollment down. Equally, the increased social capital for male students in engineering could lead to males feeling a surge of acceptance in engineering environments. This elite club in engineering to which male students belong could lead to the exclusivity of the benefits within the network leading to the underrepresentation of females within engineering.

The social structure of someone's everyday life can also allow them to access special resources (Adler & Kwon, 2002). Social capital can also be described as powerful and regular exchanges between members of a network. In other words, the social structure within which the person is embedded determines the amount and type of resources that the person is able to use. As previously discussed, sources of social capital can include not only family members, but also friends, advisors, and coworkers (Granovetter, 1973). Resources can also be found within the content of someone's relationships with other people (Adler & Kwon, 2002). This means that in order to utilize social capital theory, we must examine both the structure of relationships and the content found within those relationships.

As applied to females in engineering, Adler and Kwon's (2002) view of social capital means that a female student must have relationships with people who can help her succeed in engineering (such as encouraging parents, knowledgeable teachers, and friends who are also taking advanced science and math classes). Additionally, the simple existence of the relationship is not enough; those relationships must be high in quality. If the content of those relationships is not strong, then those relationships will not enable her to major in engineering. For example, the female student could be in an advanced math class taught by a female teacher, but if that teacher does not believe in the student's ability to succeed in engineering, then the student will not benefit from that resource.

Several conclusions and applications to females in engineering are drawn from the theoretical models presented. Following Portes (1998) and Woolcock and Narayan's (2000) concept of social capital mean recourses found within female students' peers, parents, and teachers play a role in impacting her decision to major in engineering. Additionally, acknowledging that resources are embedded in a variety of relationships and can even stem from group membership means that a female student joining an advanced math class may give her access to that specific group mentality. The complexity of social capital also means that students within a group that does not place value on math and science could share the group meaning that math and science classes should be avoided. Social capital can exist in different contexts and can place emphasis on different values, depending on the group membership.

When added to Portes' (1998) and Woolcock and Narayan's (2000) view on social capital, Adler and Kwon (2002) place a value not only on the existence of the social structure, but also on the quality of the social structure. Adler and Kwon (2002), in addition to recognizing that recourses are found within female students' peers, parents, and teachers, state that the existence of the resource structure is not enough. The social network must be high in quality in order to be fully beneficial to its members.

Additionally, Granovetter (1973) concurs that sources of social capital can include not only family members, but also friends, advisors, and coworkers. Conclusions may be drawn when taking Portes (1998), Woolcock and Narayan (2000), Adler and Kwon (2002), and Granovetter (1973) all together. Resources are found within female students' peers, parents, and teachers, resources are embedded in a variety of relationships and group memberships, and the simple existence of a social network is not enough, because the social network must also be high in quality.

From this perspective, the underrepresentation of female students in STEM fields could be because female students do not have an accurate perception of STEM fields from the beginning of their primary education, meaning that they do not understand the full scope of careers in STEM fields and specifically engineering (Darby, Hall, Downing, & Kentish, 2003). Female students also must achieve success in an environment that is not welcoming to females, which has a hand in driving down female enrollment in STEM fields (Hall & Sandler, 1982; The Chilly Collective, 1995; Opportunity 2000, 1996).

When examining only the environment in which a female student learns science and math, the issue narrows down to how female students' social network influences her perceptions of herself, her educational environment, and the STEM fields. Specifically, the decision to major in a STEM field could be highly influenced by how female students' relationships influence her perception of the field, the environment in which she learns science and math, and the people in her life who may or may not encourage her to enter into a STEM field.

Summary

We need to know more about how social influence plays a part in female students' choice of college major, because there are many benefits associated with diversity in engineering. These benefits include increased cognitive skills, increased quality of the educational experience, an increased ability to solve complex problems in new and creative ways, more creative and improved ideas, being better equipped to meet the needs of a more diverse world, and better outcomes for solutions and more creativity for team members. A student engages in a social network through peers, family members, group memberships, and teachers, which encompass resources under the umbrella of social capital. Additionally, the social network must be high in quality in order to have the most profound impact on her life.

The social support network is comprised of teachers, peers, parents, and counselors. It is important to examine this system of support to better understand the impact that the network can have on female students. This study will study the impact that the social support network has on a female student's decision to either choose or reject engineering as a college major. Results from the survey data will be analyzed with a factor analysis and an independent t-test in order to gain a better idea of the influence of a social support structure for female students.

CHAPTER III

METHODOLOGY

In order to examine the role of the social network in female students' choice of major, several considerations were made in the methodology. Questions were selected to address the participant's perception of her peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background. The instrument has also been used before (Reyer, 2007), which leads to an increase in validity and reliability. Additionally, independent t-tests and factor analysis will be used in order to compare the levels of self-reported social support between female students in engineering versus female students in science, technology, and math. Therefore, the research question and hypotheses are as follows:

Research Question

1. Do female freshmen who major in engineering at four-year, research universities report higher amounts of social network support than female freshmen who major in science, technology and math?

Research Hypotheses

1. Female engineering students will report higher levels of peer support for studying math and science in high school when compared to female students in science, technology, and math.
2. Female engineering students will report higher levels of parental support for studying

math and science in high school when compared to female students in science, technology, and math.

3. Female engineering students will report higher levels of counselor/teacher support for studying math and science in high school when compared to female students in science, technology, and math.
4. Female engineering students will be more likely to have one or both parents as an engineer when compared to female students in science, technology, and math.
5. Female engineering students will be more likely to perceive engineering as a helping profession when compared to female students in science, technology, and math.

Null Hypotheses

1. Female engineering students will not report higher levels of peer support for studying math and science in high school when compared to female students in science, technology, and math.
2. Female engineering students will not report higher levels of parental support for studying math and science in high school when compared to female students in science, technology, and math.
3. Female engineering students will not report higher levels of counselor/teacher support for studying math and science in high school when compared to female students in science, technology, and math.
4. Female engineering students will not be more likely to have one or both parents as an engineer when compared to female students in science, technology, and math.
5. Female engineering students will not be more likely to perceive engineering as a

helping profession when compared to female students in science, technology, and math.

Participants and Selection

The population was all female freshmen students who are enrolled in science, technology, engineering, and math at Oklahoma State University (N = 215) for the Fall 2011 semester. Specifically, students who received the survey were majoring in science, technology, engineering and math; specific majors were Pre-Medical, Pre-Veterinary Science, Mathematics, Physics, Biology, Aerospace Engineering, Architecture, Architectural Engineering, Biosystems and Agricultural Engineering, Chemical Engineering, Civil Engineering, Environmental Engineering, Electrical Engineering, Computer Engineering, Industrial Engineering and Management, General Engineering, Mechanical Engineering, Mechanical Engineering Technology, Electrical Engineering Technology, Construction Management Technology, and Fire Protection and Safety Technology. The sample is a convenience sample, in that the survey was given to all students who met the requirements and the data garnered was from students who filled out the survey (n = 103). Since 215 female students received the survey and 103 students participated in the study, a response rate of 47.9% was achieved. Specifically, a response rate of 27% was received from engineering female freshmen and a response rate of 57% was received from female freshmen majoring in science, technology, or math.

Instrumentation

The survey (see Appendix A) was modified from the survey used by Reyer (2007). This specific survey was originally given to students before their first year in college at Bradley University. That 60-question instrument was designed to measure student interests in science, technology, engineering and mathematics (STEM) fields, and their support and encouragement networks. The original instrument was slightly modified to meet the specific needs of this study, but the wording of the questions was not changed in the modification. The only modifications made to the survey instrument included the removal of questions that did not specifically address the needs of the study, and questions that addressed demographics were added. The instrument used for this study consisted of 52 questions (40 of which employed a seven point Likert scale, 10 of which were multiple choice, and 2 questions that were open-ended) and addressed peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background.

Variables and Questions Used to Measure Them

Peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background were addressed in the survey instrument. Specifically, questions 7-10 addressed peer influence, questions 3-6 and 11-12 addressed parental influence, questions 13-16 addressed teacher/counselor influence, questions 17-28 addressed the student's perception of engineering, questions 39-50 and 51-52 addressed academic background, and questions 48-50 addressed basic demographics (see Appendix A).

Questions regarding peer influence inquired about friends in math and science classes, and the level of math and science enjoyment within the participant's peer group. Questions regarding parental influence asked about parental encouragement in science and math, parental skill level in science and math, parental educational achievement, and whether or not the parents were engineers. Questions regarding teacher and counselor influence focused on teacher and counselor encouragement in science and math, as well as the skill level of science and math teachers. Perceptions of engineering questions sought insights regarding the participant's view of engineering. Academic background questions gathered information regarding the type and amount of science and math classes that the participants have taken in high school, as well as questions regarding the respondent's confidence in science and math.

Data Collection

Data was collected both in person and online. Advisors in the College of Arts and Sciences and in the College of Engineering, Architecture and Technology were given the surveys, along with distribution directions and a recruitment script, at the beginning of New Student Orientation and Enrollment. The survey was distributed to students during their meeting with an academic advisor, and a neutral location was provided to return the surveys. No incentives or rewards were offered for participation in the study, and the advisors did not know if their students participated in the study. A total of 66 surveys were returned through the advisor-to-student request.

To increase response rate, the PI created an online survey (www.surveymonkey.com/STEMatOSU) using the Survey Monkey software. When collecting the data with the online survey, the Dillman (2009) tailored design method was used. Participants received a pre-notice e-mail and one reminder e-mail about the survey, which was intended to increase the response rate. Correspondence to prospective participants was personalized with their first name (Cook, Heath & Thompson, 2000) as a way to increase online response rates. A total of three e-mails were sent to the participants asking for their participation in the study. The first e-mail alerted participants to look for the survey in seven days (see Appendix B). The second e-mail was sent seven days later and included a link to the online survey (see Appendix C). The third e-mail was sent seven days later and reminded students again to take the online survey (see Appendix D). This timeframe allowed the data collection to be open for two weeks. The online survey garnered 54 more responses from participants.

Expected response rates for the online survey exceeded the normal published guidelines for online surveys. In a study published in the *Journal of Engineering Education,* Jones, Paretti, Hein, and Knott (2010) obtained a 27.5% response rate by visiting engineering introduction classes, e-mailing the survey within 24 hours of visiting the class, and offering a chance to win a $40 gift card at the campus bookstore. Nathan, Tran, Atwood, Prevost, and Phelps (2010), also published in the *Journal of Engineering Education*, received a 12.13% response rate by e-mailing a survey and not providing any pre-notices or follow-up activities. In another study published in the *Journal of Engineering Education*, a 45% response rate was received for the online survey of the missed methods study (Trenor, Yu, Waight, & Zerda, 2008). Several recently published studies have also only reported their final sample size with no mention of an overall response rate (Lin & Tsai, 2009; Qualters, Sheahan, Mason, & Navick, 2008).

Strategies to increase online response rates have also been analyzed. The Dillman (2009) tailored design method stresses the importance of pre-notice e-mails and reminder e-mails for online surveys. The use of incentives is insufficient in increasing the survey response rate (Sheehan, 2001; Baruch & Holtom, 2008; Cook, Heath & Thompson, 2000). After analyzing response rates for 31 studies that employed online surveys, an average of a 24% response rate was found (Sheehan, 2001). Additionally, response rates for online surveys have relatively stabilized over the past ten years (Baruch & Holtom, 2008).

After utilizing both in-person and online data collection methods, a total of 120 surveys were returned by the participants. However, after adjusting for the same participants filling out both the paper survey and the online survey by using the student's identification number, the study had a total of 103 participants, which makes a 47.9% response rate. If the same person completed the survey both in person and online (n = 17), the online response was omitted to reduce the risk of a test-retest error.

Data Analysis

The survey instrument was pilot tested with a convenience sample on the Oklahoma State University campus in January 2011. Question validity and clarity revealed by the pilot test were then addressed. Based on feedback received from the participants during the pilot testing, questions were revised and some questions were omitted. Responses were then grouped into four main scales and responses in each scale were summated together: social influence (questions 3-10; *modeltotal*), encouragement (questions 11-16; *encouragetotal*), perceptions of engineering (questions 17-24 and 27-28; *perceptiontotal*) and career motivation (questions 25-26; *careertotal*). A factor analysis, independent t-test, and multivariate analysis was completed on the four factors as a whole, and individual questions were not be analyzed. Chronbach's Alpha was utilized in order to test the reliability of the scales, and all responses were graphically checked for normality. Levene's Test for Equality of Variances revealed that the results did not violate homogeneity of variances.

Summary

The variables of peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background will be addressed in a 52 question survey that utilizes Likert scale, multiple choice, and open-ended questions. This survey has been modified from a previous instrument used by Reyer (2007) at Bradley University. Data collection will be completed using the Dillman (2009) tailored design model. A multivariate analysis, factor analysis, Chronbach's Alpha, and Levene's Test for Equality of Variances are the statistical methods employed by this study.

CHAPTER IV

RESULTS

The purpose of this study was to examine how female students' social networks, through the lens of social capital, influence their choices to major in engineering. First, participants took a paper or online survey regarding their perceived social network support in high school. Scales analyzed were social influence, encouragement, perceptions of engineering, and career motivation. Statistical analysis included a check of reliability, inter-correlations, factor analysis, and an independent t-test.

Hypotheses

The research hypotheses considered the categories of peer support, parental support, counselor/teacher support, and a perception of engineering. Therefore, the dependent variable categories outlined in the research hypotheses (peer support, parental support, counselor/teacher support, and a perception of engineering) were included in the data analysis in a variety of ways. The data analysis focused on the dependent variables of social influence, encouragement, perceptions of engineering, and career motivation instead of each research hypothesis individually and focused on the type of support instead of the provider of the support. This was done in order to properly emphasize the type of support and not the source of the support.

Data analysis executed through the lens of the individual providers of the social network support (peers, teachers/counselors, and parents) would have brought up the theoretical implication that the types of support are not as important as the source of the support itself. However, this data analysis has been conducted with the understanding that the categories of support, coming from the social network as a whole, are more important than the individual components of the social network. Table 1 shows the data analysis category (*social influence*, *encouragement*, *perceptions of engineering*, and *career motivation*) and the specific hypothesis that each category addresses.

After questions were categorized into the four categories of dependent variables (social influence, encouragement, perceptions of engineering, and career motivation) statistical measures were used to examine the differences in the dependent variables between female freshmen majoring in engineering and female freshmen majoring in science, technology and math.

Table 1

Data Analysis Categories and Related Research Hypotheses

Social Influence

Question #	Hypothesis #
3. My mother is good in math	2
4. My mother is good in science.	2
5. My father is good in math.	2
6. My father is good in science.	2
7. My high school friends enjoyed math.	1
8. My high school friends enjoyed science.	1
9. In high school, many of my friends took advanced math classes.	1
10. In high school, many of my friends took advanced science classes.	1

Encouragement

Question #	Hypothesis #
11. My mother encouraged me to study math and science in high school.	2
12. My father encouraged me to study math and science in high school.	2
13. My guidance counselor encouraged me to study math and science in high school.	3
14. My high school guidance counselor told me I was good in math and science.	3
15. My teachers encouraged me to study math and science in high school.	3
16. My high school teachers told me I was good in math and science.	3

Perception

Question #	Hypothesis #
17. Engineers get to work with others on a consistent basis.	5
18. Majoring in engineering would allow me to help others.	5
19. An engineer needs a strong background in problem solving.	5
20. An engineer needs a strong background in problem teamwork.	5
21. An engineer needs a strong background in communication.	5
22. An engineer needs a strong background in creativity.	5
28. An engineer can be any gender.	5

Career Motivation

Question #	Hypothesis #
25. I would like a career that allows me to make a theoretical contribution to science.	5
26. I would like a career that allows me to help others.	5

Statistical Measures

Reliability

Social Influence. The social influence category included questions that were grouped together because they are all directly related to female students' social network and how that social network might influence their decisions (see Table 2). The Cronbach's Alpha rating for *social influence* was .84, which indicates a highly reliable scale. The item correlates are provided in Table 3.

Table 2

Social Influence Mean and Standard Deviations

0-7 Likert Scale	Mean	Standard Deviation	N
1. My mother is good in math	3.42	2.002	102
2. My mother is good in science.	3.5	1.913	102
3. My father is good in math.	3.39	2.33	102
4. My father is good in science.	3.27	2.097	102
5. My high school friends enjoyed math.	3.4	1.936	102
6. My high school friends enjoyed science.	3.32	1.904	102
7. In high school, many of my close friends took advanced math classes.	2.96	2.602	102
8. In high school, many of my close friends took advanced science classes.	3.35	2.547	102

Table 3

Social Influence Inter-Item Correlation Matrix

	1	2	3	4	5	6	7	8
1. My mother is good in math	1							
2. My mother is good in science.	.692**	1						
3. My father is good in math.	.219**	.289**	1					
4. My father is good in science.	.243**	.289**	.808**	1				
5. My high school friends enjoyed math.	.199**	.090**	.243**	.351**	1			
6. My high school friends enjoyed science.	.094**	.080**	.335**	.384**	.646**	1		
7. In high school, many of my friends took advanced math classes.	.167**	.189**	.530**	.494**	.522**	.652**	1	
8. In high school, many of my friends took advanced science classes.	.194**	.183**	.495**	.465**	.517**	.586**	.860**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Encouragement. The *encouragement* category included the questions that were closely related to the amount and type of encouragement that participants received in high school (see Table 4). The Cronbach's Alpha rating for *encouragement* was .94, which indicates a highly reliable scale. The item correlates are provided in Table 5.

Table 4

Encouragement Item Statistics

0-7 Likert Scale	Mean	Standard Deviation	N
1. My mother encouraged me to study math and science in high school.	3.1	2.694	102
2. My father encouraged me to study math and science in high school.	3.1	2.661	102
3. My guidance counselor encouraged me to study math and science in high school.	3.37	2.29	102
4. My high school guidance counselor told me I was good in math and science.	3.2	2.247	102
5. My teachers encouraged me to study math and science in high school.	2.82	2.66	102
6. My high school teachers told me I was good in math and science.	2.89	2.786	102

Table 5

Encouragement Inter-Item Correlation Matrix

Construct	1	2	3	4	5	6
1. My mother encouraged me to study math and science in high school.	1					
2. My father encouraged me to study math and science in high school.	.861**	1				
3. My guidance counselor encouraged me to study math and science in high school.	.647**	.655**	1			
4. My high school guidance counselor told me I was good in math and science.	.546**	.599**	.749**	1		
5. My teachers encouraged me to study math and science in high school.	.776**	.803**	.625**	.582**	1	
6. My high school teachers told me I was good in math and science.	.772**	.790**	.585**	.600**	.917**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Perceptions of Engineering. The *perceptions of engineering* category included questions that focused on how participants viewed and perceived engineering majors (see Table 6). The Cronbach's Alpha rating for *perceptions of engineering* was .97, which indicates a highly reliable scale (see Table 7). The item correlates are provided in Table 7.

Table 6

Perception Item Statistics

0-7 Likert Scale	Mean	Standard Deviation	N
1. Engineers get to work with others on a consistent basis.	3.16	2.223	100
2. Majoring in engineering would allow me to help others.	3.17	2.535	100
3. An engineer needs a strong background in problem solving.	2.72	3.022	100
4. An engineer needs a strong background in problem teamwork.	2.68	2.919	100
5. An engineer needs a strong background in communication.	2.78	2.751	100
6. An engineer needs a strong background in creativity.	2.72	2.738	100
7. An engineer can be any gender.	2.6	3.33	100

Table 7

Perception Inter-Item Correlation Matrix

Construct	1	2	3	4	5	6	7
1. Engineers get to work with others on a consistent basis.	1						
2. Majoring in engineering would allow me to help others.	.791**	1					
3. An engineer needs a strong background in problem solving.	.814**	.733**	1				
4. An engineer needs a strong background in problem teamwork.	.803**	.723**	.962**	1			
5. An engineer needs a strong background in communication.	.825**	.754**	.935**	.948**	1		
6. An engineer needs a strong background in creativity.	.792**	.713**	.955**	.942**	.916**	1	
7. An engineer can be any gender.	.777**	.676**	.957**	.928**	.907**	.937**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Career Motivation. The *career motivation* category included the questions that dealt with career motivation variables in participants (see Table 8). The Cronbach's Alpha rating for *career motivation* was .79, which indicates a highly reliable scale. The two items are significantly correlated at the .01 level ($p = .701$).

Table 8

Career Item Statistics

0-7 Likert Scale	Mean	Standard Deviation	N
1. I would like a career that allows me to make a theoretical contribution to science.	3.26	2.029	103
2. I would like a career that allows me to help others.	2.73	2.951	103

Inter-correlations

Per the previous discussion, responses were grouped into four scales and responses in each scale were summated: social influence (questions 3-10; *modeltotal*), encouragement (questions 11-16; *encouragetotal*), perceptions of engineering (questions 17-24 and 27-

28; *perceptiontotal*) and career motivation (questions 25-26; *careertotal*). Then, an inter-correlation was run between the four scales. Table 9 shows that all items were significantly correlated at the .01 level. The correlations were all in the moderate to high range. The result of Bartlett's Test of Sphericity was significant, $\chi 2 = 331.06$, $p < .001$, meaning that the null hypotheses are rejected. The KMO statistic was found to be .82. Thus, the correlation matrix was well suited for further factor analysis.

Table 9

Inter-Item Correlation Statistics

0-7 Likert Scale	1	2	3	4
1. modeltotal	1			
2. encouragetotal	.757**	1		
3. perceptiontotal	.755**	.790**	1	
4. careertotal	.684**	.731**	.877**	1

**Correlation is significant at the .01 level (2-tailed).

Factor Analysis

A PAF factor analysis was utilized in order to reduce the number of individual variables so that the data set was simpler to interpret. Additionally, the PAF analysis was utilized in order to determine whether each of the four scales (social influence, encouragement, perception of engineering and career motivation) could be analyzed as one general factor. The Scree Plot clearly indicated a one factor solution was appropriate, as expected (see Figure 1).

Figure 1

Scree Plot

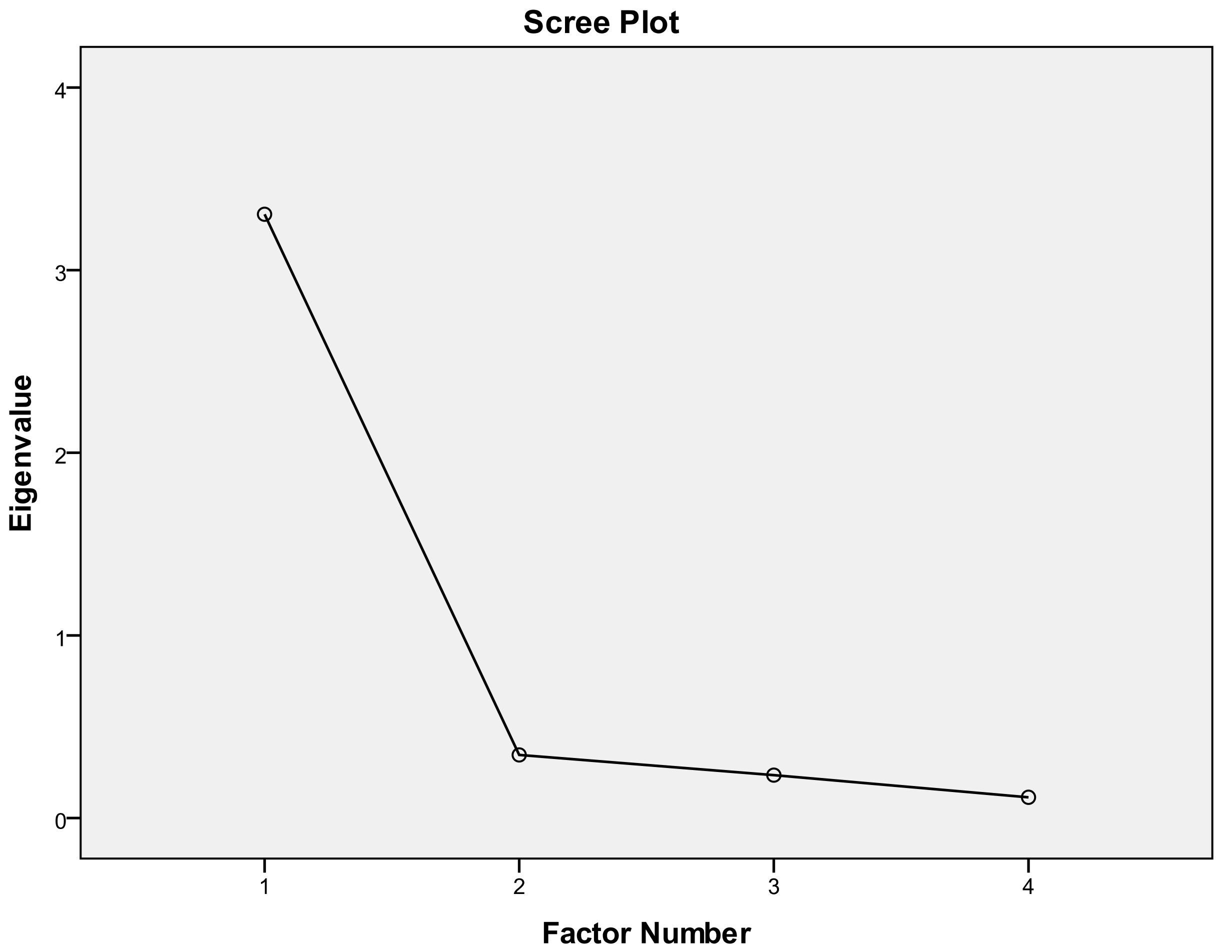

Table 10 provides the structure coefficients, commonalities, and sum of squared loads for the factor (*AllNetworkSupport*). It is obvious from the table that the scales are well represented by the one factor. Factor scores calculated using the regression method were submitted for subsequent analysis.

Table 10

Structure Coeffecients, Commonalities, and Sum of Squared Loadings

	Structure Coeffecients	Communalities
perceptiontotal	0.95	0.9
careertotal	0.88	0.77
modeltotal	0.82	0.67
encouragetotal	0.86	0.71
Sum of Squared Loadings	3.08	
Percent of Variance	77.08	

Independent t-test

Finally, an independent t-test of *AllNetworkSupport* was performed for female freshmen enrolled in engineering versus science, technology and math. Means, standard deviations, and number of participants for the two groups are reported in Table 11. The difference between the two groups was not statistically significant, $t(96) = -.001$, $p < .05$.

Table 11

Independent t-test

	Mean	Standard Deviation	n
Engineering	-0.0000972	0.91	41
Science, Technology, and Math	0.0000699	1.02	57

High School Science and Math Preparation

The variables of high school science and math preparation were analyzed for significant differences between the groups. An independent samples t-test revealed that female freshmen enrolled in engineering were significantly more likely to have taken Calculus, Pre-Calculus and Physics in high school than female freshmen enrolled in science, technology, or math. No significant difference was found in completion rates for high school Algebra, Trigonometry, Geometry, Biology, or Chemistry between females in engineering and females in other STEM fields (see Table 12).

Table 12

High School Science and Math Preparation

Course	t	df	p
Calculus	3.06	60.44	0.003
Pre-Calculus	2.59	52.99	0.012
Physics	2.25	69.08	0.028
Algebra	1	44	0.323
Trigonometry	1.3	69.82	0.197
Geometry	1	44	0.323
Biology	-0.15	89.36	0.879
Chemistry	-0.72	79.67	0.476

Summary of Findings

The relationship between social network support (specifically, social influence, encouragement, perception of engineering, and career motivation), and a female student's decision to major in engineering were examined using scale reliability tests, inter-correlation, factor analysis, and an independent t-test. While no significant differences were found between the two groups, several other interesting findings emerged.

Female freshmen enrolled in engineering were significantly more likely to have taken Calculus, Pre-Calculus and Physics in high school. Additionally, the factor analysis results indicate that the four scaled items (*perceptiontotal, modeltotal, cereertotal, encouragetotal*) are significantly correlated with one another, and a significant amount of the variance loads onto one variable. This finding suggested that the real strength in the support came from the network as whole rather than its constituent parts. Therefore, the new scale *AllNetworkSupport* was created based on the new finding and encompasses all four original scales. Chapter Five will discuss implications of these findings and recommendations for future research.

CHAPTER V

CONCLUSIONS

This study addressed the differences in social network support for female freshmen majoring in engineering versus female freshmen majoring in science, technology, or math. The four dependent variable categories analyzed were social influence, encouragement, perceptions of engineering, and career motivation. Several significant findings emerged from this study, including the fact that all types of social network support are significantly linked together and that high school science and math preparation is important. Additionally, unexpected findings included the fact that the social support network as a whole is greater than the individual components, and high school science and math preparation matter for female students in engineering.

Social Network Support

Social influence may show itself through peers, family members, and teachers and encompass resources under the umbrella of social capital. The purpose of this study was to examine how female students' social networks, through the lens of social capital as a proxy for social influence, influenced their choices to major in engineering or to major in science, technology, or math. The four scales of social network support (social influence, encouragement, perception of engineering and career motivation) are all significantly correlated with one another. Additionally, the factor analysis revealed that the four scales could be run as one general factor. This indicates a strong relationship between the four categories.

Female engineering students did not report higher levels of peer support for studying math and science in high school when compared to female students in science, technology, and math. In light of previous conclusions about math and science preparation in high school, the finding here adds to existing literature. There is no difference in peer support for studying math and science in high school between female freshmen majoring in engineering versus female freshmen majoring in science, technology and math in regards to math and science. However, as is revealed later, there is a significant difference in the actual amount of science and math taken in high school, but those differing amount seem to be happening regardless of social support.

Social Influence

Social support resources are found within the social network of peers, parents, and teachers (Portes, 1998; Woolcock & Narayan, 2000). Previous research showed strong support for the power found within peer groups. Peers can actually keep female students from deciding to major in science and engineering before they enter college (Leslie, McClure, & Oaxaca, 1998). Adolescents are likely to accept advice from friends since they view their friends as trustworthy (Crosnoe et al., 2003). Additionally, high grades in science and math classes travel within groups of friends (Riegle-Crumb, Farkas, & Muller, 2006). Female students were also more likely to take advanced courses if their friends were academically successful (Crosnoe, Riegle-Crumb, Field, Frank & Muller, 2008). Social norms also travel within groups (Crosnoe et al., 2008; Vogt, Hocevar, & Hagedorn, 2007), meaning that the social norms of studying, what classes to take, and even what major to pursue could be drawn from peer groups.

Female engineering students in this study were not more likely to have one or both parents as an engineer when compared to female students in science, technology, and math. This finding was surprising, given that previous research supported the fact that students who had a parent in physical sciences or engineering were more likely to major in physical sciences or engineering themselves (Leslie et al., 1998).

Although parental support has been shown to encourage female students to major in physical sciences or engineering (Leslie et al., 1998), parental support in this study was low. This is a problem because parents who are engineers themselves may be no longer encouraging their children to study engineering. Therefore, perhaps parental occupation only makes a difference if the parent is supporting the student. Possibly, if the parent were not supporting the student to study science and math, then significant differences would not exist.

If a student has low levels of support in one area, they could also be more likely to have low levels of support in another area, suggesting an “all or nothing” approach to social network support. As previously discussed, the inter-correlations for the four types of support were significantly correlated with one another. In other words, students are likely to have support in all four areas or no support at all, with a tendency for students who do not have support from one area to not have support from any area. Therefore, the participants from this study who are majoring in science, technology, or math are even more likely to get pushed away from engineering when choosing their academic major in college.

Additionally, the low means on the 7-point Likert scale in the social influence category indicate that female students within science technology, engineering, and math do not perceive a strong social support network. There is always the possibility that the participants actually did have what might be considered a strong social support network and did not notice; this study is based on the participants' perceptions. However, the more reasonable explanation goes along with the other findings: Deficits exist in the social support of female students in STEM fields (Vogt et al., 2007; Crawford & MacLeod, 1990; Hall & Sandler, 1982; The Chilly Collective, 1995; Opportunity 2000, 1996; Sadker & Sadker, 1994; Blinkenstaff, 2005; Warrington & Younger, 2000).

Based on these data points, a female student is highly unlikely to make her choice of major solely because of her social support network. The lack of social network support is surprising, given previous findings that the social support is useful for encouraging female students to study STEM fields (Crosnoe, Riegle-Crumb, et al., 2008; Crosnoe et al., 2008; Seymour, 1999; Leslie et al., 1998; Seymour, 1995). The fact that a social support network is important would indicate that a support network exists in the first place, and participants in this study did not have a strong perceived social support network. However, it is important to note that this study did not assess the participants' perceptions of the importance of a social support network, only the perceptions of the degree of the existence of a network.

Most importantly, the new finding here is that there is no difference in the social support network between female freshmen majoring in engineering versus science, technology and math. This is important because it means that the social support network was low for participants majoring in STEM fields in this study and also did not motivate a participant from this study to major in engineering.

Female STEM freshmen participants do not perceive themselves as having a strong social support network; therefore, the question moves to whether or not the participants in this sample had stronger social support networks than their non-STEM counterparts. Although social support network means were low for these participants, the means could be higher than their non-STEM female counterparts. In other words, what appears to be a weak network in this study could actually be a strong network when compared to non-STEM students.

The perceived low levels of social network support in high school indicate that the pipeline in high school is not strong. Therefore, some female students in high school are bounced from the engineering pipeline because of a lack of support in social influence, encouragement, career motivation, or perception of engineering. Although these participants were able to persist and major in a STEM field despite the perceived lack of social network support, other students with potential to succeed in STEM could have "leaked" from the pipeline (Blickenstaff, 2005, p. 369) due to the same lack of social network support. Encouragement for female students was also examined.

Encouragement

Adler and Kwon's (2002) view of social capital suggests that a female student must have relationships with people who can help her succeed in engineering (such as encouraging parents, knowledgeable teachers, and friends who are also taking advanced science and math classes) in order for social capital to be most effective. Additionally, the simple existence of the relationship is not enough; those relationships must be high in quality (Adler & Kwon, 2002). The sources of encouragement for this study included parents, peers, teachers, and counselors. Overall support from these sources was low for participants in this study, indicating either a lack of support or a lack of recognition of support. However, participants still chose to major in engineering even without strong encouragement.

Female engineering students did not report higher levels of parental support for studying math and science in high school when compared to female students in science, technology, and math. Different levels of parental support are not associated with participants in this study majoring in engineering instead of science, technology, or math. Even if the participants in this study had encouraging parents, there was not a difference in the encouragement between engineering female freshmen and female freshmen majoring in science technology and math.

Female engineering students also did not report higher levels of counselor/teacher support for studying math and science in high school when compared to female students in science, technology, and math. Previous literature supports the idea that female students in STEM fields receive low amounts of support to study math and science when compared to male students, but it has been unknown until this point how teacher/counselor support compares across STEM disciplines. It is important to know more about teacher and counselor support in order to have a well-rounded view of support from all angles of a student's life. This study's whole premise is to know more about the social support network, so gaining a holistic understanding of teacher/counselor support is a crucial step in this endeavor.

In light of the previous findings, it makes sense that not only is there no significant difference in levels of counselor/teacher support between the two groups of participants, but that the reported levels were low across the board. The same low level of support across STEM disciplines might be a reflection of the similarity of support, and the low levels of support could also be an indicator of the lack of overall support for female students in all STEM fields. However, encouragement is only part of the overall picture of social network support, and the participant's perceptions of engineering must also be addressed.

College freshmen are fresh off of their high school careers, so knowing more about their educational background is important in setting the proper context. There is a lack of female role models in high school science and math classes due in part to the fact that teachers in those fields are more likely to be males (Sadker & Sadker, 1994; Blinkenstaff, 2005). Additionally, female students receive less attention from teachers than the males in the university classroom (Sadker & Sadker, 1994; Blinkenstaff, 2005) and female students in general have had teachers who expect less of them than their male classmates (Warrington & Younger, 2000).

Perceptions of Engineering

Participants who were majoring in engineering were not more likely to perceive engineering as a helping profession when compared to participants majoring in science, technology and math. Previous studies have found that overall perception of engineering is important, even when the area being evaluated was not related to a helping profession: A perception of engineering as being masculine has also been a contributing factor for female students not choosing engineering majors (Powell et al., 2009), and female students could also be more likely to choose majors in which they expect to have more interaction with people (Diekman, Brown, Johnston, & Clark, 2010). The new finding here contradicts previous research: Whether or not a participant perceived engineering as a helping profession had no bearing on whether she chose engineering instead of science, technology and math as a college major.

A female freshman participant's perception of engineering in general did not motivate her to major in engineering versus science, technology, or math. However, it is important to note the areas within the perception category that are significantly correlated with one another. The questions that asked a participant about their perception of engineering were socially-oriented questions (e.g., *Engineers get to work with others*). All of these socially-oriented questions were significantly correlated with the statement *An engineer can be any gender*, indicating that participants relate socially-oriented STEM majors with both male and female genders, contradicting Diekman et al. (2010).

Career Motivation

Participants also signaled a need to contribute to science and help others. The interesting aspect here is that participants linked helping others with contributing to science. Today's high school students, therefore, seem to be more aware of the benefits of a career in science. The aspect of using science careers to help others should be explored in more detail in future studies, since clearly there is a link in the minds of the participants between the two constructs.

Students desire a career that would allow them to make a theoretical contribution to science (Nichols et al., 2007), and participants in the present study associated science with helping others. Not only did the results support Nichols et al. (2007) in that participants want to contribute to science, but also the new finding here is that helping others and contributing to science are linked together in the participants' minds. The findings from the two items that addressed career motivation, *I would like a career that allows me to make a theoretical contribution to science* and *I would like a career that allows me to help others*, are significantly correlated together. The fact that they were significantly correlated with one another indicates that participants view contributing to science as a way to help others.

Key Findings

The original premise of the study centered on a comparison between students majoring in engineering and those studying science, technology, and math. However, one of the most important outcomes of the study is that the net effect of the four types of social network support (social influence, encouragement, perception of engineering, and career motivation) is greater than that of any one of the individual components of support alone. Support from peers, parents, teachers, and counselors is more meaningful to participants than individual facets of support form one individual area. In other words, the four components of support working together created something entirely different than the four areas of support individually contributing.

Therefore, knowing how important it is for support to be given from all angles, female students majoring in engineering need to be in well-rounded rich environments. Having support from peers is better than nothing, but to really be effective, support needs to be given from peers, teachers, counselors, and parents. A piece of support here and a piece of support there is good, but it is not the same as support from a diverse type and number of supportive people in the student's life.

This could mean that a student coming from a home that is not supportive of a choice to major in engineering cannot compensate by having supportive friends at school. Or, if a student has parents who are encouraging math and science but the student's close friends are not in those same upper level math and science classes, support from home is not reinforced and is therefore less effective. Support as a whole becomes its own organism and is greater than bits and pieces of support in the student's life.

High School Science and Math Preparation

The importance of high school science and math preparation also emerged as a key finding from this study. Female freshmen majoring in engineering were more likely to have taken Calculus, Physics, and Chemistry in high school than female freshmen majoring in science, technology, or math. High school science and math preparation is important because of not only the actual knowledge that students get in these classes, but also the amount of social network support that can be gained from taking them. A significant difference was revealed in the amount of math and science preparation that female engineering freshmen received in high school. The U.S. Department of Education (2004) found that the choice of a STEM major is influenced by the amount of math and science preparation that students receive while in high school. According to Trusty (2005), female students who took higher level math classes in high school were more likely to major in engineering or science fields in college. The current study makes a new contribution to the existing body of literature, demonstrating that students who took Calculus, Pre-Calculus and Physics while in high school were more likely to major in engineering versus science, technology, and math. This suggests that the influencing variable is not simply higher level math in general. Particular classes (i.e., Calculus, Pre-Calculus and Physics) matter in the participant's choice of whether or not to major in engineering.

This finding raises more questions than answers. For instance, it is unknown if female students intentionally take calculus in high school in order to prepare for engineering, or if an interest in engineering simply attracts the person to take calculus. An interest in calculus could also attract the student to engineering. Regardless of which one comes first, it is important to know that higher levels of science and math preparation in high school are linked to female students choosing to major in engineering in college. It is important for more female students to major in engineering because more females means that the engineering field will be more diverse and will be better equipped to tackle the diverse ideas of an ever-changing world (Massachusetts Institute of Technology, 2003).

The finding related to higher levels of math and science could also be a result of students with a natural aptitude for analytical fields being attracted to higher levels of science and math in high school and then engineering majors in college. This means that the choice to major in engineering could be a natural reflection of the participant's natural strengths and interested and not completely a reflection of the social support that she receives. Or, perhaps someone who is naturally analytically-minded is more drawn to others who are like-minded and then naturally attracted to analytical fields of study.

However, the higher levels of science and math would depend partially on her primary motivating factors for taking Calculus, Pre-Calculus and Physics. If she is taking these courses to intentionally prepare for an engineering major, then continuing that support in high school would be a logical step. The student's internal motivation also could play a part here. Some students might be interested in engineering but unwilling to challenge themselves with the more demanding Calculus, Pre-Calculus and Physics coursework while in high school. Therefore, the experience with science and math courses in high school could be a reflection of the participants' interest in engineering, their own internal motivations, or a combination of the two.

On the other hand, there could be a subset of students who are well suited for engineering, and yet do not know the importance of strong high school science and math preparation. Middle school outreach programs for this sub-set of students becomes essential in motivating them to take Calculus, Pre-Calculus and Physics in high school in addition to informing them what engineers do and how students should prepare for engineering majors.

Participants enrolled in engineering were significantly more likely to have taken Calculus, Pre-Calculus and Physics in high school than their counterparts majoring in science, technology, and math. Implications for this finding mean that an important time in which to influence a female student to major in engineering is while she is enrolled in Calculus and Physics in high school. Outreach activities should also focus on encouraging more female students to take Calculus and Physics as a way to potentially increase the number of female engineering students. Socioeconomic issues also are at play here, since larger and more affluent high schools offer higher levels of science and math than less affluent high schools.

The socioeconomic issues reinforce the social capital idea that power and resources are found within relationships (Bourdieu, 1986; Portes, 1998; Woolcock & Narayan, 2000; Adler & Kwon, 2002). As applied to the course offerings at various high schools, students whose parents are more affluent would therefore be placed in more affluent high schools, would then have the opportunity to take Pre-Calculus, Calculus, and Physics, and would then be in a better position to major in engineering in college. It would be good to know more about the relationship between parental affluence and the amount of math and science preparation in high school in order to understand if students from wealthier schools have an advantage in the math and science fields.

Reaching out to students while they are still in middle school is the ideal outreach timeframe (Fouad & Smith, 1996). This would reach students who are naturally well-suited for engineering and yet do not have a clear understanding of what engineering is or what it requires. Middle school outreach would also reinforce the motivation to study engineering for students who are already interested in the field.

Math confidence also matters for female students in STEM fields (Veenstra, 2010). GPA and ACT/SAT predicted academic performance in college for female students majoring in science, technology, and math. However, for female students majoring in engineering, GPA, ACT/SAT and math confidence predict academic performance in college. Taking more math classes in high school makes female students more confident and then majoring in engineering in college is not much of a stretch.

Regardless of the student's motivation for taking higher levels of math and science in high school, the higher levels of science and math preparation are clearly important in influencing her decision to major in engineering. Whether the student happened to fall into engineering and happened to have taken Calculus and Physics in high school, or whether she was intentionally preparing for an engineering major by taking the higher level courses, the end result of engineering enrollment is the same. Therefore, more attention should be paid both to increasing the number of female students who take Calculus and Physics in high school and also to increasing awareness of engineering career opportunities to middle school and high school students.

Additionally, according to established findings, high school science and math preparation is reinforced among peer groups (Riegle-Crumb et al., 2006; Crosnoe, Field, & Muller, 2008; Crosnoe et al., 2008). In contrast, the present study found that participants did not agree that many of their close friends took the same high school science and math classes. Therefore, recruitment and outreach activities should also focus on whole group development in addition to individual recruitment. Possible examples of whole group development include visiting entire classrooms, encouraging group projects in high school classes, and helping female students get connected with others in high school who enjoy science and math. Whole group development could also contribute to a strengthened STEM pipeline.

STEM Pipeline

Several links to earlier research are found within this study. This study does not address when, the engineering pipeline had a "leak" for participants (Blickenstaff, 2005, p. 369), although the study does reinforce the need for a strong engineering pipeline. The new contribution from this study regarding the engineering pipeline is the fact that social influence, perceptions of engineering, encouragement, and career motivation are all equally important aspects of the need to retain females in the engineering pipeline.

Although the focus of this study has been engineering versus science, technology, and math, the STEM pipeline as a whole should still be examined. The STEM pipeline is damaged. The low means on the social support network scales in this study indicate that the pipeline is still leaking. Participants in this study either received support from all angles or no support at all, as indicated by the high inter-correlations. The social network support scales used in this study also had wide distributions, indicating that a select few students reported high levels of social network support across all STEM disciplines. It is unknown what differentiated those reported high levels. Knowing more about why a select few participants reported high levels of social network support would help researchers identify what went right with those students. This would help researchers and educators then apply those findings to other female freshmen.

The low levels of social network support could also indicate that female students in STEM fields have simply perceived low levels of social network support, which means that social interaction and support may not be meaningful to them. Future research should examine the perceived social support on all sides (the student, her peers, her parents, and her teachers / counselors). This would allow comparison between the student's perceived levels of support and the actual levels of support that she is receiving. This would tell us if the social network support is lacking, if the support is there but yet the participants are not perceiving it, or if the types of support given are simply not meaningful to the participants.

The fact that the participants who are enrolled in STEM fields report low levels of social network support could also indicate that the participants have strong convictions in their own decisions to major in a STEM field. Perhaps STEM fields attract those students who do not need outside support for their decisions, or perhaps STEM fields attract students who simply do not notice outside support because they are already so well grounded in their own decisions.

Another explanation of the weak levels of social network support could signal a shift in generational expectations. In previous generations, a female student in STEM fields was surprising, and so those female students stood out from the group more than their male counterparts. For today's high school students, it might be commonplace to see female students in STEM fields, and therefore the students do not pick up on any special support or attention given to them. Although it is possible that seeing female students in STEM fields is the new normal, the STEM pipeline is still leaking if these students do not follow the pipeline to a STEM major in college while their male counterparts ride the pipeline into STEM majors.

Implications and Recommendations

Social network support alone is not enough to inspire female freshmen to major in engineering instead of science, technology, and math. It is important for more female students to choose engineering as a college major so that the engineering workforce is more diverse and is better equipped to tackle the variety of challenges that engineers face. Implications for research, theory, and practice center on the weak STEM pipeline and importance of high school science and math preparation. Recommendations for research, theory, and practice focus on the development of a reliable instrument, need to reach out to students before high school, and the need to consider both the resources within relationships as much as the context of the relationships themselves.

Research

This study did not assess the participants' perceptions of the importance of a social support network, only the perceptions of the degree of existence of a network. Therefore, future research should examine what students actually value in terms of social support. There could be two separate studies that emerge from this study: One study that examines the degree of importance that participants place upon a social support network and if that importance is associated with students expressing a stronger interest in science. Next, a study could investigate social support from a variety of angles (including peers, teachers, counselors, and parents) and compare the reported levels of support to what participants perceive. This would allow researchers to gain a better idea of the actual amount of support being offered instead of viewing support solely through the lens of the participants.

Human motivational theories could also be examined in future studies. This study's primary theoretical focus was social capital, but knowing more about human motivation and social cognition would be helpful for future studies. Group memberships, which were visited in social capital, should be explored in future studies. It remains unclear if participants in this study had higher amounts of peer support as compared to their non-STEM counterparts. It also was outside of the scope of this study to consider whether this sample had higher amounts of peer support when compared to their male counterparts. Therefore, future studies should examine whether female freshmen majoring in engineering have higher levels of peer support than female freshmen in non-STEM majors or male freshmen majoring in engineering.

Future studies should examine the levels of parental support based on the parents' occupation and not on their child's choice of major. In other words, the lens for a future study should be the parental occupation and the child's choice of major would be a secondary focus. For example, a future study could compare levels of parental support to study science and math for parents who are in science and math fields versus parents who are not in science and math fields.

The limited range, as seen in the independent t-test analysis of engineering versus science, technology, and math, also sets up an alternate finding for this study. The limited range could mean that lack of a significant difference between engineering and science, technology, and math is not due to an actually lack of a difference between the two groups. This study could have reflected a low variability on each scale, meaning that there would be no significant difference because the ranges on both sides were low at the beginning of analysis. A non-response bias could have also contributed to the low range on both of the groups. Under this assumption, significant differences could exist and were not reflected due to the limited range.

Differences in social support network between female students majoring in STEM fields and female students majoring in non-STEM fields should be investigated. Studies should also investigate differences in social network support for male versus female students. Studies should also compare students' perceived levels of support versus actual levels of social network support by collecting data from a wide variety of participants, including students, parents, counselors, teachers, and peers.

Future studies should examine encouragement from the parents' point of view in addition to the students' point of view. It could be that the parents were attempting to be encouraging but that the encouragement was not perceived by the students. It is important for more female students to major in engineering in order to gain a diverse viewpoint on engineering problems and to have an engineering workforce that represents the population at large.

More research should be done to see how students perceive engineering majors and to investigate the qualities that students are interested in when choosing a major. Instead of starting with the interest and then comparing majors, first investigate what female students are looking for when choosing a major and then find majors that fit those desired qualities.

Assuming that Diekman et al.'s (2010) findings are true and that female students could also be more likely to choose majors in which they expect to have more interaction with people, the timing of the questions should be examined. The gender questions appeared at the end of a series of questions emphasizing social interaction. This indicates that after thinking of engineering as a socially-oriented major, the female participants could be more likely to agree that engineers can be any gender because they could see themselves majoring in engineering. Therefore, the survey could have unintentionally created bias in the participants in that the survey might have pre-conditioned the female participants to think of engineering as a social major and as a major that they could imagine female students choosing because of its social nature. Further follow-up is needed in order to assess whether or not participants do link gender with socially-oriented professions.

Studies could also ask if an engineer can be any gender after priming participants with questions that are not socially oriented. It is important to know if female students believe that an engineer can be any major in order to address pre-conceived notions of engineering as a way to encourage more female students to major in engineering. The survey used in this study could have unintentionally primed participants to think of engineering as a social profession, and so following up on this unanticipated finding would be worthwhile. Additionally, the significant correlation supports the notion that participants reported no stigma or negativity associated with female engineers and that participants had no preconceived ideas about whether a female student could be an engineer. Participants were all female students, and so future studies should test the differences between attitudes of male and female students on whether both genders can be engineers.

Future research should look more closely at the issue of the perception of engineering. Knowing why participants linked helping others with making a contribution to science would be beneficial to the field. It could be that participants only viewed helping others as a way to contribute to science, or it could be that participants are able to identify various ways of contributing to science. If educators knew students' viewpoints on contributing to science, perhaps those ideas could be used to effectively recruit future students in the science fields. Applied to engineering, educators could also link engineering to helping others in recruitment efforts as away to encourage more female students to enter the field.

Additionally, future research should investigate how the social support network impacts female students as early as the eighth grade (Catsambis, 1995; Lent, Brown, & Hackett, 1994; Lent, Brown, & Hackett, 2000). Studies should also examine how the social support network influences the decision making process for middle school students when they decide what types of math and science courses to take in high school. Future studies should also examine whether participants agree that an engineer can be any gender after reading statements about engineering that are not socially orientated.

Future studies should examine how college freshmen perceive the field of science and engineering. Perhaps with today's technology, more and more high school students are becoming more aware of new breakthroughs in science and research. Once students are more aware of current achievements in the science field, they might want to contribute to science.

Parents of female freshmen majoring in engineering were no more encouraging than parents of female freshmen majoring in science, technology and math. This does not mean that the parents were not encouraging, only that there was not a significant difference in the encouragement. Future studies should examine encouragement from the parents' point of view in addition to the students' point of view. It could be that the parents were attempting to be encouraging but that the encouragement was not perceived by the students. It is important for more female students to major in engineering in order to gain a diverse viewpoint on engineering problems and to have an engineering workforce that represents the population at large.

Social capital theory suggests that there is power, influence and resources in group affiliations (Adler and Kwon, 2002; Bourdieu, 1986; Portes, 1998; Woolcock & Narayan, 2000). Group membership should therefore be explored in future studies. This study examined differences within STEM, and so it is unknown if differences would have existed between STEM and non-STEM participants. Examination of peer support levels among female students as compared to male students was outside the scope of this study. Therefore, future studies should examine whether female freshmen majoring in engineering have higher levels of peer support than female freshmen in non-STEM majors or male freshmen majoring in engineering.

Female freshmen majoring in engineering are no more likely to perceive engineering as a helping profession than female freshmen majoring in science, technology, and math. This finding could be due to the fact that all female students do not perceive engineering as helping profession to begin with, regardless of major. Also, perhaps the ability to help others is not as important to female students as previous studies have suggested.

Future studies could also benefit from the survey used in this study. The survey used for this study was adapted from a survey used in an earlier study (Reyer, 2007), but reliability statistics for the scales were not known until now. With a reliability rating of .92, we now know that the scale used in this study has high internal consistency. This means that the scale is highly reliable and will deliver consistent results in measuring social network support and perceptions of engineering and should be used again in future research. Although this study brings up the question of whether the instrument unintentionally primed the participants, omitting those questions, re-ordering the questions, or testing the same instrument again would be helpful for future research.

A select few participants reported high levels of social network support. Knowing more about these participants reported high levels of social network support would help researchers identify what went right with those students. This would help researchers and educators then apply those findings to other female freshmen. Focus groups, targeted surveys to high-achieving female students, or a focus on educators would all be ways in which to learn more about what is going well in engineering education.

Whether a student can benefit from supportive relationships within an educational environment that is deficient in support for math and science, or if the educational environment itself is the most crucial aspect for encouraging future engineers, should be determined. In other words, placing the emphasis on the educational environment and testing students who have the same level of relational support in both supportive and non-supportive environments would help researcher identify if the relationships are the most important, or if the environment itself is the main influence for majoring in engineering.

Finally, more attention should be paid to the link between socio-economic status and high school math and science preparation. Since high school science and math preparation was significantly linked with a participant's choice to major in engineering, knowing more about a student's socio-economic status and how that status plays a part in the resources available at high schools would be useful. It could be that students who are from more affluent high schools have increased access to upper level science and math classes, such as Calculus and Physics. Whether or not this dynamic exists should be examined.

Theory

Social capital theory (Bourdieu, 1986; Portes, 1998; Woolcock & Narayan, 2000; Adler & Kwon, 2002) encompasses resources that are located within relationships, especially power and influence that is located within social networks (Bourdieu, 1986), and this makes social capital theory a useful lens through which to view socioeconomic factors in high schools. Bourdieu's definition of social capital focused on the "durable network of more or less institutionalized relationships of mutual acquaintance or recognition" (1986, p. 248), and especially the power that is derived from those relationships.

Therefore, social relationships and networks to which people belong are the source of real power, both in economic and social status. Attending a more affluent high school means that the student is more likely to have the chance to take higher levels science and math classes. When viewed through social capital theory, the resources found within a more affluent high school would be an advantage for students in preparing for engineering.

Peer influence has also been found to influence the types of courses that students take while in high school (Riegle-Crumb et al., 2006; Crosnoe, Riegle-Crumb, et al., 2008). Previous findings have also found that social norms travel within groups (Crosnoe et al., 2008). In contrast to other findings, this study did not support the notion that science and math courses travel within packs of friends while in high school or that participants received some type of social support from friends in high school science and math classes.

The findings do support the idea that a student can be influenced for her career path while in adolescence (Leslie et al., 1998). Specifically, this study recommends reaching out to female students before they reach high school in order to influence them to take more science and math classes while in high school. Shaping engineering careers in a positive way would support previous literature's assertion that adolescence is an important time to influence the types of science and math classes that a student will take in high school.

When considering the influence of peers, parents, teachers, and counselors, it is important to note that the co-efficient for *Perception of Engineering* was higher than the co-efficient ratings of the other three scales. This could indicate that the *perception of engineering* category could substitute for the other three scales. Knowing more about how a female freshman's perception of engineering is shaped, and knowing more about the variables that influence the way that she views engineering, would be helpful.

Career Motivation and *Encouragement* also seem to be equally important for helping a female freshmen choose a major, with *Social Influence* serving as the least important reason for choosing a major in engineering, as evidenced by the co-efficient ratings. Theoretical implications from this finding mean that influences from peers, parents, and teachers/counselors are not as meaningful as a student's own career goals and reasons for pursuing an academic major. Also, direct encouragement, such as telling a female freshmen that she is good in math and science, seems to be more meaningful than simply being surrounded by peers who are like-minded.

Previous research has also indicated a lack of female role models and support from teachers in science and math (Sadker & Sadker, 1994; Blinkenstaff, 2005; Warrington & Younger, 2000). While this study did not ascertain if participants had female role models specifically, social support was low on all sides. Therefore, this study would reinforce previous findings that there is dysfunction in positive role models for female students in STEM.

Participants in this study did not associate engineering with a particular gender, which is in contrast to earlier findings (Powell et al., 2009). Participants did view engineering as a socially-oriented major, and previous findings have stated that female students could also be more likely to choose majors in which they expect to have more interaction with people (Diekman et al., 2010). In terms of the perception of engineering, this study both reinforced previously held ideas (social orientation of engineering) and does not support other ideas (engineering associated with a particular gender).

Female college freshmen participants enrolled in science, technology, engineering, and math have weak levels of social network support, and there is no significant difference in social network support for female freshmen majoring in engineering versus female freshmen majoring in science, technology, or math. Female freshmen enrolled in engineering were more likely to have taken Calculus and Physics in high school when compared to female freshmen enrolled in science, technology, or math.

This study also contributed a reliable scale for measuring social network support to the existing body of literature. In conclusion, social network support is important for all female students majoring in a STEM field, but social network support alone is not enough to inspire female freshmen to major in engineering instead of science, technology, and math.

Practice

The lack of a significant difference of social support between participants majoring in engineering versus participants majoring in science, technology, and math means that higher amounts of peer support may not equate to a student choosing to major in engineering. However, other support approaches, such as outreach programs, should be considered in supporting female students to study engineering.

The fact that the scales are so significantly correlated with one another could mean that there is an interplay between the participants and the environment. As applied to working with female freshmen in engineering, this means that consideration should be paid to the type of support that the students find meaningful. Since this study could have addressed types of support that are not meaningful to female freshmen majoring in engineering, science, technology, or math, college professionals should take care to investigate exactly how female freshmen in STEM fields perceive and acknowledge support.

Several implications for practice can be drawn from this study. Outreach programs to middle school and high school students should be strengthened in order to increase awareness of engineering majors and to encourage female students to take more science and math classes in high school. Linking engineering fields to helping others would be another possible way to increase the number of female engineering students. More attention should also be paid at the middle school and high school level as to who is receiving social support and who is unintentionally being bounced from the engineering pipeline.

Participants showed a desire to contribute to science and help others, and the fact that participants want to contribute to science means that the female freshmen from this study do not view science as an abstract, far off field. In fact, they could want to contribute to science because they view it as an essential area of today's society. Since participants want to help others, educators should make strong ties to how engineering helps others in future recruitment efforts. Showing actual, tangible examples of real-world achievements in science would be extremely useful in motivating more female students to choose engineering as their field of study.

The implication is that female students in all STEM fields have the same access to counselor/teacher support for studying science and math. Whether a female student is interested in studying engineering pays no relevance to her access to social support network for studying science and math. The implication here is that all STEM female students have the same levels of support to study math and science, for better or for worse.

Given the low levels of counselor/teacher support for all female STEM students, programs that encourage teachers and counselors to support female students to study engineering would be a good first step. Next, programs should enable teachers and counselors to identify high achievers in high school with tangible ways to encourage them to study science and math. Examples of this might include a monthly lunch for female students in math and science classes with female engineers as guest speakers, posters of female engineers in the classrooms, and even special university tours for high-achieving female students.

The findings that participants agreed that an engineer could be any gender do not support Powell et al.'s (2009) previous argument that engineering is seen as a masculine profession by many female students. Diekman, Brown, Johnston, and Clark (2010) stated that female students could also be more likely to choose majors in which they expect to have more interaction with people. Although the present study does not clarify if participants chose their major in order to work with others, these findings support previous literature in that participants did agree that engineers get to work with others. This is important in light of Diekman et al.'s (2010) findings. If female students perceive that they will work with other in engineering, perhaps they will be more drawn to choosing engineering as their college major.

Although the focus of this study has been engineering versus science, technology, and math, the STEM pipeline as a whole should still be examined. This is because engineering is still a piece of the STEM pipeline, so strengthening and understanding the STEM pipeline can also strengthen engineering. The STEM pipeline is damaged. The low means on the social support network scales in this study confirm this. Participants in this study either received support from all angles or no support at all. The social network support scales used in this study also had wide distributions, indicating that a select few students reported high levels of social network support across all STEM disciplines. It is unknown what differentiated those reported high levels.

The low levels of social network support could also indicate that female students in STEM fields have simply perceived low levels of social network support, which means that social interaction and support may not be meaningful to them. Future research should examine the perceived social support on all sides (the student, her peers, her parents, and her teachers / counselors). This would allow comparison between the student's perceived levels of support and the actual levels of support that she is receiving. This would tell us if the social network support is lacking, if the support is there but yet the participants are not perceiving it, or if the types of support given are simply not meaningful to the participants.

The fact that the participants who are enrolled in STEM fields report low levels of social network support could also indicate that the participants have stronger convictions in their own decisions to major in a STEM field. Perhaps STEM fields attract those students who do not need outside support for their decisions, or perhaps STEM fields attract students who simply do not notice outside support because they are already so well grounded in their own decisions.

Another explanation of the weak levels of social network support could signal a shift in generational expectations. In previous generations, a female student in STEM fields was surprising, and so those female students stood out from the group more than their male counterparts. For today's high school students, it might be commonplace to see female students in STEM fields, and therefore the students do not pick up on any special support or attention given to them. Although it is possible that seeing female students in STEM fields is the new normal, the STEM pipeline is still leaking if these students do not follow the pipeline to a STEM major in college while their male counterparts ride the pipeline into STEM majors.

Limitations

Several limitations exist within this study. First, with the relatively small sample size, it is unlikely that these results can generalize to the entire population. Although 47.9% of surveys were returned by participants, the sample is still a small group. Therefore, future studies should test participants from multiple universities in order to increase the sample size and increase the ability to generalize results.

This study also recorded the participants' perception of support, which may or may not be an actual reflection of support given to the participants. Therefore, it could be that the peers, teachers, parents, and counselors were attempting to support the participants and the participants did not realize that fact. The ability to analyze support given from all angles (from the perception of the giver of support and the receiver of support) would be an interesting follow-up.

The sample also included participants who were in their freshmen year at a four-year university and therefore did not address retention. This study did also not investigate college choice or college access, since participants were already be enrolled in college. This study did not address female students who are enrolled in fields other than science, technology, engineering, or math. Finally, this study only examined female participants and did not investigate the male perception of support.

This study addressed the differences in social network support for female freshmen majoring in engineering versus female freshmen majoring in science, technology, or math. Social network support, when working together from all angles of peers, teachers, parents, and teachers/counselors, transforms itself into a new force that is more powerful than the summation of the individual parts. Math and science preparation also contributed to female freshmen choosing to major in engineering instead of choosing to major in science, technology, or math. The STEM pipeline is still weak and ways in which to reinforce it should be examined. Social network support is crucial for female freshmen who are majoring in science, technology, engineering, and math.

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APPPENDICES

Appendix A

For each of the following questions, please select the number on the scale that best represents your viewpoint.

Likert Scale Answers (7 point scale from Strongly Agree to Strongly Disagree)

1. I enjoy math.
2. I enjoy science.
3. My mother is good in math.
4. My mother is good in science.
5. My father is good in math.
6. My father is good in science.
7. My high school friends enjoyed math.
8. My high school friends enjoyed science.
9. In high school, many of my close friends took advanced math classes.
10. In high school, many of my close friends took advanced science classes.
11. My mother encouraged me to study math and science in high school.
12. My father encouraged me to study math and science in high school.
13. My guidance counselor encouraged me to study math and science in high school.
14. My high school guidance counselor told me I was good in math and science.
15. My teachers encouraged me to study math and science in high school.
16. My high school teachers told me I was good in math and science.
17. Engineers get to work with other people on a consistent basis.
18. Majoring in engineering would allow me to help others with my career.
19. An engineer needs a strong background in problem solving.

20. An engineer needs a strong background in teamwork.

21. An engineer needs a strong background in communication skills.

22. An engineer needs a strong background in creativity.

23. An engineer needs a strong background in math.

24. An engineer needs a strong background in science.

25. I would like a career that allows me to make a theoretical contribution to science.

26. I would like a career that allows me to help others.

27. An engineer can be any race.

28. An engineer can be any gender.

29. Scientists/mathematicians get to work with other people on a consistent basis.

30. Majoring in science/math would allow me to help others with my career.

31. A scientist/mathematician needs a strong background in problem solving.

32. A scientist/mathematician needs a strong background in teamwork.

33. A scientist/mathematician needs a strong background in communication skills.

34. A scientist/mathematician needs a strong background in creativity.

35. A scientist/mathematician needs a strong background in math.

36. A scientist/mathematician needs a strong background in science.

37. A scientist/mathematician can be any race.

38. A scientist/mathematician can be any gender.

Likert Scale Answers (7 point scale from Strong Positive Influence to Strong Negative Influence)

39. How did each of the following reasons influence your decision to choose your major?

a. I Always Knew I Wanted to Be An Engineer

b. I Always Knew I Wanted to Be A Scientist/Mathematician

c. Parents Encouraged Me

d. Pressure from Parents

e. Outreach from CEAT While I Was in High School

f. Teachers Encouraged Me

g. Friends Encouraged Me

h. Salary

i. Career Opportunities

j. Experience with This Field in High School

Likert Scale Answers (7 point scale from High Confidence to Low Confidence)

40. Please rate your level of math confidence.

Multiple Choice

41. Which of the following programs did you participate in while in high school (check all that apply)?

a. Pre-Engineering/Project Lead the Way

b. FIRST Robotics

c. Botball

d. Academic Team

e. Math Club

f. Science Club

g. OSSM Regional Center

h. OSSM Main Campus

42. What is your mother's highest educational attainment?

Graduate School (Master's or Doctorate)

Bachelor's Degree

Associate's Degree

High School Diploma

Some High School

43. What is your father's highest educational attainment?

Graduate School (Master's or Doctorate)

Bachelor's Degree

Associate's Degree

High School Diploma

Some High School

44. Are one or both of your parents an engineer?

Mother

Father

Both

Neither

45. Are one or both of your parents a scientist/mathematician?

Mother

Father

Both

Neither

46. Which math classes did you take in high school (select all that apply)?

Calculus

Pre-Calculus

Algebra

Trigonometry

Geometry

47. Which science classes did you take in high school (select all that apply)?

Physics

Biology

Chemistry

48. In which category would you classify your current major?

Science

Technology

Engineering

Math

49. What is your gender?

Female

Male

50. What is your ethnicity?

African American

Asian

Caucasian

Hispanic

International Student

Native American

Fill in the Blank

51. How many hours a week did you study outside of class in high school?

52. How many hours per week do you expect to study outside of class in college?

53. What is your CWID?

Appendix B

RECRUITMENT SCRIPT

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: Social Support and Academic Preparation of Incoming STEM Students

INVESTIGATORS: Kathryn Weinland and Dr. Tami Moore, Oklahoma State University

Welcome to OSU! Please take a few moments to fill out this survey (hand participant the survey). This is not required and will have no effect on your enrollment or academic standing at OSU, and it is part of a research study at OSU. If you decide to fill it out, you will be able to return it after you enroll. All of the details and necessary information are included on the consent form. Please keep a copy of the consent form for yourself.

First Request E-Mail

To be sent Tuesday, September 6

Dear FIRST NAME,

I am sending this e-mail to request your participation in a web survey about students in STEM majors. You have received this e-mail because your institution has indicated that you are currently majoring in science, technology, engineering, and math.

This survey should take 15 minutes to complete.

Results from this survey will be used to see if relationships exist between pre-college characteristics and the choice of college major. Your answers are confidential and will only be reported as aggregate results not individually identifiable or identifiable by institution. While your participation is strictly voluntary, I hope you will be willing to share your experiences and thoughts. You will also be asked to include your e-mail address if you would like to be contacted for a possible focus group, but this is also completely voluntary.

If you have any questions about this study I can be reached at (405) 269-4441 or at kathryn.weinland @okstate.edu.

Please click on the following link into your web browser to participate in the web survey:

https://www.surveymonkey.com/s/STEMatOSU

I appreciate your time and thank you very much for participating in this study.

Sincerely,

Kathryn Weinland, Ph.D. Candidate

Educational Leadership and Policy Studies (HIED)

Oklahoma State University

Tami L. Moore, Ph.D.

Professor, Higher Education

Oklahoma State University

700 N. Greenwood Ave., Main Hall 2439, Tulsa, OK 74106

O: 918-594-8107

Tami.moore@okstate.edu

Appendix C

Second Request/Follow Up E-Mail

To be sent

Monday, September 12

Dear FIRST NAME,

Last week you should have received a request to participate in a web survey about STEM enrollment by e-mail. If you have already taken the time to complete the survey, thank you for participating.

If you have not had the opportunity to participate in the study, please consider doing so. This survey should take 15 minutes to complete. Results from this survey will be used to see if relationships exist between pre-college characteristics and the choice of college major. Your answers are confidential and will only be reported as aggregate results not individually identifiable or identifiable by institution. While your participation is strictly voluntary, I hope you will be willing to share your experiences and thoughts. You will also be asked to include your e-mail address if you would like to be contacted for a possible focus group, but this is also completely voluntary.

If you have any questions about this study I can be reached at (405) 269-4441 or at kathryn.weinland @okstate.edu.

Please click on the following link into your web browser to participate in the web survey:

https://www.surveymonkey.com/s/STEMatOSU

I appreciate your time and thank you very much for participating in this study.

Sincerely,

Kathryn Weinland, Ph.D. Candidate

Educational Leadership and Policy Studies (HIED)

Oklahoma State University

Tami L. Moore, Ph.D.

Professor, Higher Education

Oklahoma State University

700 N. Greenwood Ave., Main Hall 2439, Tulsa, OK 74106

O: 918-594-8107

Tami.moore@okstate.edu

Appendix D

Oklahoma State University Institutional Review Board

Date:	Thursday, September 01, 2011	Protocol Expires:	5/2/2012
IRB Application No:	ED11108		
Proposal Title:	Social Support and Academic Preparation of Incoming STEM Students		

Reviewed and Processed as: Expedited

Modification

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Kathryn Weinland
101 EN
Stillwater, OK 74077

Tami Moore
2439 Main Hall
Tulsa, OK 74106

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

The modification rquest to allow for on-line recruitment and completion of the survey by freshman students over the age of 18 is approved.

Signature :

Shelia Kennison, Chair, Institutional Review Board

Thursday, September 01, 2011
Date

VITA

Kathryn Ann Weinland

Candidate for the Degree of

Doctor of Philosophy

Thesis: HOW SOCIAL NETWORKS INFLUENCE FEMALE STUDENTS' CHOICES TO MAJOR IN ENGINEERING

Major Field: Educational Leadership and Policy Studies (HIED)

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Educational Leadership and Policy Studies (HIED) at Oklahoma State University, Stillwater, Oklahoma in May 2012.

Completed the requirements for the Master of Education in Higher Education in at the University of Arkansas, Fayetteville, AR in 2007.

Completed the requirements for the Bachelor of Arts in Psychology at Oklahoma State University, Stillwater, OK, in 2005.

Experience: Employed by Oklahoma State University College of Arts and Sciences, Department of Psychology, as a Teaching Associate, August 2011 to present; Employed by Oklahoma State University College of Engineering, Architecture and Technology, Department of CEAT Student Academic Serivces, as the Coordinator of Prospective Student Services, September 2008 to March 2012; Employed by Oklahoma State University, Department of Housing and Residential Life, as a Resident Director, July 2007 to September 2008; Employed by the University of Arkansas Honors College, as a Graduate Assistant for Honors College Recruitment, August 2005 to May 2007.

Professional Memberships: Association for the Study of Higher Education, WEPAN

Name: Kathryn Ann Weinland Date of Degree: May 2012

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: HOW SOCIAL NETWORKS INFLUENCE FEMALE STUDENTS' CHOICES TO MAJOR IN ENGINEERING

Pages in Study: 99 Candidate for the Degree of Doctor of Philosophy

Major Field: Educational Leadership and Policy Studies (HIED)

Scope and Method of Study: This study examined how social influence plays a part in female students' choices of college major, specifically engineering instead of science, technology, and math. Social influence may show itself through peers, family members, and teachers and may encompass resources under the umbrella of social capital. The purpose of this study was to examine how female students' social networks, through the lens of social capital, influence her major choice of whether or not to study engineering. The variables of peer influence, parental influence, teacher/counselor influence, perception of engineering, and academic background were addressed in a 52 question, Likert scale survey. This survey has been modified from an instrument previously used by Reyer (2007) at Bradley University. Data collection was completed using the Dillman (2009) tailored design model. Responses were grouped into four main scales of the dependent variables of social influence, encouragement, perceptions of engineering and career motivation. A factor analysis was completed on the four factors as a whole, and individual questions were not be analyzed.

Findings and Conclusions: This study addressed the differences in social network support for female freshmen majoring in engineering versus female freshmen majoring in science, technology, or math. Social network support, when working together from all angles of peers, teachers, parents, and teachers/counselors, transforms itself into a new force that is more powerful than the summation of the individual parts. Math and science preparation also contributed to female freshmen choosing to major in engineering instead of choosing to major in science, technology, or math. The STEM pipeline is still weak and ways in which to reinforce it should be examined. Social network support is crucial for female freshmen who are majoring in science, technology, engineering, and math.

ADVISER'S APPROVAL: Tami L. Moore