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# Exploring the Factors that Influence and Motivate Female Students to Enroll and Persist in Collegiate STEM Degree Programs: A Mixed Methods Study

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# Exploring the Factors that Influence and Motivate Female Students to Enroll and Persist in Collegiate STEM Degree Programs: A Mixed Methods Study

By

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Exploring the Factors that Influence and Motivate Female Students to Enroll and Persist in Collegiate STEM Degree Programs: A Mixed Methods Study

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Nationally, the need for an increase in interest, enrollment, and degrees awarded from science, technology, engineering and mathematics (STEM) degree programs continues to suffer. While students are enrolling in collegiate STEM degree programs, it is not occurring at a rate that meets the workforce demand. In addition to the concern that there is not a sufficient amount of collegiate STEM majors, there is a concern over too few females enrolling and persisting in collegiate STEM degree programs.

This mixed methods sequential exploratory research study considered the factors that influence and motivate undergraduate female students to enroll and persist in collegiate STEM degree programs. The research study was conducted in four phases. The first phase of the study focused on exploring the factors that influenced first-year female freshmen to enroll in a collegiate STEM degree program. Qualitative data were collected from undergraduate females enrolled in a STEM degree program. The second phase, instrument development, involved developing a survey instrument that consisted of 15 questions. The survey included a combination of (a) the Motivated Student Learning Questionnaire, (b) the questions developed from the findings from the qualitative phase, and (c) a demographic section. In the third phase of the research study, quantitative data collection, the survey instrument was administered to a sample of undergraduate female

STEM majors. The fourth phase integrated the findings from the qualitative and quantitative phases.

Five factors were considered as being significant to undergraduate female STEM majors when choosing a collegiate degree program: (a) helping others in their career, (b) having access to pre-collegiate STEM exposure, (c) obtaining information about STEM career pathways, (d) establishing relationships with influential stakeholders, and (e) developing confidence in math and science.  The findings from this study illustrate the role of K-12 STEM educators, pre-collegiate STEM outreach programs, and STEM education policymakers in influencing and motivating female students to enroll and persist in collegiate STEM degree programs.

# DEDICATION

For my parents who instilled in me the value of education and encouraged me to reach for the stars. –Red

“When mother-cow is chewing grass its young ones watch its mouth.”

— Chinua Achebe, *Things Fall Apart*

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"If you want to go quickly, go alone.  If you want to go far, then go to together."

-African Proverb

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# CHAPTER 1: INTRODUCTION

## Introduction to the Research Study

Declining student interest in collegiate science, technology, engineering, and mathematics (STEM) degree programs is a nationwide concern. The American College Testing (ACT) organization reported that " from the 2010–2012 national ACT-tested graduating classes (N = 1,167,221), just over 1 in 10 graduates indicated interest in a STEM major or occupation" (American College Testing, 2013, p. 19). The U.S. Department of Commerce (2011) estimated that STEM careers would grow 17 percent by 2018, which is nearly double the growth for non-STEM fields. It is projected that by 2018, the U.S. will have more than 1.2 million unfilled STEM jobs because there will not be enough qualified workers to fill them (U.S. Department of Commerce, 2011). Of particular concern are the low numbers of females entering the STEM workforce. An insufficient number of females graduating from collegiate STEM degree programs results in workforce demands for diversity not being met, as more than half of all bachelor's degree graduates are female. This study aimed to explore the factors that influence and motivate female students to enroll and persist in collegiate STEM programs. The results of the study suggest that by providing increased access to pre-collegiate STEM activities, instilling confidence in female students, and establishing student and industry-based mentoring programs so that students can learn about STEM career pathways, more female students will enroll and persist in collegiate STEM degree programs.

## Background

**National STEM concern.** Federal, state and local organizations have dedicated significant resources to addressing the national STEM crisis. In 2007, the Committee on Science, Engineering, and Public Policy reported on the state of STEM education in the United States, expressing the urgency in addressing this issue as "the domestic and world economics depends more and more on science and engineering. But our primary and secondary schools do not seem able to produce enough students with the interest, motivation, knowledge, and skills they will need to compete and prosper in the emerging world" (p. 94). In 2010, President Obama hosted a White House Science Fair celebrating the winners of a broad range of STEM program competitions. The science fair was a testament to the impact that can be realized when young people take an interest in the sciences. The science fair was hosted in support of President Obama's November 2009 initiative, *Educate to Innovate*, which strove to move American students to top rankings in math and science achievement by 2020 (The White House, 2010).

> President Obama has identified STEM education as necessary for laying the new foundation for America's future prosperity. Presidential leadership on the issue has already made a difference. The President made STEM education a priority as part of the Administration's $4 billion Race to the Top (RTT) competition. States were encouraged to develop a comprehensive strategy to improve achievement in STEM subjects, to partner with local institutions, and to broaden participation of women and underrepresented minorities. As a result, the winning states are undertaking decisive actions to embed improvements in STEM education into their overall educational plans (The White House Press Secretary, October 2010).

**STEM focus**. The focus on STEM education began in 1802 with the establishment of the United States Military Academy at West Point, which was done in response to the national demand for qualified engineers to build infrastructure and to provide the workforce with qualified designers of railroads, bridges, and roads (Jolly, 2009). More than a half-century later, in 1862, the Morrill Act was enacted to provide support to colleges and universities with academic programs in agriculture, mechanical arts, science, and engineering programs (Jolly, 2009). When the Soviet satellite, Sputnik, was launched in 1957, the United States began to invest more time and funding in the sciences (Jolly, 2009). The National Defense Education Act was established in 1958 in response to the need for the United States to compete globally in the sciences (Jolly, 2009). As a result, the federal government dedicated one billion dollars over the next four years in support of STEM education reform. The focus on STEM education continues to grow from the fear that China and India will pass the United States in the global economy, as they excel in these academic disciplines.

**STEM industry projections.** In January 2010, the Department of Defense called attention to the consistent decline in the number of college graduates with degrees from STEM programs (Jolly, 2009). The national decline in the number of students entering STEM fields significantly affects many influential companies and government agencies. If the United States is going to meet the industry demand for more qualified graduates from collegiate STEM programs, there needs to be increased numbers of female students enrolling, persisting and graduating from these degree programs (Hill, Corbett, & Rose, 2010). However, the National Science Board (2004) reported that the number of females enrolling in STEM collegiate programs significantly decreased between 1993 and 1999. Furthermore, according to the National Science Foundation's 2010 Science and Engineering Indicators, despite the increase in the number of females earning bachelor's degrees, the share of bachelor's degrees earned by females in computer sciences, mathematics, and engineering declined during this time.

In 2010, the National Science Foundation's Science and Engineering Indicators reported that females earned an average of 58% of all bachelor's degrees awarded since 2002. Although females have earned about half of all science and engineering bachelor's degrees since 2000, variations persist among academic majors (i.e., engineering, computer science, psychology) (National Science Foundation's Science and Engineering Indicators, 2010). On the other hand, in 2007, men earned the majority of bachelor's degrees awarded in engineering, computer sciences, and physics (81%, 81%, and 79%, respectively), as reported by the National Science Foundation's Science and Engineering Indicators (2010). The only STEM areas where females earned 50% or more of bachelor's degrees awarded were in biological sciences (60%), agricultural sciences (50%), and chemistry (50%) (National Science Foundation's Science and Engineering Indicators, 2010).

## Purpose Statement

The purpose of this sequential exploratory mixed methods research study was to identify the factors that influence and motivate female students to enroll and persist in collegiate STEM programs.

**Method overview.** The data collection involved four phases, beginning with a qualitative exploration of pre-collegiate math and science experiences of first-year female collegiate freshmen who declared themselves to be a STEM major. The next phase involved the development of an instrument designed to measure the factors that influence female students to enroll and persist in collegiate STEM degree programs. In the third phase of the research study, this instrument was administered to undergraduate female STEM majors. The research design concluded with a fourth phase, synthesis, where the qualitative and quantitative results were integrated and the results were disseminated.

**Significance of the Research**

This research study informs STEM education policy, addressing the national concern over too few females enrolling and persisting in collegiate STEM degree programs. The findings from this research illustrate: (a) the importance of pre-collegiate STEM exposure, (b) the impact of informal and formal STEM experiences, and (c) the influence of internal and external motivators on female enrollment and persistence in collegiate STEM programs.

**Audiences That Will Benefit**

The findings from this research study are of interest to STEM educators and policymakers at the local and national levels. The results provide STEM educators with a greater understanding of the factors that affect a female student in her decision to enroll in a STEM program. The findings from this study address the call from federal agencies such as the National Science Foundation and U.S. Department of Education to increase the number of females enrolling in collegiate STEM programs.

**Research Questions**

The research study consisted of one primary question and 12 sub-questions. The primary question was: What are the factors that influence and motivate female students to enroll and persist in collegiate STEM programs? The additional questions developed for this study are given below.

**Phase I: Qualitative Research Questions**

1) Which pre-collegiate experiences influenced females to enroll in a collegiate STEM degree program?
2) Which stakeholders influence collegiate females in their decision-making process?
3) Does entering a career that helps others matter to female students?
4) How can confidence be instilled in females so that they can persist in collegiate STEM programs?
5) What can educators do to recruit more females to STEM degree programs?

**Phase III: Quantitative Research Questions**

1) What are the primary influences for female students to enroll in collegiate STEM degree programs?
2) Do females enrolled in a collegiate STEM degree program report high levels of self-confidence as it relates to their expected success in the degree program?
3) What are the primary influences that keep female students motivated in a collegiate STEM degree program?
4) What is the primary factor that influences female students in their decision to enroll in a collegiate STEM degree program?
5) Does it matter to females enrolled in a STEM degree program if they are making a difference in the lives of others?
6) Are grades of greater importance to females than their male peers?

**Phase IV: Synthesis Mixed Methods Research Question**

In what ways do the quantitative results support the qualitative findings and the qualitative findings support the quantitative results?

**Definition of Terms**

The following definitions are applicable to this study:

*Collegiate***.** Post-K-12 education.

*First-Year Freshman Student***.** "A student attending any institution for the first time at the undergraduate level. Includes students enrolled in the fall term who attended college for the first time in the prior summer term. Also includes students who entered with advanced standing (college credits earned before graduation from high school)" (Common Data Set Initiative, 2010).

*First-Generation College Student***.** Undergraduates whose parents never enrolled in postsecondary education (National Center for Education Statistics, 1998).

*Midwestern University***.** The location for the first phase of research was conducted at a public university that is classified by the Carnegie Foundation as a Research University with very high research activity; it is a land-grant university and a member of the Association of Public and Land-grant Universities.

*STEM Pipeline Program***.** A pre-collegiate program that is designed to expose and engage students to the fields of science, technology, engineering or mathematics.

*Pre-collegiate***.** Occurring before college, i.e., K-12 education.

*Pre-collegiate STEM activities.* Activities that are described as after-school classes, multi-day STEM programs, STEM hobbies, working in a STEM environment, math- and science-focused extra-curricular programs, field trips, etc. (Fantz et al., 2011).

*Pre-engineering and technology programs.* A K-12 curriculum program that focuses on engineering and technology. Project Lead the Way's Pathway To Engineering is an example of a pre-engineering and technology program.

*Project Lead The Way (PLTW).* PLTW is the nation's leading provider of rigorous and innovative Science, Technology, Engineering, and Mathematics (STEM) curriculum programs that are delivered to elementary, middle and high school students. Students create, design, build, discover, collaborate and solve problems while applying what they learn in math and science (Project Lead The Way, 2013).

*Self-efficacy.* The belief and thoughts held by an individual about his/her ability to attain a goal and succeed (Hutchison et al., 2006).

*STEM.* An acronym that stands for the fields of study in science, technology, engineering, and mathematics.

*STEM field.* Some federal agencies, such as the NSF, use a broader definition of STEM that includes psychology and the social sciences (e.g., political science, economics) as well as the so-called core sciences and engineering (e.g., physics, chemistry, mathematics). Seven others, including the Department of Homeland Security and the U.S. Immigration and Customs Enforcement, use a narrower definition that generally excludes social sciences and focuses on mathematics, chemistry, physics, computer and information sciences, and engineering. Some analysts argue that field-specific definitions such as these are too static and that definitions of STEM should be interdisciplinary (America COMPETES Reauthorization Act of 2010; U.S. Department of Homeland Security, Immigration and Customs and Enforcement, 2012; Moon & Singer, 2012). The following science, technology, engineering, and mathematics programs were included in this research study: Actuarial Science, Agricultural Engineering, Animal Science, Architectural Engineering, Biochemistry, Biological Sciences, Biological Systems Engineering, Chemical Engineering, Chemistry, Civil Engineering, Computer Engineering, Computer Science, Construction Engineering, Construction Management, Electrical Engineering, Electronics Engineering, Industrial Engineering, Industrial and Management Systems Engineering, Mathematics, Mechanical Engineering, Physical Science, Physics, and Water Science.

***STEM major.*** An undergraduate student who has declared an academic major (first or second major) in a STEM field (Chen & Weko, 2009).

***Socioeconomic status (SES).*** Socioeconomic status is often measured as a combination of education, income, and occupation. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power, and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. SES is relevant to all realms of behavioral and social science, including research, practice, education, and advocacy (American Psychological Association, 2013).

**Limitations and Advantages**

The limitations and advantages of the study include the following:

1. Purposeful sampling was used in both the qualitative and quantitative phases of the study; participants were intentionally selected based on their gender, declared major, and academic year of study. This approach ensured that there was a balance of group sizes when multiple groups are to be selected (Black, 1999).
2. Qualitative research allows the opportunity for varying interpretations of the data, and hence findings from Phase I may be interpreted differently by readers.
3. The author serves in an administrative capacity in the engineering college at the research location, so investigator bias may affect the analysis of the findings.
4. The research study was limited to undergraduate female students who have self-declared as a STEM academic major.
5. The participant pool of first-year female freshmen and upperclassmen came from a Midwestern university, which may limit generalizability.
6. The participant pool of first-year female freshmen and upperclassmen came from an institution that the Carnegie Foundation describes as within the "Research Universities (very high research activity)" category. Typically, research institutions are the leading producers of science and engineering degrees at the bachelor's, master's and doctoral levels (National Science Foundation, 2012).
7. There was no control group against which to compare the findings. The data collected represent only the voices and experiences of undergraduate females

enrolled in collegiate STEM degree programs at the Midwestern university.

8. There were small sample sizes in the collection of both qualitative and quantitative data.
9. There were insufficient data to conduct a large-scale statistical analysis.

# CHAPTER 2: REVIEW OF LITERATURE

## Purpose

The following chapter is structured to provide an analysis of selected research studies that highlight the findings deemed the most influential factors in female students' decisions to enroll in and persist through a collegiate STEM degree program. This chapter is structured as follows. A report on females enrolled in collegiate STEM programs is provided. Next, two characteristics, confidence and persistence, are explored as an attempt to understand why females are not enrolling in collegiate STEM programs at the same rate as their male peers. Third, there is a discussion of the role of pre-collegiate STEM experiences in female enrollment in STEM degree programs. The chapter concludes with a discussion of what was learned from the literature and what still needs to be addressed relative to the enrollment and persistence of females in collegiate STEM programs.

## Literature Themes

**Enrollment trends**. In 2012, Siebens and Ryan reported that according to the 2009 U.S. Department of Commerce Economics and Statistics Administration Census report, more than half of college graduates are female (54.7%). However, females are earning less than 15% of the collegiate degrees in STEM programs while their male peers are earning 87% of collegiate STEM degrees (Siebens & Ryan, 2012). In 2011, the U.S. Department of Education reported that since 1998 the number of females enrolling in higher education has exceeded the number of males. Despite the increased enrollment of females in collegiate degree programs, male enrollment in STEM programs continues to surpass female enrollment.

Does it matter if there are females enrolled in collegiate STEM programs? Increasing diversity in STEM fields provides for more voices to be heard, addresses the concerns of social equity, increases innovation and competiveness, and helps address the industry concern that there are too few qualified individuals in the STEM workforce (Espinosa, 2011; Hill, Corbett, & Rose, 2010; Leslie, McClure, & Oaxaca, 1998). The literature highlighted two main issues that should be considered in the discussion as to why it matters that females are not enrolling in collegiate STEM programs.

The first issue discussed in the literature emphasizes the need to prepare more students for the global economy. There is a national interest in remedying the fact that there are too few college graduates entering the STEM workforce. With the exception of computer science, most science and engineering fields have experienced an increase in the number of bachelor’s degrees awarded (National Science Foundation, 2012). While students are enrolling in collegiate STEM degree programs, it is not occurring at a rate that meets the workforce demand. The Bureau of Labor Statistics occupational projections for 2006-2016 indicated that enrollment in science and engineering fields would need to more than double to meet occupational demands (National Science Foundation, 2010). Equally important, Dave et al. (2012) reported that the predicted growth of STEM fields will exceed that of the available qualified workforce. Hill et al. (2010) echoed the report researched by Dave et al. (2012) by stating, “...expanding and developing the STEM workforce is a critical issue for government, industry leaders, and educators" (p. 2). Consequently, the 2007 U.S. Department of Labor report stated that STEM "…fields have become increasingly central to U.S. economic competitiveness and growth" (p. 1). A proposed solution for addressing the issue of too few qualified workers is to engage females, as they are an underrepresented population in STEM fields and they are enrolling in collegiate degree programs at greater percentages than their male peers (Dave et al., 2012).

The second concern over too few females in the STEM workforce focused on the need for diverse opinions to be heard in the STEM fields. Hill et al. (2010) wrote that "attracting and retaining more women in the STEM workforce will maximize innovation, creativity, and competitiveness…. [Additionally] with a more diverse workforce, scientific and technological products, services, and solutions are likely to be better designed and more likely to represent all users" (p. 3). Espinosa (2011) reiterated the call for wide-ranging voices mirrored by Hill et al. (2010) by stating that there "…is the need for diverse experiences and perspectives…which speaks to a scientific community in search of broad-based solutions to an array of global-health-care, environmental, and infrastructure challenges" (p. 211).

In a related study, Hall (2011) sought to address the percentage decline in the number of STEM degrees awarded, reporting that "while the actual enrollment in STEM degree fields increased from 519,000 students in 1994-1995 to 578, 000 students in 2003-2004, the proportion of undergraduate degrees awarded in STEM fields actually declined from 32% to 27% of all degrees awarded" (p. 32).

These data led Hall (2011) to query why this was happening and how it could be addressed. In a quantitative research study, the researcher set out to determine the factors that were influential in developing an interest in STEM careers among secondary school students. The research study drew from rural schools in the southeast involving four different populations: (a) high school students, (b) parents of high school students, (c) high school personnel (teachers and counselors), and (d) college students. The high school students, who ranged in age from 12 to 18 years old (N = 118), were provided a two-part questionnaire. The two-part questionnaire included a section that asked students to rate 10 specific influences (friends, peers, parents, teachers, counselors, the media, degree options, earning potential, and affordability of college program) on their career consideration. The second part of the questionnaire asked students to rate the importance of four factors (having friends with the same interest, someone in their family who is working in a particular field, a teacher who encouraged them, someone at their school with knowledge of career options) in developing their current career interests. The parents (N = 184) were asked to complete a survey regarding the aspirations they held for their sons and/or daughters. High school teachers and counselors (N = 13) completed a survey regarding their knowledge of careers in STEM. Lastly, the college student participants (N = 83) were asked to complete the same survey that the high school students completed with the addition of one question: “When did you decide on engineering as your career choice?” (Hall, 2011, p. 36).

The findings from this study provided educators with two practical recommendations on how to increase student interest in STEM programs. Hall (2011) called for providing students with knowledge about STEM fields and STEM career pathways. In his research, Hall (2011) found that high school students rated their interest in a field as the most important factor in choosing a career and parental influence as the second most important factor. All of the parents who participated in the study indicated that they wanted their son and/or daughter to obtain an advanced degree. Shockingly, of the high school teachers surveyed, the majority of whom were teaching math and science, more than half (62.5%) did not believe they were knowledgeable about career options in engineering and technology. The findings from the college student survey were similar to the findings from the high school student survey, in that interest in the field was influential in collegiate major choice and career decision, followed by parental influence. Hall (2011) found that high school students were most influenced by personal interest in a field when choosing a career path.

Hall (2011) recommended that more resources be dedicated to pre-collegiate STEM opportunities that bridge the study of math and science and actual careers in STEM fields (e.g., working as a civil engineer, biochemist, or statistician). It was disconcerting to learn that more than half of the math and science teachers surveyed did not think they were knowledgeable about career paths for students interested in STEM fields. This finding was attributed to the location of the research study, as it was a rural area and in a lower socio-economic status community.

In 1992, Blank and Engler wanted to know how STEM education in the United States had improved since the release of the "A Nation at Risk: The Imperative For Educational Reform" in 1983. The 1983 report examined the quality of education in the

United States, calling attention to the concern that American schools were failing. A little over ten years later, Blank & Engler (1992) wanted to know if STEM education had improved by asking the questions: (1) are students receiving more instruction in science and math?; (2) has the supply of qualified mathematics and science teachers improved?; and (3) are more students learning more science and mathematics in the classroom? The researchers addressed these questions by reviewing data obtained from the National Center for Education Statistics, the National Assessment of Educational Progress (NAEP), the Council of Chief State School Officers' State Indicators of Science and Mathematics Education, and the National Center for Education Statistics Schools and Staffing Survey. In their review of data, the researchers found that (1) the number of students enrolling in science and mathematics courses at the high school level had increased; (2) students were scoring higher on the NAEP science and mathematics assessments, but students in the U.S. continued to score below the level of proficiency in mathematics for their age and grade level; and (3) most states were not experiencing a shortage in the number of science and mathematics teachers; however, it was not clear if the current teachers were qualified to teach in these areas (Blank & Engler, 1992).

Almost ten years later, NAEP released 2011 data as it relates to (a) student performance in mathematics and science, (b) student enrollment in advanced mathematics and science course, and (c) qualified teachers in the classrooms. According to NAEP, fourth and eighth graders have shown improvement in mathematics scores. From 1990 to 2011, the average fourth grader's NAEP mathematics score increased by 28 points, from 213 to 241 (mathematics scale ranges from 0–500). During that same period, the average eighth grader's score increased by 21 points, from 263 to 284 (mathematics scale ranges from 0–500). In 2009, the twelfth grade mathematics score was three points higher than in 2005 (U.S. Department of Education, National Center for Education Statistics - Mathematics Performance, 2013). Furthermore, in 2011 the performance scores for fourth graders in the United States ranked in the top 15 in mathematics and in the top 10 in science among the education systems. Similarly, for eighth graders, math performance scores in the United States ranked in the top 24 and science performance scores ranked in the top 23 among the education systems (U.S. Department of Education, National Center for Education Statistics – International Assessments, 2013).

The trend in U.S. high school students taking advanced mathematics and science course shows an increase between 1990 and 2009. Overall, the percentage of students who have completed mathematics courses in Algebra I, Geometry, Algebra II/Trigonometry, Analysis/PreCalculus, Statistics/Probability, and Calculus had increased. Specifically, between 1990 and 2009, the percentage of high school graduates who had completed calculus more than doubled (7% to 16%), and almost 25% more students completed algebra II/trigonometry (U.S. Department of Education, National Center for Education Statistics –High School Course Taking, 2013). Moreover, approximately 20% more high school graduates had taken science courses in chemistry and physics, and about 10% more graduates earned at least one credit in biology, chemistry, and physics in 2009 than in 1990 trigonometry (U.S. Department of Education, National Center for Education Statistics –High School Course Taking, 2013). The factors that are contributing to increased student interest and performance in science and mathematics were not addressed.

In 1992, Blank and Engler reported that 42% of all mathematics high school teachers and 54% of all science high school teachers had a collegiate degree in their respective teaching assignment. In contrast, the 2007-2008 Schools and Staffing Survey (SASS) reported a decrease in teacher qualifications during this period. The SASS reports the qualifications of high schools teachers in their teaching assignments by asking high school teachers (a) if they are certified in their teaching assignment, and (b) what their major was in college. It was found that 12% of teachers whose subject assignment was secondary mathematics and four percent of science teachers had neither a major nor a certification in the subject. There is an apparent decrease in the percentage of qualified teachers teaching in their assigned areas.

Along these lines, Lyons, Jafri and St. Louis (2012) conducted an assessment of a pathway program that has successfully increased student enrollment and persistence in collegiate STEM programs. The researchers called for educators and policymakers to move away from the STEM pipeline theory as this approach has led to a “leaky pipeline.” The STEM pipeline theory advocates for access to a high quality K-12 STEM education program that begins in elementary school, feeds to middle school, carries into high school and continues to enrollment in and graduation from a collegiate STEM program. The pipeline model, according to Lyons et al. (2012), has resulted in underrepresented students such as females being left behind, as there is not always consistent access to these programs. The researchers defined underrepresented students in the sciences as

"…students of color, girls, students from low socioeconomic backgrounds and from under-resourced schools, and those who struggle academically" (Lyons et al., 2012, p. 2). Lyons et al. (2012) called for the purposeful development of programs and policies to address the issues faced by students who are underrepresented in STEM disciplines. The researchers recommended programs like the Chicago-based Project Exploration's Youth-Science Pathways as an example of an effective youth development and science education program that focuses more on overall student development than on a single pathway.

Since its inception in 1999, 1200 students have participated in Project Exploration's programs. In 2009, Project Exploration launched an online survey and hosted in-depth interviews with its alumni to gather data on alumni interest and participation in science educational and career endeavors. The researchers found that participants in the Project Exploration programs were more likely to graduate from high school, go to college, and major in science as compared to their peers. Additionally, the researchers reported that 60% of alumni were enrolled in a four-year collegiate STEM degree program and 60% of alumni who graduated from college had a degree in a STEM-related field (Lyons et al., 2012). Program alumni noted in the interviews that they benefited from having someone know their name, participating in a program that never ended, learning how to write, and being recognized for their adventures and accomplishments in STEM. The Youth-Science Pathways program differs from other STEM-focused programs as it focuses on integrating STEM experiences into students' academic, social and emotional development instead of emphasizing a career in STEM as the outcome. The program's framework focuses on three learning strands: Explore (students participate in an in-depth investigation of a discipline), Pursue (students focus on STEM skill-building through internships and leaderships roles), and Discover (youth development and identity building), as well as 14 competencies that span youth development and STEM inquiry by integrating science process skills and youth development assets (Lyons et al., 2012). The competencies include: building models, understanding math, building scientific knowledge, investigating, understanding science as a social endeavor, observing, reflecting, collaborating, taking initiative, being curious, communicating, being part of a community, developing leadership, and developing self-identity (Lyons et al., 2012, p.7). The researchers concluded by advocating for educators and policymakers to implement pathway programs that focus on developing the whole student and integrating STEM education and activities into this process.

**Possible Factors in Low Female Enrollment in STEM**

Past research has suggested that males and females have the capacity to compete at the same level in math and science in elementary and middle school, but when they enroll in more advanced courses, females do not succeed or persist at the same rates as their male peers. In the previously discussed research study conducted by Leslie et al. (1998) that involved a review of data from the 1971 and 1980 Cooperative Institution Program, the researchers found that females begin to experience decreasing levels of confidence as they progress to advanced courses in math and science. In one research study conducted by Multon, Brown and Lent (1991), the researchers conducted a meta-analysis on the relationship of self-efficacy beliefs and academic performance and persistence. The researchers sought to complete an extensive analysis of past research that relates to self-efficacy beliefs and their relationship to academic performance and persistence outcomes, and to use quantitative research methods to demonstrate the relationship among these factors. For this study, the researchers chose studies that had (a) measured for self-efficacy, (b) measured for academic performance or persistence, and (c) included sufficient information to calculate appropriate effect size estimates. After an initial review of 68 papers, the researchers ended up with a sample size of less than half ($N = 39$). The researchers concluded that there was a "…positive and statistically significant relationship among self-efficacy beliefs and academic performance and persistence outcomes across a wide variety of subjects" (Multon et al., 1991, p. 30). The following section discusses self-confidence as it affects female enrollment and persistence in collegiate STEM programs.

**Female confidence in math and science.** Confidence is a key predictor of success of female students in science, technology, engineering, and mathematics classrooms. Numerous studies have shown that women tend to drop out of STEM classes not because of low grades, but because of a lack of confidence. Female students often believe that they are not performing as well in class as their male peers, even when their grades demonstrate otherwise.

Researchers continue to explore why females are not enrolling in collegiate STEM programs at the same rate as their male peers. Past research has attributed the low enrollment numbers to a number of factors: (a) a lack of female students' understanding of the career opportunities available to them, (b) a misunderstanding of what STEM education is, (c) a lack of female mentoring opportunities, (d) low numbers of females teaching advanced math and science courses, (e) females' perception of their ability to succeed in math and science, (f) personal feelings of intimidation surrounding advanced math and science requirements, and (g) a loss in confidence in excelling at math and science (Dave et al., 2012; Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2006; Rinn, McQueen, Clark & Rumsey, 2008).

In a related study that looked at confidence through the lens of self-concept, Rinn et al. (2008) questioned why there continues to be a growing gender gap in collegiate STEM programs as it relates to an individual's self-concept. Past research has concluded that elementary and secondary school males and females are succeeding at math and science at the same level. In spite of this, females are not persisting at the same rates and, as a result, they are not enrolling in collegiate STEM degree programs. The researchers used the Internal/External Frame of Reference Model, a tool for illustrating how an individual's math and verbal concepts operate, to explain gender differences in math and verbal achievement and to address the question of why females are failing to enroll in and persist through collegiate STEM degree programs. The research study involved seventh through tenth graders who had attended a gifted student summer camp ($N = 181$). The researchers assessed the participants' math and verbal achievements by using their SAT/ACT scores, and they administered the Self Description Questionnaire II that measures self-concept. It was found that females scored significantly higher than males on verbal achievement and self-concept. Unexpectedly, it was found that there were no differences between gender groups in math achievement and self-concept. In summary, there was no difference found among males and females in how they develop their math and verbal self-concepts. If females and males understand math concepts in the same way, why are they not experiencing the same level of confidence? Rinn et al. (2008) did not address this question, but concluded with a call for additional research in this area so that the question of why females fail to enter STEM fields at rates consistent with their abilities and male peers can be addressed.

In a study conducted by Gilligan et al. (1991, 1994), the researchers explored the results from a national self-esteem survey ($N$ = 3,000), "Shortchanging Girls, Shortchanging America," that was conducted by the American Association of University Women. The 92-item self-esteem survey administered to female and male students in fourth through tenth grade was structured so that it had three foci. The first focus was on the examination of the differences held by females and males in their perception of themselves and their futures. The second focus was on how career and future aspirations are developed and if these aspirations differ according to gender. The third focus of the survey was on the relationship of math and science skills to self-esteem and career goals as related to females and males. In addition to the three foci mentioned, the survey captured data on the participants' attitudes about school, personal self-esteem, gender roles, classroom experiences, and career aspirations (Gilligan et al., 1991, 1994).

Gilligan et al. (1991, 1994) reported a gender gap that occurs with females as they get older as it relates to (a) perception of math and science, and (b) self-esteem. The researchers found that in elementary school, 81% of girls "like math;" this number decreased to 68% in middle school and 61% in high school. For boys, 84% reported liking math in elementary school, 68% in middle school, and 72% in high school. Both genders experienced a decrease in their affinity for math; however, females declined by a larger percentage. When girls and boys were asked if they were good at math, “half of all elementary school boys, but only one-third of all elementary school girls, say they are good at math” (Gilligan et al., 1991, 1994, p. 11), concluding that by high school 25% of males and 14% of females reported that they were good at math. The researchers stated that “…girls’ perceptions of their ability in math and science had the strongest relationship to their self-esteem; as girls “learn” that they are not good at these subjects, their sense of self-worth and aspirations for themselves deteriorate” (Gilligan et al., 1991, 1994, p. 10). Additionally, it was found that there is a gender gap in self-esteem that increased with age, that declining self-esteem influenced career choices, that female confidence in math and science was a determinant of female students’ likelihood to persist and stay motivated in STEM majors, and that family and school had the greatest impact on adolescent self-esteem.

Given these findings, the researchers called for schools to change how they relate to girls in the classroom by initiating conversations with the girls to make them feel more important, providing students better opportunities for active learning, giving girls detailed instructions for tasks and allowing them to work independently, providing praise to girls for the quality and intellect of their work, and proactively encouraging females to pursue careers in STEM (Gilligan et al., 1991, 1994).

Researchers have further drilled down the concept of confidence in order to look at the role of self-efficacy in persistence and success in collegiate STEM majors in females. Self-efficacy is a social cognitive theory that is context-specific and can be used as a gauge for testing for competence and to determine if an individual will persist in and succeed at a given goal (Bandura, 1977). Self-efficacy has been used as a hypothesis for testing and understanding why there continues to be a low enrollment of females in academic majors that are perceived as male-dominated (Pajares & Miller, 1994; Zeldin et al., 2008). The social learning theorist credited with defining self-efficacy and its role in motivation is Albert Bandura (1977). Bandura described the relationship among self-efficacy and motivation as "…how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (Bandura, 1977, p. 191). Current research relies on the theory of self-efficacy to try to understand why females are less likely to persist in the face of obstacles and aversions when it comes to math and science.

In one study, Pajares and Miller (1994) tested for the role of self-efficacy and self-concept beliefs in mathematics problem-solving as it relates to gender. Path analysis, a statistical method of finding cause and effect, was used by the researchers to test for the role of self-efficacy in mathematics. The researchers considered:

> Whether the confidence with which students [$N = 350$] approach the solving of math problems had stronger direct effects on their problem-solving performance than did math self-concept, math anxiety, perceived usefulness of mathematics, prior experience with mathematics, and gender…[additionally, the researchers tested]…whether self-efficacy mediate[s] the effect of gender and prior experience on both the common mechanics and problem solving performance. (Pajares & Miller, 1994, p. 193)

The researchers concluded that "…. men and women differed in performance, self-efficacy, and self-concept…these differences were mediated by differences in the students' self-efficacy perceptions" (Pajares and Miller, 1994, p. 200). The researchers found that how well a student thinks he or she can perform on a test influences how well he or she will actually do, so "…the poorer performance and lower self-concept of the female students were largely due to lower judgments of their capability" (Pajares and Miller, 1994, p. 200). It was found that males experienced higher levels of performance self-efficacy and self-concept but lower levels of anxiety. How are males developing higher levels of self-efficacy and self-concept and lower levels of anxiety and females are not? Pajares and Miller (1994) did not provide the reader with an answer as to why differences exist in the levels of anxiety experienced by males or females. Aside from recommending that teachers assess students' self-efficacy to gain additional insight into student performance, and researchers determine how students develop inaccurate self-efficacy, the researchers did not share any recommendations for closing the gender gap so that females can compete in the STEM fields at the same level as their male peers. The following research study will explore the factors that influence and motivate females to persist in STEM degree programs despite these obstacles.

In a similar study, Leslie et al. (1998) sought to address the national concern over the underrepresentation of females in science and engineering. In this study, the researchers looked at results from the 1971 and 1980 Cooperative Institutional Research Program files. The program collected data on students from their pre-college years through graduate education and employment. The researchers also reviewed the National

Longitudinal Survey of Youth that included interviews from individuals ranging in ages from 14 to 22 (N = 9,628). The researchers focused on three concepts: (a) self-concept/self-efficacy, (b) peer influence, and (c) goal commitment to explain the underrepresentation of women in STEM programs. The first concept, self-concept/self-efficacy, was defined as the result of female students' success in math and science in middle and secondary school as well as parental influence. The lower levels of confidence in math and science experienced by females as they progress into advanced levels of these courses results in a decreased likelihood of females persisting in collegiate STEM programs; however, the researchers noted that having a parent who has a career in a STEM field could positively influence the self-concept/self-efficacy held by female students (Leslie et al., 1998).

The second concept, peer influence, was considered one of the most influential factors for why secondary school females lose confidence in math and science. Secondary school is a time where females experience "…[a lack of] confidence, low self-esteem, timidity and tentativeness…. in regard to science and mathematics, as is the perception on the part of girls that boys are more able in math and science than they are" (Leslie et al., 1998, p. 262). Unfortunately, the study did not specifically address the factors that cause a reduction in female students' confidence in math and science.

The third concept, goal commitment, is the by-product of decreased levels of self-efficacy and peer influence. As expected, as females feel less self-confident in math and science and begin to think that their male peers are naturally better at STEM-related academic subjects, they are less likely to commit themselves to a collegiate STEM degree goal because they do not want to fail.

Leslie et al. (1998) concluded with three recommendations for how to increase female enrollment in and persistence through collegiate STEM degree programs. The researchers advised educators to implement early intervention programs in middle and secondary school as an effective means for increasing female enrollment in collegiate STEM programs, to offer challenging opportunities in math and science for females in secondary school, and to provide students at the collegiate level with stronger support systems so that they can persist despite challenges faced.

**Female persistence in collegiate STEM programs.** A number of studies have focused on factors related to female students' persistence in a collegiate STEM degree program. As previously reported, past researchers have demonstrated that male and female performance in math and science is equal until more advanced courses are introduced. As females enroll in more advanced courses, their confidence in their academic abilities drops markedly, as does their subsequent enrollment in these courses. The drop in enrollment was found to be most severe in female students as they transition from elementary to high school, as their confidence in math and science declined (Gilligan et al., 1991, 1994; Blank & Engler, 1992; Rittmayer & Beier, 2008). If female students are at the same level as their male peers up until the introduction of advanced courses, what is affecting their ability to persist? In one report on females in STEM, conducted by Rittmayer and Beier (2008), the researchers explained that females and males perceive success in different ways. A female student receiving a B score on a math exam may view this as a poor grade and her lack of ability to succeed in math. In contrast, her male peer may view receiving a C on the same exam as a success that validates his ability to succeed at math. The confidence gap among female and male students has resulted in a decline in females persisting in STEM fields. The researchers concluded that developing curriculum programs (e.g., laboratory work, experiments, design projects, and after school programs) and grading systems that better meet the personal needs of female students may address the confidence gap experienced by female students when it comes to STEM fields, resulting in increased collegiate enrollment in those programs.

Past studies on the topic of persistence concluded that self-efficacy was an influential factor in female students' success in STEM programs and that females with high self-efficacy demonstrated coping skills, commitment, and mental preparedness. Similarly, females with high self-efficacy were more likely to persist in an academic major or career choice than females with lower self-efficacy, as they had a strong belief in their ability to perform. These studies further demonstrated that self-efficacy contributed to increasing a female student's likelihood of persisting in situations where her academic abilities were challenged (Leslie et al., 1998; MacGuire & Halpin, 1995; Rittmayer & Beier, 2008; Hutchison et al., 2006). In MacGuire and Halpin's (1995) qualitative study, the researchers looked at undergraduate student retention in colleges of engineering. The researchers interviewed 24 undergraduate students to find out why they persisted or did not persist as engineering majors. Those students who had decided to switch majors stated that they faced difficulty in the major, did not have strong study or coping skills, and did not fully understand what type of career opportunities were available to them. The students who indicated that they planned to persist as engineering majors said they were determined, displayed strong coping skills, and felt mentally prepared to be successful. MacGuire and Halpin (1995) concluded that more students might persist in collegiate STEM programs if higher education institutions developed better retention programs that mentally prepared students for the rigorous nature of STEM programs.

In a related study, it was found that females were more likely to enroll and persist in STEM programs if they had high self-efficacy as it relates to mathematics achievement (Hackett, 1985; Zeldin et al. 2008). In Hackett's (1985) research study, she hypothesized that if a student had high self-efficacy in mathematics, the student could overcome gender stereotypes, compensate for poor preparation in mathematics, and feel confident in her perceived achievement when it comes to choosing a math-related major. Hackett (1985) defined mathematics self-efficacy as a "…specific estimate of confidence in one's ability to perform well with regard to particular mathematics tasks or, in particular, math and math-related courses" (p. 48). In this study, the researcher tested her hypothesis by administering two math questionnaires (Mathematics Self-Efficacy Scale and Fennema-Sherman Mathematics Attitude Scales) and the Bem Sex Role Inventory, which measures for perceived traditional gender roles. The math questionnaires and the Bem Sex Role Inventory were provided to undergraduate student participants (N = 262) to gain a better understanding for why females are less likely to consider male-dominated career paths (e.g., collegiate STEM programs). The researcher found a high correlation among self-efficacy and math-related programs, ACT mathematics score, math anxiety, and the number of years of high school mathematics completed. Not surprisingly, Hackett (1985) found that gender and years of high school mathematics were strong predictors of math ACT scores. In particular, she found that years of high school mathematics, gender, mathematical self-efficacy, and math anxiety were predictors of college program choice. Hackett (1985) concluded that mathematical self-efficacy, the level of anxiety experienced, and the likelihood of enrolling in a collegiate math-related program were influenced by two factors: gender-related socialization (e.g., males are better at math than females) and the level of preparation in mathematics. How do you reverse the effects of gender-related socialization in male-dominated careers? Hackett (1985) recommended that career counselors and educators break down math and science stereotypes held by female students, as the students hold perceptions of their personal abilities and gender stereotypes of career options.

In further research, Meece, Wigfield, and Eccles (1990) conducted a two-year longitudinal study that measured students' attitudes about math anxiety and math achievement to determine the cause of their anxiety. The researchers worked with a sample of seventh through ninth grade students (N = 250) to assess the influence of past math grades, perceived math ability, and expectation of math performance on reported math anxiety. Meece et al. (1990) found that math anxiety was related to students' math self-concept, expectation of performance, and value perceptions. In conclusion, the researchers found that the performance expectation held by students was a good predictor of their math grades, their value perception, and their likelihood of enrolling in a math course. The reader can assume that students who think they are poor at math will have a greater chance of performing poorly on a math exam and will be less likely to enroll in a collegiate STEM program, regardless of performance. Surprisingly, Meece et al. (1990) found that the results were consistent regardless of gender. The researchers recommended that educators implement math anxiety programs that help students to manage their emotional stress by increasing students' self-efficacy and reducing anxiety. Above all, the researchers stressed that educators can enhance female students' valuing of math by providing real world examples and relating the classroom experiences to careers.

**Effects of Pre-Collegiate STEM Programs on Female Enrollment**

In addition to providing high school students with exposure to advanced math and science courses, pre-collegiate STEM programs are designed to act as a pipeline to collegiate STEM degrees. Researchers have argued that increased levels of exposure to pre-collegiate math and science lead to higher self-efficacy, which may then lead to an increased likelihood for enrollment in and persistence through a collegiate STEM degree program (Fantz, Siller, & DeMiranda, 2011; Jenson et al., 2011; Hackett, 1985; Zeldin et al., 2008).

In one qualitative study, Dave et al. (2012) explored the reasons for a lack of females in the STEM fields. The researchers hypothesized that females were more likely to consider collegiate majors and careers if they believe these majors and careers make a positive impact on society and if they are exposed to female role models. The investigators tested their hypothesis with high school sophomores and juniors in a week-long math- and science-focused summer camp. Fifteen participants were engaged in hands-on activities with female teachers and college-age mentors as part of the Math Options Summer Camp. The activities emphasized teamwork, design, and ergonomics in addition to mechanical engineering, steel cutting, electrical engineering, and plastic engineering workshops. The summer camp provided the participants with practical experience, the foundation to gain a better understanding of the hard sciences, and an opportunity to build confidence in their ability to succeed in a collegiate STEM degree program. Dave et al. (2012) found that participants benefited from interactions with the college student mentors, which increased their level of comfort with science. As a result of the additional exposure to math and science, many of the participants indicated that they would take math or science courses even if they were not required, and agreed that it is important for everyone to have a basic understanding of the STEM fields. The study reported that females were not as encouraged as males to consider collegiate STEM degree programs. The researchers concluded that female students gained a better understanding of the specific STEM disciplines as a result of the camp. For participants who had an interest in pursuing a STEM field, the camp solidified their decision, and for participants who did not know much about STEM, it was a mind-opening experience (Dave et al., 2012).

In the study by Fantz et al. (2011), the researchers looked at the student experience by considering the relationship among pre-collegiate engineering factors (e.g., outreach programs, field trips, exposure to engineering colleges, summer camps) and engineering students' self-efficacy. In particular, the researchers wanted to know if there were some types of pre-collegiate engineering factors associated with higher self-efficacy than others. The researchers hypothesized that the more rigorous the pre-collegiate experience, the more likely a student would possess a higher self-efficacy in math and science, resulting in an increased likelihood that the student would enroll in and persist through a collegiate engineering program.

Fantz et al. (2011) measured the students' engineering self-efficacy by administering the Motivated Strategies for Learning Questionnaire (MSLQ) to participants. MSLQ is a tool used to assess students' level of motivation to persist in a degree program and their likelihood of using different learning strategies for collegiate study. The MSLQ was administered to first year undergraduate students (N=332) who were enrolled in an engineering college. Of the 332 students who participated in the study, 81% were male (N=269) and less than 20% were female (N=62).

The results from the questionnaire led to two comparison groups: those who did not experience pre-collegiate engineering activities and those who did experience pre-collegiate engineering activities. Fantz et al. (2011) further drilled down the two comparison groups so that there were two sub-categories for those who did experience pre-collegiate engineering activities: formal experiences and informal experiences. If a student indicated that he/she did experience pre-collegiate engineering activities, the researchers considered the type of experience as either formal or informal. Formal pre-collegiate experiences were defined as "…middle school or high school courses, summer and out-of-school programs, and single-day field trips" (Fantz et al., 2011, p. 606). Informal pre-collegiate experiences included "…work experience and personal experiences with toys and hobbies" (Fantz et al., 2011, p. 606).

These researchers found that there were significant differences in engineering students' self-efficacy resulting from the types of pre-collegiate engineering experiences they had. Of the 53 types of pre-collegiate engineering experiences considered by the researchers, seven had significant differences in self-efficacy scores. Of the seven pre-collegiate activities (technology class, engineering class, programming as a hobby, electronics as a hobby, robotics as a hobby, model rockets as a hobby, and production of video games as a hobby) that displayed significant differences in self-efficacy scores, five were categorized as informal experiences (programming as a hobby, electronics as a hobby, robotics as a hobby, model rockets as a hobby, and producing video games as a hobby). Fantz et al. (2011) attributed higher levels of self-efficacy to pre-collegiate activities that were described as hobbies because they called upon the student to have: "…self-motivation, use of problem solving strategies, hands-on application of complex subject matter, use of computer applications, and immediate feedback on success of effort" (p. 100). Does this mean that informal pre-collegiate engineering activities lead to higher engineering self-efficacy and are more likely to result in enrollment in collegiate engineering colleges? Fantz et al. (2011) found that hobbies and formal classes with structured curricula (e.g., technology and engineering classes) were also associated with higher levels of engineering self-efficacy in participants. Furthermore, students who had pre-collegiate experiences (formal and informal) were associated with higher self-efficacy in engineering than their peers who did not have these experiences, which would lead to a greater likelihood of enrolling in and persisting through collegiate engineering programs.

Fantz et al. (2011) concluded with a call for more resources to be focused on developing pre-collegiate STEM experiences for K-12 students, as they lead to higher self-efficacy in students and a greater likelihood for enrollment in and persistence through a collegiate STEM major. The findings are not surprising as it seems obvious that students who are participating in pre-engineering classes, engineering summer camps, math and science hobbies, and so on are more likely to enroll in and persist through collegiate STEM programs than students who have not had those experiences. The researchers called for more rigorous pre-collegiate engineering activities that include higher levels of mathematics and engineering and targeting of students who display an interest in these courses through their hobbies.

In one quantitative study, Espinosa (2011) looked at the effects of pre-collegiate activities, experiences in college, and institutional setting on the persistence of females ($N=1385$) in collegiate STEM majors. Espinosa's (2011) research revealed that females were more likely to enroll in and persist through collegiate STEM programs if they had the opportunity to engage with their peers and participate in STEM-related student organizations, and if they were made aware of altruistic career opportunities. The findings from the study called for developing cohort STEM programs that provide female students with a greater sense of community, increasing the number of student organizations related to STEM fields (e.g., Society of Women Engineers), and providing female students with real world experiences that demonstrate how a career in STEM can influence environmental, social, and economic problems.

With regard to increasing K-12 resources and access to pre-collegiate STEM programs, organizations such as American College Testing (ACT) encourage secondary institutions to align their academic standards with higher education institutions and provide more college readiness opportunities so that students are better prepared for collegiate STEM programs. Consequently, ACT recommended that educators raise expectations of students so that they develop strong math and science skills by requiring that all students complete three years of a rigorous math and science course sequence (American College Testing, 2006).

Another advocate of pre-collegiate STEM curricula is the non-profit organization Project Lead the Way (PLTW). PLTW is a national provider of pre-engineering and technology education curricular programs for middle and secondary schools committed to preparing students for the global economy by increasing access to and preparation for collegiate STEM degree programs. PLTW was established in 1997 to prepare students to be innovative and productive leaders in Science, Technology, Engineering, and Mathematics (Project Lead the Way, 2013).

Since its inception, PLTW has served as an effective tool for increasing collegiate enrollment in STEM degree programs. In a survey of PLTW (2009) seniors, it was found that more than 90% intended to pursue a four-year degree as compared to the national average of 67%. Consequently, 70% of PLTW high school seniors indicated that they intended to study engineering, technology, or computer science. PLTW reported that "college students, who took PLTW courses in high school, study engineering and technology at 5 to 10 times the rate of those students who did not take PLTW courses in high school and also have higher retention rates in their fields of study" (PLTW, 2009). PLTW partners with high schools and institutions of higher education to provide a rigorous, relevant STEM education to K-12 students. Higher education institutions are involved in the process of educating both students and their teachers, as they serve as trainers to high school teachers in math and science in their preparation for teaching the PLTW curriculum.

**Conclusion**

The review of literature included a discussion on the importance of increasing the number of females enrolling in collegiate STEM programs in order to add diversity in STEM fields providing for more voices to be heard, address the concerns of social equity, increase innovation and competiveness, and help to address the industry concern that there are too few qualified individuals in the STEM workforce (Espinosa, 2011; Hill et al., 2010; Leslie et al., 1998). Additionally, an exploration of confidence and persistence was conducted as an attempt to understand why females are not enrolling in collegiate STEM programs at the same rate as their male peers. In a study conducted by Gilligan et al. (1991, 1994), the researchers explored the results from a national self-esteem survey that was administered to males and females. The researchers concluded that there is a gender gap in self-esteem that increases with age and that females experience it more dramatically. The researchers called for changes in how math and science classes are taught so that females are more engaged in the classroom. Lastly, there was an examination of the role of pre-collegiate STEM experiences in female enrollment in STEM degree programs. Espinosa (2011) looked at the effects of pre-collegiate activities, experiences in college, and institutional setting on the persistence of females in collegiate STEM majors, calling for the development of cohort STEM programs that provide female students with a greater sense of community, increasing the number of student organizations related to STEM fields (e.g., Society of Women Engineers), and providing female students with real world experiences that show how a career in STEM can influence environmental, social, and economic problems.

Female enrollment and persistence in collegiate STEM programs cannot be attributed to the influence of one factor alone. The review of literature includes previous research that offered a range of factors for why females are not enrolling in STEM programs and recommendations for reversing this trend. Past research has attributed the low enrollment numbers to a variety of factors:

- lack of female students' understanding of the career opportunities available to them,
- a misunderstanding of what STEM education is,
- the lack of female mentoring opportunities,
- the low numbers of females teaching advanced math and science courses,
- the self-perception held by female students of their ability to succeed in math and science,
- personal feelings of intimidation surrounding advanced math and science requirements, and
- a loss in confidence to excel at math and science.

With so many factors to consider, how do educators know where to focus their resources?

The review of literature proposed many factors, but it did not fully address what influences and motivates female students to enroll and persist in collegiate STEM degree programs. The literature reviewed leads to a call for greater exploration of why female students continue to lag behind their male peers in math and science courses despite their apparent ability to succeed.

Much of the literature reviewed called for additional research. For example, Rinn et al. (2008) called for additional studies to examine why females fail to enter STEM fields at rates consistent with their abilities and male peers. Similarly, Pajares and Miller (1994) did not provide the reader with an answer as to why differences exist in the levels of anxiety experienced by males or females, leaving the reader to question why males are developing higher levels of self-efficacy and self-concept and lower levels of anxiety and females are not. Leslie et al. (1998) recommended that future research consider the factors that are causing females to lose confidence in their academic abilities in math and science. Hackett (1985) concluded that mathematical self-efficacy, the level of anxiety experienced, and the likelihood of enrolling in a collegiate math-related major were influenced by two factors: gender-related socialization (e.g., males are better at math than females) and the level of preparation in mathematics, leaving the unanswered question to be: How do you reverse the effects of gender-related socialization in male-dominated careers? What is missing from these studies is an understanding of which pre-collegiate factors contribute to pre-collegiate female students' likelihood of enrolling in collegiate STEM programs.

This study will contribute new lines of inquiry to the literature of STEM education by researching and analyzing the secondary school experiences of undergraduate female STEM majors.  Past research has considered the factors that may affect a female student's decision to enroll in collegiate STEM programs.  However, no studies have provided enough insight or a solution to the problem of female enrollment and persistence in collegiate STEM degree programs.  This study is designed to address the national concern of too few females in collegiate STEM degree programs by exploring the factors that influence and motivate female students to enroll in collegiate STEM degree programs.

# CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

## Research Problem

Nationally, the need for an increase in interest, enrollment, and degrees awarded from science, technology, engineering and mathematics (STEM) degree programs continues to suffer. In 2010, the National Science Foundation reported that 32% of bachelor's degrees earned were in science and engineering. While students are enrolling in collegiate STEM degree programs, it is not occurring at a rate that meets the workforce demand. In 2009, the Organization for Economic Cooperation and Development reported that "the United States ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering [STEM degree programs]" (p. 70). In addition to the national concern over the low number of students enrolling in collegiate STEM programs, there is a growing concern over too few females entering the STEM workforce. If collegiate STEM degree programs are not able to recruit females, then the workforce will not have enough qualified employees to recruit, as more than half of all bachelor's degree graduates are female. The following research study addresses the national concern that there are too few females enrolling in collegiate STEM degree programs by exploring the factors that influence and motivate female students to enroll and persist in collegiate STEM programs.

## Theoretical Framework

The theoretical perspective underlying this study is the fundamental framework of Social Cognitive Theory (SCT), which combines personal learning and observed learning. Here the framework stems from Social Learning Theory (SLT). The basic premise of SCT is that individuals not only learn from their own experiences, but also from observing the actions of others (Office of Behavioral & Social Sciences Research, 2013). SLT began in the 1960s by Bandura; it involves self-efficacy and personal goals, and extends it to learned behavior (Bandura, 1977). The key constructs of SCT include observational learning, reinforcement, self-control, and self-efficacy (Office of Behavioral & Social Sciences Research, 2013). Bandura (1971) wrote, "…virtually all learning phenomena result[s] from direct experiences…[or] through observation of other people's behavior" (p. 2). Bandura explained how behavior is strengthened or weakened by its consequence so behavior that is punished will be less likely to reoccur while rewarded behavior is repeated (Bandura, 1971). Figure 1, on the next page, illustrates Bandura's (1977) Model of Reciprocal Determinism, which is a theory that explains an individual's behavior as influencing and being influenced by personal factors and the social environment. The Model of Reciprocal Determinism displays how personal factors such as female ability in math and science and environmental factors such as pre-collegiate exposure to STEM education programs interact and influence behavior.

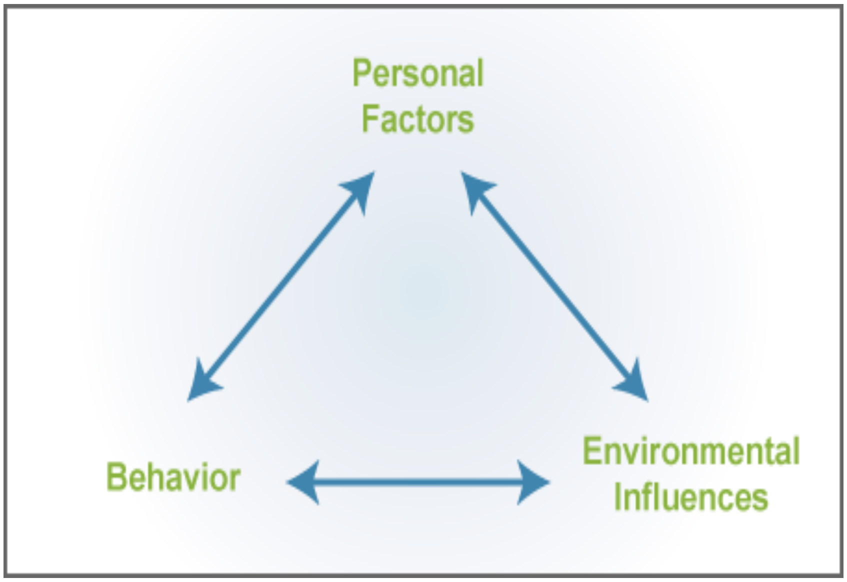



*Figure 1*. Bandura's model of reciprocal determinism. This figure illustrates how the characteristic, determinism, is influenced by personal factors, behavior, and environmental influences.

Fantz, Siller, and DeMiranda (2011) acknowledged the research of Bandura (1977) and Pajares (1996) by commenting that "…when researchers looked at engineering self-efficacy among college engineering students, they found that students were significantly affected by their self-efficacy beliefs in their choices to pursue and persist in engineering" (p. 607). According to Bandura (1977), there are four major information sources that act simultaneously and interactively in the development of personal self-efficacy (p. 195):

1. Performance Accomplishments – personal mastery experiences.
2. Vicarious Experiences – seeing others perform and master provides the observer with the sense that they can master it, too, with persistence.
3. Verbal Persuasion – positive and/or negative feedback received from others.

4. Psychological States – pleasant or unpleasant emotional states (feelings of anxiety or vulnerability).

Hackett (1985) looked at the role of self-efficacy in female students' choice of math-related majors, proposing that "…lower self-efficacy expectations on the part of women were strongly predictive of the traditionality of careers under consideration" (p.47), which reflects the low number of females enrolling in mathematics-related majors. Zeldin, Britner, and Pajares (2008) discussed how past positive performance may result in strong self-efficacy and affect an individual's ability to accomplish similar tasks in the future, while past negative performance can lead to a lower self-efficacy and belief in an inability to attain goals. Both Hackett (1985) and Zeldin et al. (2008) explored the effects of pre-collegiate science, technology, engineering, and mathematics experiences on female student self-confidence as it relates to math and science.

Self-confidence, how an individual views his/her ability to succeed, has been considered as a key contributor to success in goal attainment. Researchers interested in addressing the national call for more females in STEM have considered self-confidence in math and science as a tool to gauge the likelihood of enrollment in a collegiate STEM program (Hill et al., 2010; Rinn et al., 2008) and as a determinant of success for collegiate students (Jenson, Petri, Day, Truman, & Duffy, 2011). Rittmayer and Beier (2008) reported that female self-confidence significantly drops from elementary to high school as belief in her ability to be successful in math and science declines.

## Research Design

**Mixed methods research design.** This study used a mixed methods research design to address the concern that too few females are enrolling in collegiate STEM degree programs. The research problem was addressed though the lens of Bandura's Model of Reciprocal Determinism (1977) by considering how female student behavior influences and is influenced by personal factors and the social environment. A mixed methods research design procedure was used for collecting, analyzing, and combining both qualitative and quantitative data during the research process within a single study (Creswell, 2002; Creswell & Plano Clark, 2011). The mixed methods research design model relied on the research findings from the qualitative phase to enhance the data collection in the quantitative phase, and thus provided a more comprehensive understanding of a complex topic (Creswell & Plano Clark, 2007; Creswell, Shope, Plano Clark, & Green, 2006).

***Research design model.*** The sequential exploratory research design was characterized by four phases: (a) collection and analysis of qualitative data through female students' participation in focus group sessions; (b) review of the qualitative findings in order to develop a survey instrument that combines two independent surveys (findings from the qualitative phase, Phase I and the pre-existing Motivated Student Learning Questionnaire; (c) administering of a newly developed survey instrument; and (d) synthesis of the findings (Creswell & Plano Clark, 2007). Figure 2, *Sequential Exploratory Design qual➔QUAN,* illustrates the sequential exploratory research method used in this research study.

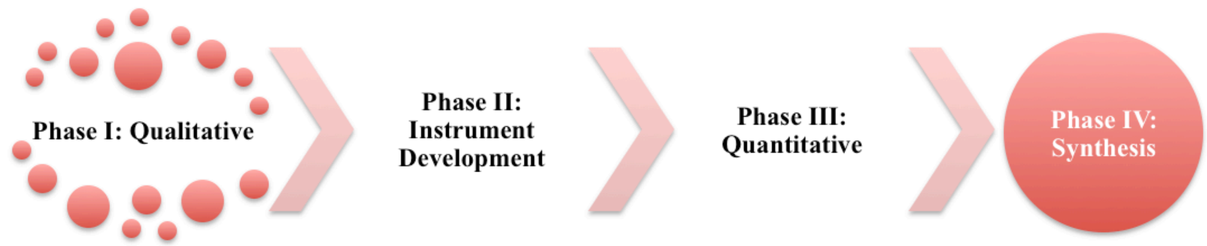



*Figure 2.* Sequential Exploratory Design qual ➔ QUAN. This figure illustrates the four phases of the research process.

**Rationale.** The mixed methods research design allowed for factors to be determined and tested in two different ways. The integration of qualitative and quantitative data collection was a pragmatic approach to exploring the factors that influence and motivate female students to enroll and persist in collegiate STEM degree programs (Creswell & Plano Clark, 2007). There were two reasons for choosing a mixed methods research design: (a) to approach the question through a new methodology; and (b) to expand the methodology, resulting in a more comprehensive exploration of the topic.

***New methodology.*** Past research that addressed the research problem of too few females enrolling in collegiate STEM degree programs has been limited to a single data set collection. Research that focuses on a single data set limits the researcher to either focusing on gaining an understanding of the participants' personal experiences through qualitative research or looking at the research question from a cause-and-effect standpoint through the collection of quantitative data. The single data set collection does not allow for the experiences that influence women to enroll and persist in a collegiate STEM degree program to be fully understood. Espinosa (2011) wrote that despite the discussion and need for more females in STEM, there is a "…scant body of work on a population deemed critical to our nation's scientific and technological advancement" (p. 211). Through an exploratory mixed methods research design, both qualitative and quantitative data were gathered, providing for an additional means for addressing the problem.

***Method expansion*.** The second reason for a mixed methods research approach was method expansion, which provides the researcher with an opportunity to expand the scope, breadth, and range of inquiry when approaching the research question (Greene, Caracelli, & Graham, 1989). In an effort to approach the research question in a manner that differs from past research, the sequential exploratory mixed methods research design model provided for the opportunity to build upon a pre-existing research tool that was then used to address the research question. In this research study, the qualitative findings shaped the direction of the entire study, as they were used to guide the development of the quantitative tool (Creswell et al., 2006).

## Research Question

The research questions developed to address the concern that there is an insufficient number of females enrolling and persisting in collegiate STEM degree programs resulted from the review of past research studies that addressed this topic, see *Chapter 2: Review of Literature*. The research study was driven by the overall research question: What are the factors that influence and motivate female students to enroll and persist in collegiate STEM programs? Sub-themes to the overall research question considered that exposing females to career paths in STEM, instilling female confidence in math and science, increasing female student exposure to pre-collegiate STEM degree programs, and connecting how a career in STEM can make a difference in the lives of others will influence and motivate more female students to enroll and persist in collegiate STEM programs.

**Rationale.** The research question was addressed through a pragmatist mixed methods research methodology. Morgan (2007) described the pragmatic approach to social science research methodology as the connection of theory and data as: (a) abduction which considers the converting of observations into theories and those theories into action; (b) relationship to research as intersubjective, which involves communication and shared meaning; and (c) inference from data as transferability, which considers the generalizability of the data. Through a pragmatic approach to addressing the research question, a qualitative exploration of experiences of first-year freshmen female students enrolled in a collegiate STEM degree program was conducted, and then those findings were built upon to determine which factors influenced and motivated female students to enroll and persist.

**Research Site**

**Mission.** In both the collection of qualitative and quantitative data, the sample population was drawn from undergraduate female students enrolled in collegiate STEM programs at a predominately white Midwestern university (MU) in the United States. The research site is a public four-year Midwestern university. In 2011, the total enrollment was 24,593, comprising an undergraduate enrollment of 19,345, graduate enrollment of 4,679, and 569 professional enrollment. More than half of the students were male

(53.9%) and the majority of students were white (82.4%). The Carnegie Foundation lists MU as within the "Research Universities (very high research activity)" category, and the Higher Learning Commission of the North Central Association of Colleges and Schools accredits the university. MU states its role as serving as an intellectual and cultural resource for the state which it fulfills through the three missions of the University: teaching, research, and service (Carnegie Foundation, 2014).

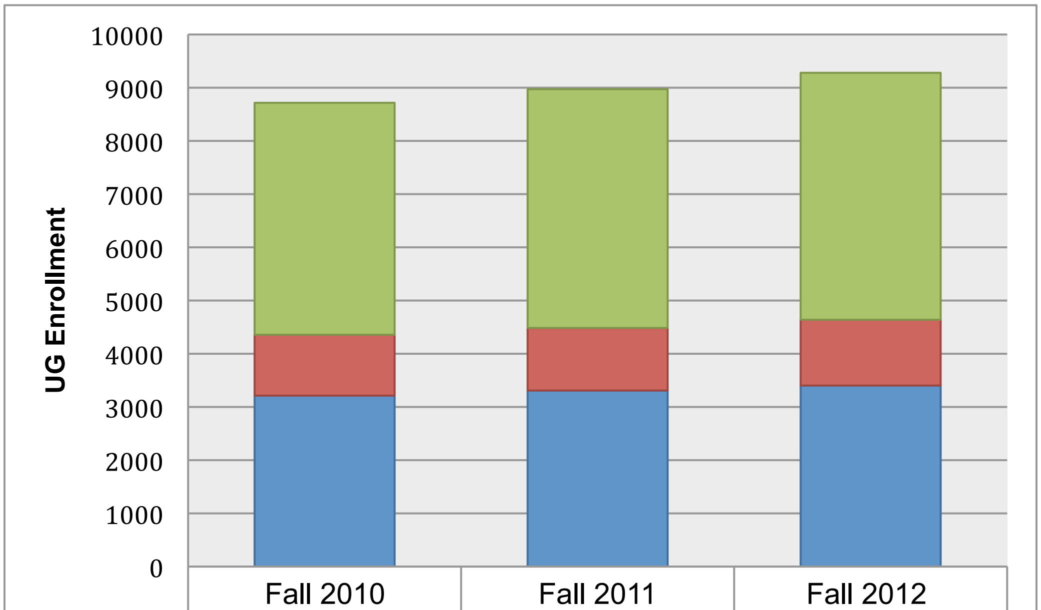
**STEM initiative.** MU advocates for the advancement of females in STEM through its support of the National Science Foundation's Advancement of Women in Academic Science and Engineering Careers (ADVANCE) initiative. MU supports the National Science Foundation's ADVANCE initiative, as the program

- helps to grow the state's economy and the ability to compete for workers,
- supports hiring more female faculty as a means for increasing the number of female students in STEM fields,
- fosters a competitive workplace as all faculty are welcome regardless of gender,
- promotes diverse research teams, and
- recognizes the quality of research and creative solutions that occur when diverse views and perspectives are considered (ADVANCE-Nebraska, 2013).

**Undergraduate student enrollment at MU.** For the 2012 – 2013 academic year, the total enrollment at MU was 24,207. Approximately 45% of the undergraduate enrollment was female (*n* = *8*,658). Of those who were female, 46% were freshmen, 49% were sophomores, 45% were juniors, and 45% were seniors as shown in Table 1: *2012-2013 MU Student Enrollment*. MU's Institutional Research and Planning Office reported the average ACT for first-time freshmen as 25.4 in fall 2012 (Office of Institutional Research and Planning, 2012).

Table 1

2010-2012 MU STEM Undergraduate Enrollment




| | Fall 2010 | Fall 2011 | Fall 2012 |
|---|---|---|---|
| Total | 4358 | 4486 | 4640 |
| Female | 1145 | 1177 | 1237 |
| Male | 3213 | 3309 | 3403 |

*Note.* Midwestern university STEM undergraduate enrollment data as reported by Institutional Research and Planning (Fall 2010, Fall 2011, Fall 2012).

**Undergraduate STEM enrollment at MU.** The Office of Institutional Research and Planning (2012) reported that from 2010 to 2012, MU experienced a 5% increase in undergraduate student enrollment in STEM programs. During this period of time, as reported in Table 1: *Undergraduate STEM Enrollment at MU*, undergraduate female enrollment in STEM programs increased by 8 percent, while male enrollment in undergraduate STEM programs increased by 6 percent. As can be seen, female enrollment is increasing, but not at the pace needed. In 2014, the National Science Foundation reported that women have earned about 57% of all bachelor's degrees and half of all science bachelor's degrees since the late 1990s. However, men earn a majority of bachelor's degrees in engineering, computer sciences, and physics, while more women than men earn degrees in chemistry; biological, agricultural, and social sciences; and psychology. Furthermore, in the last 10 years, the proportion of S&E bachelor's degrees awarded to women has not grown measurably and has declined in computer sciences, mathematics, and engineering (National Science Foundation, 2014).

On the next page, the data shared in Table 2, *STEM Undergraduate Enrollment by Gender at MU*, demonstrates that the collegiate STEM program at MU with the highest enrollment of undergraduate female students is Animal Science (63%). The Biological Sciences program boasts a higher female than male enrollment at 53%. While the Biological Systems Engineering program experienced a small decline in overall undergraduate enrollment from 2010 to 2012 (606 in 2010 and 593 in fall 2012), female enrollment has been maintained at 51% of the total enrollment. Despite the growth experienced by electrical engineering, female enrollment remains around 7%. Although the Civil Engineering program has had a consistent undergraduate enrollment of approximately 465 students, only 15% of these students are female. Additionally, Table 2, shows that there are an increasing number of females enrolling in collegiate STEM degree programs; however, there remains a substantial gap between female and male enrollment.

Table 2

STEM Undergraduate Enrollment by Gender at MU

| | Fall 2010 | | | Fall 2011 | | | Fall 2012 | | |
|---|---|---|---|---|---|---|---|---|---|
| Program | M | F | Total | M | F | Total | M | F | Total |
| Actuarial Science | 106 | 81 | 187 | 125 | 94 | 219 | 165 | 90 | 255 |
| Agricultural Eng. | 36 | 2 | 38 | 42 | 3 | 45 | 45 | 1 | 46 |
| Animal Science | 103 | 160 | 263 | 100 | 163 | 263 | 109 | 190 | 299 |
| Architectural Eng. | 171 | 50 | 221 | 160 | 44 | 204 | 130 | 42 | 172 |
| Biochemistry | 179 | 143 | 322 | 176 | 139 | 315 | 153 | 139 | 292 |
| Biological Sciences | 291 | 315 | 606 | 314 | 327 | 641 | 276 | 317 | 593 |
| Biological Systems Eng. | 115 | 69 | 184 | 120 | 80 | 200 | 133 | 96 | 229 |
| Chemical Eng. | 137 | 33 | 170 | 158 | 44 | 202 | 176 | 48 | 224 |
| Chemistry | 60 | 45 | 105 | 56 | 45 | 101 | 63 | 47 | 110 |
| Civil Eng. | 408 | 62 | 470 | 397 | 67 | 464 | 390 | 73 | 463 |
| Computer Eng. | 238 | 18 | 256 | 238 | 14 | 252 | 247 | 21 | 268 |
| Computer Science | 177 | 19 | 196 | 191 | 20 | 211 | 235 | 22 | 257 |
| Construction Eng. | 41 | 4 | 45 | 36 | 3 | 39 | 33 | 3 | 36 |
| Construction Management | 295 | 18 | 313 | 273 | 12 | 285 | 236 | 12 | 248 |
| Electrical Eng. | 166 | 11 | 177 | 190 | 16 | 206 | 215 | 17 | 232 |
| Electronics Eng. | 65 | 4 | 69 | 61 | 4 | 65 | 74 | 7 | 81 |
| Industrial Eng. | 46 | 21 | 67 | 39 | 17 | 56 | 19 | 9 | 28 |
| Industrial and Mgmt. Systems Eng. | 45 | 7 | 32 | 16 | 3 | 19 | 3 | 1 | 4 |
| Mathematics | 76 | 51 | 127 | 86 | 37 | 123 | 93 | 50 | 143 |
| Mechanical Eng. | 435 | 30 | 465 | 478 | 39 | 517 | 522 | 40 | 562 |
| Physical Science | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 2 |
| Physics | 56 | 6 | 62 | 62 | 6 | 68 | 72 | 10 | 82 |
| Water Science | 6 | 2 | 8 | 7 | 2 | 9 | 11 | 2 | 13 |
| Total | 3252 | 1152 | 4384 | 3325 | 1179 | 4504 | 3402 | 1237 | 4639 |

*Note.* Midwestern university undergraduate enrollment data by STEM major as reported by Institutional Research and Planning (Fall 2010, Fall 2011, Fall 212).

**Pilot Study**

**Rationale.** In early fall 2012, prior to engaging the targeted population in the research study, a pilot study was conducted with female graduate students who were enrolled in STEM programs at MU. The pilot study sample population comprised only female graduate students because of convenience sampling, and because the population has had longer experiences with STEM education. Teddlie and Yu (2007) described convenience sampling as "…drawing samples that are both easily accessible and willing to participate in a study" (p. 201). The female students who participated in the pilot study were not too far removed from their pre-collegiate and collegiate STEM experiences, which provided for a meaningful conversation about the factors that influenced their decision to enroll and persist in a STEM major. The pilot study was conducted for four primary reasons:

1) The pilot study permitted preliminary testing of the hypothesis that through increased pre-collegiate exposure to STEM curriculum programs in both formal and informal settings, more females would enroll and persist in collegiate STEM degree programs.
2) The study provided the opportunity to test the proposed research method for data collection.
3) The study allowed for the checking of proposed transcription and analysis approaches.
4) The study proved the usefulness of a methodological approach for answering the research question (Woken, n.d.).

**Graduate STEM enrollment at MU.** In Table 3, *Graduate Enrollment by Gender for Specific STEM Programs*, illustrates how female enrollment in graduate STEM degree programs at MU has remained at 30% of the overall graduate student population over the past three years. The graduate STEM degree program with the largest female population is engineering; however, females only comprise 20% of the total enrollment. The graduate program in mathematics enrolls almost an equal number of males and females, with an average three-year enrollment of 89 students. The computer science program enrolls a disproportionate number of female students (25%), while sustaining a total enrollment of 99 students per year.

Table 3

Graduate Enrollment by Gender for Specific STEM Programs

| | Fall 2010 | | | Fall 2011 | | | Fall 2012 | | |
|---|---|---|---|---|---|---|---|---|---|
| Program | M | F | Total | M | F | Total | M | F | Total |
| Actuarial Science | 20 | 15 | 35 | 24 | 18 | 42 | 19 | 12 | 31 |
| Agricultural & Biological Systems Eng. | 12 | 7 | 19 | 7 | 4 | 11 | 12 | 6 | 18 |
| Animal Science | 32 | 37 | 69 | 30 | 27 | 57 | 30 | 30 | 60 |
| Architectural Eng. | 32 | 5 | 37 | 36 | 13 | 49 | 31 | 13 | 44 |
| Biochemistry | 21 | 15 | 36 | 19 | 15 | 34 | 17 | 13 | 30 |
| Biological Sciences | 45 | 40 | 85 | 48 | 40 | 88 | 43 | 38 | 81 |
| Chemical Eng. | 3 | 2 | 5 | 1 | 1 | 2 | 1 | 0 | 1 |
| Chemistry | 70 | 34 | 104 | 68 | 33 | 101 | 72 | 37 | 109 |
| Civil Eng. | 53 | 6 | 59 | 55 | 6 | 61 | 38 | 6 | 44 |
| Computer Science | 74 | 25 | 99 | 79 | 26 | 105 | 71 | 23 | 94 |
| Construction | 6 | 1 | 7 | 3 | 3 | 6 | 7 | 3 | 10 |
| Electrical Eng. | 10 | 2 | 12 | 21 | 1 | 22 | 11 | 4 | 15 |
| Engineering | 247 | 61 | 308 | 253 | 64 | 317 | 251 | 63 | 314 |
| Engineering Mechanics | 17 | 4 | 21 | 14 | 3 | 17 | 11 | 2 | 13 |
| Industrial and Management Systems Eng. | 25 | 7 | 32 | 16 | 3 | 19 | 3 | 1 | 4 |
| Information Technology | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| Mathematics | 51 | 48 | 99 | 41 | 40 | 81 | 45 | 42 | 87 |
| Mechanical Eng. | 32 | 2 | 34 | 25 | 2 | 27 | 18 | 1 | 19 |
| Physics and Astronomy | 56 | 12 | 68 | 61 | 15 | 76 | 62 | 12 | 74 |
| Statistics | 38 | 24 | 62 | 38 | 32 | 70 | 35 | 32 | 67 |
| Total | 845 | 347 | 1192 | 840 | 346 | 1186 | 778 | 338 | 1116 |

*Note.* Midwestern university graduate enrollment data by specific STEM degree as reported by Institutional Research and Planning (Fall 2010, Fall 2011, Fall 2012).

**Research Model.** The pilot study involved a two-pronged approach to addressing the research question. The first prong engaged female graduate students in a focus group session. The second prong entailed the administering of the newly developed survey and a section of the pre-existing Motivated Student Learning Questionnaire to the sample population. Figure 3, *Pilot Study Process*, details the pilot study process, which provides the sample size, goal of each phase, and results.

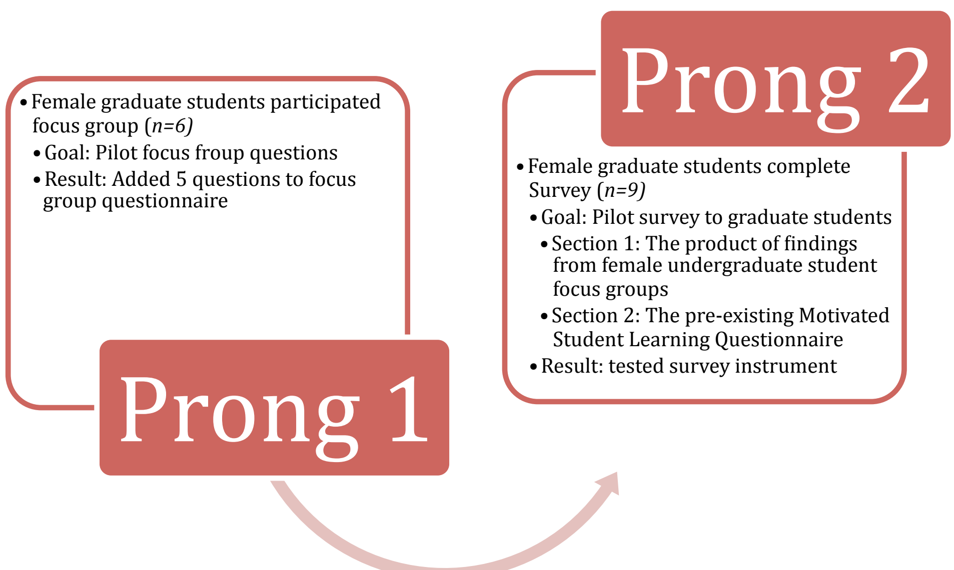



*Figure 3.* Pilot Study Process. This figure illustrates the two-pronged approach to collecting data in the pilot study.

**First Prong.** A recruitment email message was sent to female graduate students (*N* = 32) enrolled in a STEM degree program at MU inviting them to participate in the focus group session. Appendix A includes a copy of the email message that was sent to female graduate students. The email message notified the recipient that she had been selected to participate in a study at the university that aimed to gain a better understanding of the factors that influence and motivate female students to enroll and persist in STEM programs. The focus group session conversation centered on a discussion of pre-collegiate math and science experiences. The discussion group was scheduled for approximately 60 minutes with time for introductions and pizza.

***Demographics***. In addition to the focus group discussion, participants were asked to complete a demographic sheet so that additional information could be collected. Thirty-two female graduate students were sent an invitation to participate in the focus group; there was a 19% participation rate ($n$ = 6) in the focus group. The majority of participants were enrolled in a master's degree program ($n$ = 5). All participants reported a socio-economic status of middle to upper-middle class. Table 4, *Demographics for Graduate Student Participants in Pilot Study,* shows that all but one participant reported the highest level of education received by their parents as college graduate.

Table 4

Demographics for Graduate Student Participants in Pilot Study

| Academic Program | Degree | State of Residence | SES | Mother's Education | Father's Education |
|---|---|---|---|---|---|
| Architectural Eng. | Master | Nebraska | Middle Class | Bachelor’s Degree | Graduate Degree |
| Architectural Eng. | Master | Nebraska | Middle Class | Some College | Some College |
| Architectural Eng. | Master | Nebraska | Middle Class | Bachelor’s Degree | Bachelor’s Degree |
| Architectural Eng. | Master | Washington | Middle Class | Bachelor’s Degree | License |
| Architectural Eng. | Doctorate | China | Middle Class | Graduate Degree | Bachelor’s Degree |
| Computer Eng. | Master of Science | Amman | Upper-Middle Class | Bachelor’s Degree | Bachelor’s Degree |

*Note.* Data represent the demographics of the six graduate females who participated in the focus group sessions.

***Focus group questions***. Pilot study participants were engaged in a conversation that focused on their pre-collegiate math and science experiences. The eight focus group questions, listed in Table 5, *Pilot Study Focus Group Questions*, were directed to participants as a means for starting a discussion of their math and science experiences.

Table 5

Pilot Study Focus Group Questions

| |
|---|
| 1) Why did you enroll in a STEM program? |
| 2) Did you consider any other programs when looking at colleges? |
| 3) Was there a particular moment that stands out for you when you decided that this was the right major for you?<br>• Probe if there was a particular teacher who piqued interest<br>• Probe if parents influenced decision |
| 4) What do you like about science and math? |
| 5) Did you participate in a pre-engineering and technology curriculum in high school, e.g., a STEM magnet or Project Lead the Way school? |
| 6) Did you participate in math- and science-focused after school programs or camp activities? |
| 7) Did you participate in any STEM-related programs in high school?<br>• Probe about what they liked<br>• Probe about what they did not like |
| 8) Do you think that males go into STEM for the same reasons as females? |

*Note*. Questions were asked of graduate students who participated in the pilot study.

***Focus group results***. During the focus group session, two themes encountered in the review of literature (Chapter 2: *Review of Literature*) were brought up in the conversation. The two themes discussed included (a) altruism, and (b) self-confidence and motivation.

*Altruism*. Wanting a career that helps people and makes a difference was a theme that came up frequently in the review of literature. Espinosa's (2011) research emphasized that females are more likely to enroll in and persist through collegiate STEM programs if they were made aware of altruistic career opportunities. During the focus group with the female graduate students enrolled in collegiate STEM degree programs, the theme was echoed by many of the participants in the focus group session. In particular, one female recalled:

> Part of the reason I chose the mechanical options was that I was really interesting[ed] in how it uses energy and how that would impact people, the cost of things, and the mechanical systems can control the air quality and different things like that. It can really…it seems to me…would make the biggest difference on people's lives in the building industry. (Graduate Student Participant, fall 2012)

*Self-confidence and motivation.* The theme of self-confidence and motivation emerged from the discussion among the female participants in the graduate focus group session about how it felt to be the only female in the classroom. One participant shared how she relied on her past experiences with advanced math and science courses to overcome her feeling like an outlier as the only female in her class. "[I felt] Maybe a little out of place, but not too much. Most of the guys I already knew [from previous classes], I had taken a class with the teacher before so I didn't feel too out of place." Another participant told a similar story by stating, "I realized, in high school, it definitely hit me when I walked into an engineering class, I was the only girl of about 30 engineering students." Research by Fantz et al. (2011) reinforced the feelings experienced by participants as he discussed how females rely on their self-confidence to persist in situations where they feel that they are in the minority. Fantz et al. (2011) called for more resources to be focused on developing pre-collegiate STEM experiences for K-12 students, as these experiences lead to self-confidence in students and a greater likelihood for enrollment in and persistence through a collegiate STEM major.

Repetitive patterns emerged in the review of the transcripts from the graduate student focus groups, resulting in themes. As illustrated in Table 6, *Newly Developed Focus Group Questions*, five additional questions were added to the list of questions that were asked of the first-year female freshmen students, as a result of the pilot study.

| Table 6 | |
|---|---|
| Newly Developed Focus Group Questions | |
| 1) | Does it matter if you impact others? |
| 2) | What do you think educators can do to encourage more females in math and science – STEM? |
| 3) | How do you feel if you get a B on a homework or exam after you worked really hard to prepare for it? |
| 4) | What motivates you to persist in this major? |
| 5) | What are the top three reasons why you chose this major? |

*Note.* Questions listed in Table 7 were developed from the themes that emerged during the Pilot Study phase of the research study involving female graduate students enrolled in a STEM degree program.

**Second Prong.** The second prong of the pilot study involved the testing of the newly developed survey and a section of the pre-existing Motivated Student Learning Questionnaire with a sample population of female graduate students. The survey was electronically administered to ($N$ = 32) female graduate students, resulting in a 28% response rate. Of that number, ($n$ = 9) students completed the survey and provided feedback on changes that could improve the survey tool. Based on the feedback received from the female graduate students, changes were not made to the survey prior to administering it to female undergraduate students.

***Demographics.*** All but one of the survey respondents was enrolled in a graduate program in Architectural Engineering. There was one student enrolled in a graduate program in Construction Management. Four of the respondents were enrolled in a PhD program and the remaining five were enrolled in a Master of Architectural Engineering program. More than half (67%) of respondents reported their ethnicity as white and 22% reported as Asian. All respondents reported the highest level of education received by their parents as at least college graduate, with three reporting an advanced degree.

***Survey questions.*** The survey consisted of 15 questions with one question focused on motivation and self-confidence, six questions dedicated to pre-collegiate experiences, and nine questions that collected demographic information from the sample population. Appendix B, *Undergraduate Survey Tool*, includes the six primary questions that inquired about (a) why female graduate students enrolled in a STEM major, (b) which factors influenced the respondent to persist, and (c) how the female graduate students perceived grades.

***Survey results.*** The following section includes the results from the survey that was piloted to female graduate students enrolled in a STEM degree program. The pilot study sample size was small ($n = 9$), so the results were only used to check for consistency in response. For this study, a value of 0.70 for Cronbach's α was considered acceptable. Cronbach's α "…provide[s] a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same concept or construct and…it is connected to the inter-relatedness of the items within the test" (Tavakol & Dennick, 2011, p. 53). The pilot instrument had a Cronbach's α of 0.88. The instrument measured the scales consistently, so it was unaltered for the final instrument that was administered to the sample population of undergraduate female students. The final instrument produced similar results with a Cronbach's α of 0.94. A full analysis was conducted on the graduate student data before reviewing the undergraduate student findings.

**Phase I: Qualitative Research**

The collection of qualitative data focused on investigating the participants' phenomenological understanding of the experiences that influenced their enrollment in collegiate STEM degree programs. Qualitative research is, as Creswell (2009) explained, a "means for exploring and understanding the meaning individuals or groups ascribe to a …problem…[the] research involves emerging questions and procedures, data building from particulars to general themes, and the researcher making interpretations of the meaning of the data" (p. 4). The theoretical framework constructivism guided the collection of qualitative data. Broadly, the constructivist theoretical framework assumes that multiple realities exist, and that we construct the meanings of experiences through interaction with others (Guba & Lincoln, 1994). The constructivist approach to the collection of qualitative data emphasizes the gaining of a personal understanding of the experiences of participants through conversations with a small, select group of students. For this research study, qualitative data were collected through the engagement of participants in a focus group setting.

**Sampling method.** The first phase involved the purposeful sampling of undergraduate female students to participate in focus group sessions. Creswell and Plano Clark (2007) described purposeful sampling as choosing participants who have had experience with the concept being explored. The sampling process involved soliciting from a pre-determined demographic to participate in a focus group session. The pre-determined demographic was defined as: female undergraduate student, categorized as a first-year female freshman (0-26 credit hours), and enrolled in a collegiate STEM program. The selection of students to participate in the focus groups was consistent with the selection of the sample that would be part of the second phase of the research study, quantitative data collection. To recruit focus group participants, an email message was sent to all female first-year freshmen students ($N = 265$) enrolled in a collegiate STEM degree program at MU inviting them to participate in a focus group session. Of the 265 students who fit the participant criteria and were sent the email, approximately 5% ($n = 13$) contributed to the focus group sessions. Appendix C, *Focus Group: Undergraduate Student Recruitment Email*, contains the sample email used to recruit first-year female freshmen students to participate in the focus group phase of the research study.

**Participants.** Thirteen females enrolled in an undergraduate STEM degree program participated in the focus group session during fall and winter 2012. As reported on the next page in Table 7, *Focus Group Undergraduate Female Student Demographics*, the majors represented in the focus group include: Actuarial Science (n = 1), Architectural Engineering (n = 5), Biochemistry (n = 1), Biological Sciences (n = 3), Biology/Pre-Medicine (n = 1), and Computer Engineering (n = 2). Eleven of the participants reported their race as white while the remaining two were classified as Middle East/Omani and African American/Black. The majority of participants were residents of the state of MU. All focus group participants reported that the highest level of education in their family was at least a four-year college degree. Twelve of the 13 participants reported their socioeconomic status as at least middle class with 42% as upper-middle class. When asked to report their mother's highest education, 85% reported at least a college graduate; for their father's highest education, 77% reported at least a college graduate.

Table 7

Focus Group Undergraduate Female Student Demographics

| Major | Race | High School State | Family Education | SES[1] |
|---|---|---|---|---|
| Actuarial Science | White | Texas | Bachelor's Degree | Middle |
| Architectural Eng. | Middle East | Middle East | Doctorate or PhD | Upper-Middle |
| Architectural Eng. | White | Nebraska | Bachelor's Degree | Middle |
| Architectural Eng. | White | Nebraska | Bachelor's Degree | Lower-Middle |
| Architectural Eng. | White | Nebraska | Graduate Degree | Upper-Middle |
| Architectural Eng. | White | Illinois | Graduate Degree | Upper-Middle |
| Biochemistry | African American | Nebraska | Graduate Degree | Middle |
| Biological Sciences | White | Iowa | Bachelor's Degree | Middle |
| Biological Sciences | White | Nebraska | Doctorate or PhD | Upper-Middle |
| Biological Sciences | White | Nebraska | Bachelor's Degree | Middle |
| Biology/Pre-Medicine | White | Nebraska | Bachelor's Degree | Upper-Middle |
| Computer Eng. | White | Nebraska | Graduate Degree | Middle |
| Computer Eng. | White | Nebraska | Graduate Degree | Middle |

*Note.* Data represents the demographics of the 13 undergraduate females who participated in the focus group sessions.

[1]Socioeconomic Status

**Data collection.** The primary method for qualitative data collection was through participants sharing their experiences in a focus group session. Krueger (2009) wrote that the goal of the focus group was to gain insight into attitudes, perceptions, and opinions of participants, and that there were six characteristics of a focus group described as:

- involving people (6 to 10)
- assembling a series of groups
- possessing certain characteristics
- resulting in data
- structured in a qualitative manner
- facilitating a focused discussion

The focus groups were limited in size to six participants so that there was (a) sufficient time to hear from everyone, (b) comfort felt by participants when sharing insights, and (c) diversity among participants (Krueger, 2009). A total of four focus groups were scheduled, with two focus groups hosted on each campus of MU. The first two meetings were hosted at the flagship location of MU, and the second sets of meetings were hosted on the metropolitan campus. Both MU campus locations offer collegiate STEM degree programs. Each focus group session was scheduled for 60 minutes in length, including time for eating pizza and conducting introductions.

The collection of qualitative data focused on exploring the experiences that influenced female first-year freshmen students to enroll in collegiate STEM programs and the collection of demographic information. An example of the Participant Demographic Worksheet is given in Appendix D. The 13 open-ended questions with probing sub-questions used to lead the conversation are listed in Table 8, *Undergraduate Female Collegiate STEM Major Focus Group Questions.*

| Table 8 |
| --- |
| Undergraduate Female Collegiate STEM Major Focus Group Questions |
| 1) Why did you enroll in a STEM program? |
| 2) Did you consider any other programs when looking at colleges? |
| 3) Was there a particular moment that stands out for you when you decided that this was the right major for you?<br>• Probe if there was a particular teacher who piqued interest<br>• Probe if parents influenced decision |
| 4) What do you like about science and math?<br>• Probe if they had female math and science teachers |
| 5) Did you participate in a pre-engineering and technology curriculum in high school, e.g., a magnet math and science or Project Lead the Way school. |
| 6) Did you participate in math- and science-focused after school programs or camp activities? |
| 7) Did you participate in any STEM-related programs in high school?<br>• Probe about what they liked<br>• Probe about what they did not like |
| 8) Do you think that males go into STEM for the same reason as females? |
| 9) Does it matter if you impact others? |
| 10) What do you think educators can do to encourage more females in math and science – STEM? |
| 11) How do you feel if you get a B on a homework or exam after you worked really hard to prepare for it? |
| 12) What motivates you to persist in this major? |
| 13) What are the top three reasons why you chose this major? |

*Note.* Focus group questions that were asked of undergraduate female collegiate STEM majors.

The focus group questions were structured so that the conversation began with a general discussion of participants' experiences. As the participants grew more comfortable with sharing their math and science knowledge in the group dynamic, the questions became more specific to personal pre-collegiate STEM experiences and long-term career plans. The undirected conversation among the participants provided additional insight into which factors influenced their decision to enroll in a STEM program, and revealed unexpected characteristics of the demographic (Franz, 2011).

**Data analysis.** The four focus group sessions were audio-recorded with the permission of participants. A second party who maintained the confidentiality of participants transcribed the recordings verbatim. Creswell (2009) described the data analysis process as an "ongoing process involving continual reflection about the data…data analysis involves collecting open-ended data, based on asking general questions and developing an analysis from the information supplied by participants" (p. 184). Saldaña (2009) wrote that there is not a standardized methodology for coding qualitative data; there are only suggestions for employing consistency.

***Analysis process.*** The analysis process for the transcripts followed these nine steps:

1. *Preparing and organizing the data*. An electronic research notebook was maintained so that notes and observations made during the focus group sessions could be revisited. At the conclusion of each focus group session, time was spent reflecting on big ideas that would be beneficial to future meetings. At the conclusion of the session, big ideas were noted in the electronic research notebook.
2. *Reviewing the data*. Once the transcriptions from the focus group sessions were received from the transcriber, a second review of data was conducted by

listening to the audio file while reading through the transcripts to verify accuracy of the transcription. Appendix E includes the Transcriber Confidentiality Agreement. At the beginning of each transcript, a summary of the focus group session was included with field notes when applicable. All participant identifiers were removed from the data at this step. The cleaned data were reviewed so that a systematic evaluation and interpretation of the qualitative text could occur.

3. *Facilitating member checking*. A critical step was to validate, ensure accuracy, and obtain a general sense of the information. This was accomplished by a comprehensive review of each document, field note, and focus group transcript (Creswell, 2009). To ensure the credibility and validity of qualitative findings, participants were engaged in respondent validation, which occurred through member checking. The member checking process involved the researcher emailing the participants (*N* = 13) a summary of the transcription and themes from the focus group sessions after all identifiable data were removed. Any feedback that was received by the researcher from participants was taken into account and incorporated into the narrative descriptions.
4. *Conducting coding*. The systematic coding process involved a detailed analysis to address predetermined and emerging codes (Creswell, 2009). The predetermined codes were defined as themes that had emerged in the review of literature, while the emerging codes were themes that developed during the

first phase of the research study. The coding process involved three steps: (a) meaningful segments of text data were identified and two to three word codes were recorded in Microsoft Excel, (b) the segmented data were gathered into categories, and (c) the categories were labeled with a term that reflected the voices of the participants – an in vivo method (Creswell, 2009).

5. *Developing themes*. The primary goal of the data analysis was to produce themes. The themes are an outcome of coding, categorization, and analytical reflection (Saldaña, 2009). The code to theme model for qualitative inquiry is displayed in Figure 4, *Codes-to-theory model for qualitative inquiry* (Saldaña, 2009). The coding process from the previous step was used to generate 12 themes that are reflected in Appendix F, *Undergraduate Focus Group Qualitative Themes*. Through the process of recoding the data, the codes became more refined, resulting in a reduction in the number of codes so that the review of findings includes four themes that best represented the research study. The generated themes are used as headings in the findings section, Chapter 4: *Findings*, of the research study as they represented multiple perspectives and included quotations from participants (Creswell, 2009).

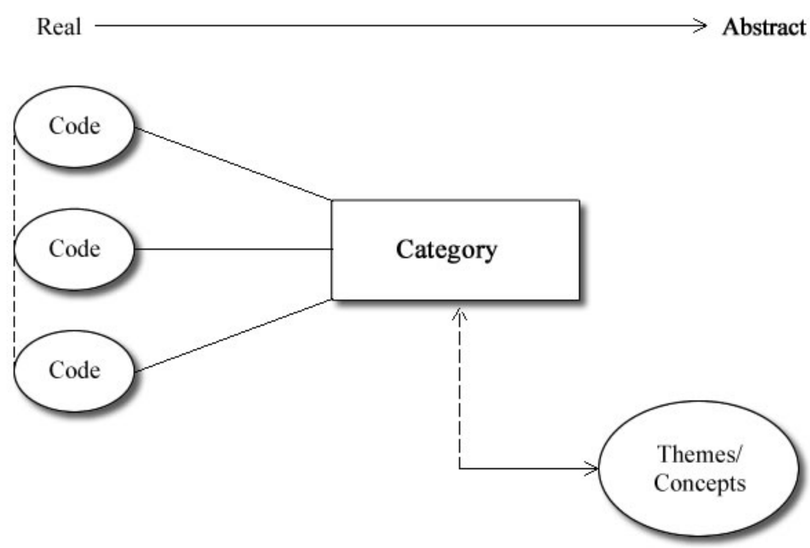



*Figure 4.* Codes-to-theory model for qualitative inquiry. Saldaña's (2009) codes-to-theory model for qualitative inquiry was a strategy used for analyzing the qualitative data.

6. *Validating themes*. A comprehensive review of the text stored in Microsoft Excel was conducted to ensure continuity among the themes. The original transcripts served as a reference point to validate the data. At this stage, a peer reviewer analyzed select transcripts and codes for additional theme validation. The theme validation process involved the emailing of focus group transcripts to a colleague to request that she review the text to confirm that the proposed themes were an accurate reflection of the stories shared by the female participants.

7. *Composing descriptions*. Narrative descriptions were used to represent the findings of the analysis. The descriptions included subthemes, multiple perspectives from individuals, and quotations. The process model titled

Sequential Exploratory Design (Fig. 2, *Sequential Exploratory Design qual➔QUAN*) was used as a visual to convey the text data (Creswell, 2009).

8. *Applying theory and literature*. Finally, there was a compare and contrast with the literature reviewed for the final evaluation of the assertions (Creswell, 2007). Factors that influenced enrollment in a collegiate STEM program were identified and described.
9. *Developing the survey*. The factors and comments were converted into survey questions and items that were used in the third phase of the study, quantitative data collection.

**Validation.** Three validity strategies were integrated into the qualitative research process.

1. ***Triangulation***. This process involved the examination of themes from different sources. The themes resulted from the focus group sessions, observation of the student participants, and a comparison of the findings to the literature reviewed in Chapter 2, *Review of Literature*.
2. ***Member checking.*** This process was accomplished by means of emailing student participants the themed passages in an effort to determine if the participants thought they were accurate.
3. ***Colleague validity.*** This process was implemented in order to enhance the accuracy of the study. A peer who holds a doctorate in education and has much experience with qualitative methodologies was asked to participate in the colleague validity process. The colleague reviewed the study and findings, asked

questions about the study, and interpreted the results from the perspective of someone who was not involved in the research process.

**Ethical Concerns**

Prior to launching the research study, approval was received from the Institutional Research Board (IRB) at the research site. The IRB reviews "...research projects that involve human subjects to ensure that subjects are not placed at undue risk, that they give informed consent to their participation, and that their rights and welfare are protected throughout the project" (Office of Research & Economic Development, 2013).

Participants in the research study were provided a certified, approved informed consent form that, if signed, indicated that they agreed to participate in the research study and had the option to withdraw from the study at any time. The backgrounds of the participants were reported in aggregate, describing the group as a whole, rather than describing each participant in order to protect their identity. As an additional protection of confidentiality, the research site was described by broad descriptors and it is not named. Since the research study was concerned with factors that influence and motivate female students to enroll and persist in collegiate STEM degree programs, which was not a particularly sensitive topic, it was not expected that participating in this study would have any negative impact on the participants. The focus groups were recorded on a digital recorder and then transcribed by a transcriptionist who had signed a confidentiality statement. The audio files and transcripts were stored on a password-protected computer in a locked office. The transcriptions will be kept no longer than three years beyond the conclusion of the study.

**Phase II: Instrument Development**

**Survey Instrument.** In a sequential exploratory research design model with an emphasis on quantitative data collection, there is reliance on the qualitative findings from Phase I in the development of the survey instrument (Creswell & Plano Clark, 2007). The themes and factors from Phase I were used to develop a survey instrument that was constructed to address the research question. The themes from the qualitative phase formed the basis of the survey instrument. The interviewees' language was used to phrase some of the questions. The survey administered to the participants consisted of 15 questions that were a combination of (a) the Motivated Student Learning Questionnaire, (b) the questions developed from the findings from the qualitative phase, and (c) a demographic section.

***Motivated student learning questionnaire (MSLQ).*** Pintrich, Smith, Garcia, and McKeachie (1991; 1993) developed the Motivated Student Learning Questionnaire (MSLQ) at the National Center for Research to Improve Postsecondary Teaching and Learning, which is located at the University of Michigan, to assess college students' motivational orientations and their use of different learning strategies.

There are two sections and 81 items in the MSLQ, which can be used by researchers independently or as a whole. Section One of the MSLQ focuses on motivation and self-confidence, and the second section focuses on learning strategies. For this study, the eight items relating to motivation and self-confidence were used. In order to measure the STEM motivation of the students, the concept of STEM was integrated into the MSLQ. To add the domain of STEM to the instrument, the survey was modified to replace the generic label "class" with "STEM Major," as illustrated in Table 9, *Motivated Student Learning Questionnaire Statements*. The survey questions employed a 7-point Likert scale to evaluate a student's learning motivation. Participants rated eight statements on a 7-point scale where 1= not at all true of me to 7=very true of me.

Table 9

Motivated Student Learning Questionnaire Statements

| | |
|---|---|
| 1. | I believe I will receive an excellent GPA in my STEM major. |
| 2. | I'm certain I can understand the most difficult material presented in the readings for my STEM major. |
| 3. | I'm confident I can understand the basic concepts taught in my STEM major. |
| 4. | I'm confident I can do an excellent job on the assignments and tests in my STEM major. |
| 5. | I am confident I can understand the most complex material presented by the faculty in my STEM major. |
| 6. | I expect to do well in my STEM major. |
| 7. | I'm certain I can master the skills being taught in my STEM major. |
| 8. | Considering the difficulty of the courses, the teachers, and my skills, I think I will do well in my STEM major. |

*Note.* The eight statements from the Motivated Student Learning Questionnaire that were integrated into the survey instrument.

*Rationale.* The MSLQ survey was chosen as an instrument to be administered in Phase III of this research study. The MSLQ was used as a tool to test for female self-confidence as it relates to motivation and persistence. In past research studies, the MSLQ was administered to first-year engineering students enrolled at Colorado State University to determine the effects of pre-collegiate engineering experience on student self-confidence (Fantz et al., 2011). The researchers hypothesized that "…the greater the rigor of a pre-collegiate experience, the more it will contribute to a student's self-efficacy related to engineering studies" (Fantz et al., 2011, p. 604). Fantz et al. (2011) concluded that greater focus should be placed on developing K-12 technology and pre-engineering teachers, as they influence the success of students. In 2000, Joo, Bong and Choi explored the effects of student motivation on performance as it relates to web-based instruction. The researchers administered the MSLQ to junior high school students ($N$=152) who were participating in web-based instruction to explore the relationship among the motivational variables that were indicative of influencing students' learning and performance (Joo et al., 2000). The researchers found a positive relationship between students' self-confidence and performance. Joo et al. (2000) concluded that students who had earlier experiences and exposure to the information performed better when tested. The researchers called for greater access to pre-collegiate STEM programs in younger years and teacher awareness of student progress in these programs.

**Six Newly Developed Questions.**

***Rationale.*** The themes that emerged during the qualitative phase were used to develop a questionnaire that represents the point of interface where the qualitative and quantitative meet (Creswell & Plano Clark, 2007; 2011). The second half of the survey consisted of nine questions that reflected the themes shared by focus group participants about the factors that influenced their decision to enroll and persist in a collegiate STEM program.

***Instrument Questions.*** The nine newly developed question answer types were structured as response items that included a 7-point Likert scale, dichotomous answer type (Yes or No) question, and multiple-choice items. The items are listed on the next page in Table 10, *Survey Instrument: Themes, Variables, Survey Items, and Response Items*. The themes from the qualitative phase evolved into variables that were included in the collection of quantitative data. For example, to test for the theme altruistic, the variable 'altruism' was included in the survey instrument and respondents were asked, "is it important to you to have a career that positively impacts society?".

**Assumptions**

Three assumptions were made throughout this research study.

1) The first assumption was that all of the participants in the study were female students.
2) The second assumption was that the female students who participated in the focus group session, Phase I, had freshman class standing (0 – 26 credit hours) and were enrolled in a collegiate STEM program.
3) The third assumption was that the female students who completed the survey and were in the sample population from which the quantitative data, Phase III, were collected had sophomore, junior, or senior class standing (27 plus credit hours) and were enrolled in a collegiate STEM program.

Table 10

Survey Instrument: Themes, Variables, Survey Items, and Response Items

| Theme | Variable | Survey Item | Response Item |
|---|---|---|---|
| Altruistic | *Altruism* | Is it important to you to have a career that positively impacts society? | Yes or No |
| Influential Stakeholder | *Self-confidence and motivation, Desire to succeed, Career Path* | What are the reasons why you chose this major? | I enjoy math<br>I enjoy science<br>I see great career opportunities<br>I want to help others<br>I think that there are great salary opportunities<br>I appreciate the job security<br>This field interests me<br>I was good at math and science, Personal capabilities<br>Preparedness to succeed<br>Desire to pursue this major |
| Grades | *Grade Perception Gender* | Do grades matter to you?<br>Do you feel grades matter more to your male peers than they do to you? | Yes or No<br>Yes or No |
| How to Influence Females into STEM | *Pre-collegiate STEM exposure Influential Stakeholder* | What is the primary factor that influenced you to enroll in a collegiate STEM major? | I am good at math and science<br>My mother or father work in a STEM field<br>I attended a science summer camp and I really liked it<br>I attended a pre-engineering and technology high school<br>I participated in math and science focused extra-curricular activities<br>I wanted career options<br>My school counselor encouraged me<br>My high school teacher encouraged me |
| Self-confidence to Enroll and Persist | *Self-confidence and motivation* | What influences keep you motivated in this major? | Career goals<br>Parents/Family<br>Faculty<br>Challenging major<br>Friends<br>Personal Motivators<br>Desire to pursue this major |
| Effect of Parents' Highest Level of Education on Student's ACT and GPA | *Parent Education Student ACT Student GPA* | What was your composite ACT score?<br>What is your GPA?<br>What is the highest level of education completed by your parents? | Self-Reported Data |

*Note.* The themes, variables, survey items, and response items that were used to develop the survey instrument.

**Phase III: Quantitative Research**

The benefit of a quantitative phase of a mixed methods research study is that it increases the sample population, which provides an opportunity to generalize the results (Creswell & Plano Clark, 2007). The collection of quantitative data was framed by the positivist paradigm as it focused on (a) experimental testing of the hypothesis, and (b) cause-and-effect analysis of the research questions.

**Positivist paradigm**. Creswell (2009) described the positivist paradigm of quantitative research as "a means for testing objective theories by examining the relationship among variables…[variables] can be measured …so that numbers can be analyzed using statistical procedures" (p. 4). For example, in the effort to determine the factors that influence female students to enroll and persist in collegiate STEM programs, a positivist research design approach focuses on the cause-and-effect relationship among female students' participation in pre-collegiate STEM activities and enrollment in collegiate STEM programs. This approach limits the study so that the researcher makes the assumption that one action causes another.

**Sampling Method**

Collins, Onwuegbuzie, and Sutton (2006) explained that to optimize the sample size in a mixed methods research study, the number of participants involved in the study should be increased. Because of this, the research study was expanded to a larger population. Participants in the third phase of the research study were upper-class (credit hours earned reported as 26 plus) undergraduate female students who had declared a

STEM major. Appendix G includes the email that was sent to all upper-class undergraduate female students inviting them to participate in the study.

**Incentive.** In this study, approximately 35% of the sampled population (*N* = 800) responded to the survey invitation. As an incentive to participate in the research study, students who completed the survey were entered into a raffle to win an iTunes gift card amounting to $30.00. It was explained to the sample population that the overall odds of winning the iTunes gift card were dependent on the number of people who participated, but they had at least a 1 in 1000 odds of winning. In order to determine the winner of the gift card, a random uniform number was generated. Participant number 40 was randomly chosen as the recipient of the $30.00 Apple Store gift card. Each participant who completed the survey had equal probability (.003401361) or .34% chance of winning the Apple Store gift card. The recipient number was randomly generated as a number between 1 and 294.

## Sample Population

On the next page in Table 11, *Major and Corresponding Response Rate,* the survey response rate for the sample population (*N* = 278), which comprised 32% sophomores, 30% juniors, and 38% seniors are reported. The average grade point average (GPA) of the sample population was 3.53 with a range of 2.0 – 4.0. Twenty-three STEM majors from MU were represented in this research study. The three STEM majors with the highest response rate were Biological Sciences (*n* = 45), Animal Science (*n* = 34), and Biochemistry (*n* = 28).

Table 11

Major and Corresponding Response Rate

| Major | Number of Responses |
|---|---|
| Actuarial Science | 18 |
| Agricultural Engineering | 2 |
| Animal Science | 34 |
| Architectural Engineering | 18 |
| Biochemistry | 28 |
| Biological Sciences | 64 |
| Biological Systems Engineering | 1 |
| Chemical Engineering | 11 |
| Chemistry | 3 |
| Civil Engineering | 25 |
| Computer Engineering | 6 |
| Computer Science | 8 |
| Construction Engineering | 3 |
| Construction Management | 4 |
| Electrical Engineering | 6 |
| Electronics Engineering | 5 |
| Industrial and Mgmt. Systems Eng. | 4 |
| Industrial Engineering | 1 |
| Mathematics and Statistics | 19 |
| Mechanical Engineering | 13 |
| Physical Science | 0 |
| Physics and Astronomy | 3 |
| Water Science | 2 |
| Total | 278 |

*Note.* The survey response rate is reported along with the corresponding undergraduate STEM major.

## Data Collection

Data were collected using an online survey tool as opposed to a paper and pencil method. The online survey tool provided a convenient method for participants to respond, a reliable method for the researcher to export the data, and a standardized approach for data collection. The survey was administered electronically through Qualtrics, which is a web-based research surveying software that allows for designing, distributing, and analyzing survey data. Data were securely stored in compliance with federal law, the Family Educational Rights and Privacy Act (FERPA), which protects the privacy of student education records (Qualtrics, n.d.). Personalized email invitations were generated in Qualtrics and sent to all eligible participants in the sample population. The initial email message launching the survey was sent to the sample population on November 26, 2012. Follow-up email messages were sent to non-respondents in the sample population encouraging them to participate in the research study.

## Data Analysis

**Data Cleaning.** Statistical Package for the Social Sciences (SPSS) version 21 and Microsoft Excel software were used to analyze the data collected for this study. An exploratory data analysis, along with descriptive statistics, was used to determine the following:

1. Problems with the data such as missing values, non-normal distributions, and outliers;
2. Relationships among the variables; and

3. Assumptions to be verified so that inferential statistics could be used in the analysis of data.

As reported in Table 12, *Quantitative Data Cleaning Procedures*, the data were reviewed by running descriptive statistics, examining missing data, and checking frequencies. Additionally, newly created variables were tested for their reliability by analyzing the Cronbach's α, which measures the survey instrument for internal consistency of a test or scale.

Table 12

Quantitative Data Cleaning Procedures

| Data Cleaning | Description |
|---|---|
| Conducted data screening | Descriptive statistics, listwise deletion, and frequencies |
| Cronbach's α | Provide an estimate of the reliability of a psychometric test |

*Note.* The quantitative data were reviewed through an analysis of descriptive statistics, running of frequencies, and testing for reliability.

**Data Review.** On the next page, Table 13, *Summary of Deleted Cases*, reflects the results of cleaning the data and is displayed on the next page. When the survey was launched in fall 2012, 294 upper-class undergraduate female students enrolled in a STEM degree program had started the survey, but only 276 had completed it.

Given the small sample population, advanced statistical analysis was not a viable option. Reported findings focused on the results as provided by Qualtrics. The reported results include mean, variance, standard deviation, frequency, and descriptive statistics.

Table 13

Summary of Deleted Cases

| Process | Count |
|---|---|
| Total Cases in Database | 294 |
| Incomplete Cases | 18 |
| Total Cases Used | 276 |

*Note.* Two hundred and ninety-four undergraduate females enrolled in a collegiate STEM degree program attempted the survey and 276 of them completed it.

**Ethical Concerns**

To protect the rights of the sample population, a disclosure statement was included in the email invitation that was sent to students stating: "You, the student, may refuse to participate without any loss of benefit, which you are otherwise entitled to. You may also refuse to answer some or all the questions if you don't feel comfortable with those questions. All responses will be kept confidential." Appendix H contains the certified IRB that was provided to each participant. As stated in the informed consent form, consent to participate was implied in completing the online survey. The backgrounds of the participants were reported in aggregate, describing the group as a whole, rather than describing each individual in order to protect their identity. The researcher did not collect identifiable information, including Internet Protocol (IP) addresses. As an additional protection of confidentiality, the research site was described by broad descriptors and is not named. The research study was concerned with factors that influence and motivate female students to enroll and persist in a collegiate STEM degree program, which was not a particularly sensitive topic; therefore, it was not expected that participating in this study had any negative impact on the sample population. The data were stored on a password-protected computer in a locked office and will be kept no longer than three years beyond the conclusion of the study.

**Phase IV: Synthesis**

**Mixed Methods Analysis.** The data were collected in a sequential research design. The qualitative study data were collected and analyzed before the design and construction of the survey instrument. The quantitative results were used to confirm and prioritize the recommendations from the qualitative phase. The results from Phase III of the study confirm the findings from Phase I of the study. In summary, the findings from both the qualitative and quantitative phases provide insight into the factors that influence and motivate female students to enroll and persist in a collegiate STEM degree program. The findings from the research study will be reported in Chapter 4: *Findings*.

# CHAPTER 4: FINDINGS

## Research Study

This research study addressed the national concern that there are too few females enrolling in collegiate STEM degree programs by exploring the factors that influence and motivate female students to enroll and persist in collegiate STEM programs. The research question framing this study was: What are the factors that influence and motivate female students to enroll and persist in collegiate STEM programs? The research study was structured as a sequential exploratory mixed methods design organized into four phases:

- (I) collection and analysis of qualitative data through female student engagement in focus group sessions;
- (II) development of a survey instrument that was the product of combining two independent surveys: (a) a survey that was the product of findings from the qualitative phase, Phase I, and (b) the second survey that was the pre-existing Motivated Student Learning Questionnaire;
- (III) collection and analysis of quantitative data through the review of survey findings; and
- (IV) synthesis of the findings.

The study was organized so that the pre-collegiate STEM experiences of female students enrolled in collegiate STEM degree programs at a public Midwestern university could be explored. This chapter provides a detailed account of the findings from Phase I (qualitative data collection) and Phase III (quantitative data collection).

**Purpose**

The purpose of this chapter is to report the findings from this research study, which focused on identifying the factors that influence and motivate female students to enroll and persist in collegiate STEM programs. The chapter is arranged so that the findings from the first phase of the research study, Qualitative Phase, and the findings from the third phase of the research study, Quantitative Phase, are reported.

**Phase I: Qualitative**

**Participants.** A total of 13 first-year female freshmen enrolled in STEM degree programs participated in the focus group session during fall 2012. The majors represented in the focus group include: Actuarial Science ($N = 1$), Architectural Engineering ($N = 5$), Biochemistry ($N = 1$), Biological Sciences ($N = 3$), Biology/Pre-Medicine ($N = 1$), and Computer Engineering ($N = 2$). Eleven of the participants reported their race as white while the remaining two classified themselves as Omani or African American/Black. The majority of participants were in-state students as they were residents of the state of the Midwestern university. All focus group participants reported that the highest level of education in their family was at least a four-year college degree. When asked to report their mother's highest education received, 85% reported at least a college graduate; for their father's highest education received, 77% reported at least a college graduate. Twelve of the 13 participants reported their socio-economic status as at least middle class with 42% as upper-middle class.

The following research questions drove the collection of qualitative data.

**Research questions.**

1) Which pre-collegiate experiences influenced females to enroll in a collegiate STEM degree program?
2) Which stakeholders influence collegiate females in their decision making process?
3) Does entering a career that helps others matter to female students?
4) How can confidence be instilled in females so that they can persist in collegiate STEM programs?
5) What can educators do to recruit more females to STEM degree programs?

## Findings

**Themes.** The themes that emerged during the collection of qualitative data were formulated into a model, as shown in Figure 5 on the next page, that identifies the influential factors for females in STEM collegiate degree programs. Female focus group participants shared stories of pre-collegiate experiences that had influenced their decision to enroll and persist in a collegiate STEM degree program. Figure 5, *Influential factors for females*, illustrates the components that were considered as influencing and motivating female students to enroll and persist in a collegiate STEM degree program: altruism, career pathways, confidence to enroll and persist, and pre-collegiate STEM exposure. The model represents the key components narrated by first-year female freshmen who participated in the focus group sessions when asked why they enrolled in a collegiate STEM degree program. The comments recounted below are from focus group participants and are representative of the stories told during the sessions.

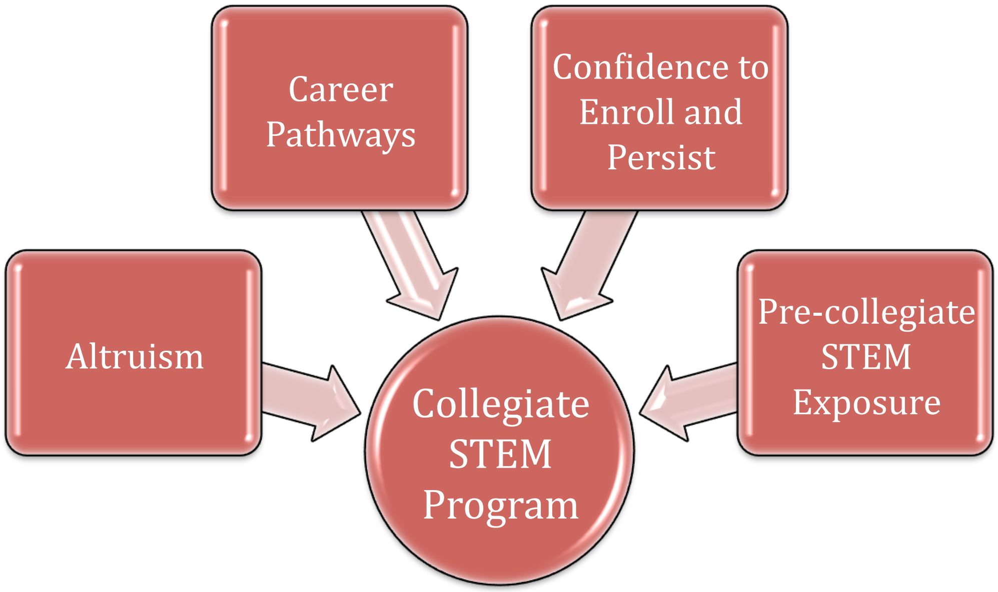



*Figure 5.* Influential factors for females. This figure illustrates the four influential factors reported by undergraduate females who participated in the focus group sessions.

***Altruism.*** According to a report from Modi, Schoenberg, and Salmond (2012) of the Girl Scout Research Institute entitled "Generation STEM: What Girls Say about Science, Technology, Engineering, and Math" (2012), 90% of girls want to help people and make a difference in the world, yet only 13% of them identify a STEM career as a way to make that dream a reality. In this research study, almost one-third of the focus group participants spoke of their desire to have a career where they made a difference in the lives of others. By connecting how a career in STEM can help people and make a difference in the world, more female students may become interested in the collegiate degree program. One participant said, "… I love biology, because of the future, all of the great things that can come out of being a doctor… getting to help people, there's a lot of benefits." Some participants acknowledged that having a career in STEM may better society even though it may not be apparent. "People don't come into this room and say, 'they did a really good job making sure this room can stand up with the structure and temperature.' They don't think about that; you're affecting them even though they don't realize it." Another student articulated, "I want a job where I can help people and I'm taking care of people." This sentiment was echoed by her peer who vocalized, "I'm a people person, I like people. I want a job where I can help people and I'm taking care of people."

***Confidence to enroll and persist.*** Focus group participants were asked about what motivates them to persist when they are feeling inundated by homework, work, and other external factors. Overwhelmingly, the focus group participants expressed how their (a) passion for having a career in STEM, (b) support received from influential stakeholders (parents and/or teachers), and (c) confidence in their math and science ability motivated them to persist through obstacles faced.

*Passion for STEM.* One participant expressed, "I love biology, for whatever reason. I'll take whatever else I have to take to get to it. I've always wanted to go to medical school." Focus group participants expressed how they persisted as a minority in their math and science courses because they were confident they could be successful. While one participant described how she overcame the struggles of a difficult course as:

> I'm not going to lie, I really struggled in calculus last year and thought, if this is what it's going to be like and I have to struggle every single day, I don't know. Struggles are part of life and I looked past it. Like you said earlier, it's more focused on the ultimate goal. You have to keep focus that it gets better. I can do this. I think they go hand-in-hand, getting good grades and the confidence. Obviously, if you get bad grades, you're not going to have the confidence there.

> But there's still people who get good grades but still don't have the confidence to do it. One doesn't cause the other; you have to have both.

*Support from influential stakeholders***.** For some participants, the confidence to enroll and persist despite obstacles faced came from supportive stakeholders – parents, friends, and teachers. For one participant, the confidence to persist despite obstacles faced came from her mother. The student recalled,

> My mom…calls me once a week and tells me, 'you can do it, what's going on, you need to keep it up.' She always tells me I can be a doctor if I want. 'Just put in the work for it, I'll make it happen for you; get you a tutor, whatever you need.'

***Influential stakeholder***. Focus group participants were asked if there was a particular moment that stood out for them as to when they decided that they wanted to pursue a collegiate STEM degree program. Further questions led to inquiring if there was an influential stakeholder who had guided their decision by piquing their interest in a STEM degree program. In response to the questions asked of the participants, there were two primary influential stakeholders, parents and teachers, who affected the participants' decision to enroll and persist in a collegiate STEM degree program.

*Parent.* Participants articulated the degree to which their parents influenced their decision to enroll in a collegiate STEM degree program as (a) the student wanted a career like their parents, or (b) the parent advised the student to explore a career path in a STEM field. One participant recounted, "[my] parent's friend exposed me [to STEM careers]. I went to their work and looked into what they did. It seemed really interesting to me." Many students commented that either their mother or father worked in a STEM field and that having access to information about these careers influenced their decision to enroll. One student stated,

> Dad is a civil engineer so when I was in 7th and 8th grade, I loved making floor plans. I was like, 'I'm going to be an architect!' Obviously, being an engineer he was like, 'No! You can't be an architect! How about architectural engineering?' I said, 'Yeah, that's exactly what I'm going to do.' I didn't really know about it until visits [at the university] and stuff. Every time I learned more about it I was like, this is the perfect fit for me. 'Yes!' It's just, I went almost half of my life saying that was what I wanted to do and I didn't even know.

One female freshman participant mentioned, "[I] really fell in love with it [math and science] when I was little." Another participant expressed the particular moment that stood out for her as affecting her passion for STEM as "…[I] started loving sciences when I started getting good grades in it." Other participants acknowledged that they were influenced by the passion held by others. One participant recalled how her parent served as an influential stakeholder:

> My dad is an engineer and he's been pushing for one of his kids [to be an engineer]. I didn't necessarily want to do it when I was in high school and I didn't really have any idea what he did. He works at [an engineering company], so some of the things he does he can't tell me. I'm going; 'Your job must be really boring; I don't want to do that' [then] I came across computer engineering. One of my teachers told me about it. It sounded interesting.

Another focus group participant had a similar experience, so when asked if her parents influenced her decision, she responded,

> I took it from my father. It's funny because he's a petroleum engineer but he loves architecture. Not architectural engineering, just architecture. He loves to design so he designed our house, and his friends' house, and my aunt's house. The house is really creative, so every time I look at it like, so, we talk about it.

One participant described a conversation about possible college majors that she had with her parents.

> I always knew I loved math. Through high school it was either a field in medicine… [or] engineering. When it comes to college and scholarships, they had found out through work friends, that it [engineering] was a field not a lot of girls were in, there were definitely scholarships for it. My parents said, 'check it out,

> and see if it's something you'd be interested in.' At first, when I Google [d] it, I saw chemical engineering, which I wanted to look into. There were a lot of different things but nothing really clicked. Then I saw architectural engineering. When I finally figured it out, it was the best option for me.

*Teacher.* Participants expressed how their formal and informal interactions with their teachers affected how they felt about courses (i.e., math or science) and their interest in collegiate majors. One participant recalled the experiences she had as a sixth grader in math class that influenced her choice of major: "The last time I had a woman math teacher was in sixth grade; she was my favorite teacher. That was when I realized I was good at math. When I was getting over 100 percent in class, she actually moved me up a grade in math, so that definitely started my process. After her I've had all male teachers; it's been an all-male field for me." Additionally, the excitement generated by teachers in the classroom affects the students' perception of the course material in turn.

> She was our chemistry teacher and she was the greatest; she made me love chemistry. She was one of those inspiring people. I talked to her a lot about what I wanted to go into and how hard it was. She said, 'you can do it.' I go back and visit her sometimes. She had such a bright personality and she's spunky. So, she'd have little weird happy dances and stuff like that to make the class fun. She got everyone to put forth their answers and participate in class so that was helpful. That class was really like a family in a way.

Another participant disclosed how she overcame the frustrations of not succeeding as "a bad grade just told me I needed to take on the challenge more. I didn't feel necessarily discouraged; I just needed to work harder because I know that I can do it." One participant, a graduate of an all-female high school, recounted that "our teachers have always pushed on us, young independent thinking women, leaders. That's the values they've always instilled in us, that we can do whatever we want and succeed."

A focus group participant recalled how beneficial it was for her when her teacher provided the class with an opportunity to learn about careers in math and science. The female participants shared how having real world applications for math and science that connected the academic courses to career opportunities made it more appealing for them as a collegiate degree option. One participant vocalized, “The only reason I went into engineering is because our physics teacher had a lot of speakers come in [to share] ‘Here’s what our engineering students do on a day-to-day basis’. One participant called for an application of the classes taught in secondary school, “if they [teachers] would just explain what you would use this information [and] how you can apply it.”

For another student, taking time to meet with her teachers to talk through her interests influenced the major that she chose.

> Well, I didn’t really know what it was until I sat down and talked to my physics teacher and my guidance counselor about it [architectural engineering]. I want to do architecture, but I really want to involve more math and science…I’ve always had math and science there and so I don’t want to just drop it behind.
>
> Two participants chronicled how their teachers’ excitement engaged the class:
>
> My physics teacher is the one who influenced me the most in science. He loved it and he would start explaining, then he’d keep explaining past what he should have stopped at. We’d be learning more and more and more. He’d be so happy going on and on, then he’d realize, ‘You aren’t in that class, let’s go back.’ He would explain it to everyone. I was one of two girls in my AP physics class. He didn’t treat us any differently and he explained everything to us the same as the rest of the class. There was a little separation with the rest of the class when grouping because we’re girls. Other than that, all the teachers that I had have treated the whole class the same because we were all there to learn.
>
> I really liked my eighth grade science teacher. You could tell she loved science and what she did. We did a lot of experiments and dissections and I really loved doing hands-on kind of things instead of reading out of a textbook and learning that way. I like learning the material and then getting to apply it.

One participant recalled how she benefited from her teacher going the extra mile by introducing new concepts to the class:

> I've had teachers who teach us stuff that we didn't actually have to know. They thought we would find it interesting so they took the extra time to find the YouTube video or to find this or that to show to us to make it more interesting. My calculus teacher taught me Pre-Calc [Calculus] and Calc [Calculus] I; she would take time to share, 'I found a music video about Pi' or 'I found this about fractals'. Stuff that we didn't have to know but background things, which made it more interesting and would make someone want to do it as a career.

A participant shared how having a high school teacher who called upon the students to not just know the concepts, but to apply their knowledge to real world case studies, piqued her interest in the sciences.

> My biology, psychology, and anatomy professor was really good at what he did. A lot of students didn't like his way of teaching because it was almost like a college professor. He would lecture; he would go off on a tangent on some random story. Where other people saw that he put the lesson into the story so you could remember it. I think the way that he taught, even on his tests, it wasn't what did you know, it was if you could take that knowledge and apply it to different concepts. That's why a lot of the people didn't like those classes, but I found it really helpful in biology because that's what the tests are here in college. He really prepared me for biology.

*Confidence in math and science ability.* A participant described her surprise in learning how supportive the physics faculty were during a college visit and how their encouragement motivated her to enroll.

> I found that the [physics] professors, instead of being, 'You're a girl, you might not make it,' they were very accepting and helpful because I was a girl. They were trying to help me out even more because it is a male- dominated field.

Female participants recalled how they relied on their confidence in their ability to be successful despite the uneasy feeling they had when visiting with faculty and colleges or being the only female in a class of males.

> [I was] not discouraged, but I definitely had teachers, or [when] visiting colleges where the professors thought that coming in as a woman you're already a step behind the bar with the rest of the people. Even based on appearance and how you come off, they already are judging you as opposed to looking at your academic [record] and your resume. In that aspect, I was a bit discouraged. I also knew that academics-wise and grade-wise it stands for itself. If my appearance wasn't what they considered engineering, I can definitely prove myself through my grades and my work ethic.

> I was in a mechanical drafting class and there were all boys and I was the only [girl]. I kind of wanted to drop the class, but after learning about the technology I started getting it. I thought, 'you don't need to be a boy to go into a logistic class.'

One female discussed the difficulty faced in advanced math and science coursework.

> I think many people like what is easy. You do this, and that's it, something that is easy. Math and science are hard, when I tell people I'm a biochemistry major, they're like, 'ooooh, you're smart.' I'm thinking maybe I am but maybe not. They have that mindset that biology and math are hard and they cannot do it, so they'd rather do the easy stuff.

***Pre-collegiate STEM exposure.*** Focus group participants were asked if they participated in a pre-engineering and technology curriculum in high school, math and science-focused after school programs, engineering summer camps, or any STEM-related programs in high school. Undergraduate females shared that they participated in robotics competitions, attended math days at the university, and took part in high school field trips to science labs. Figure 6 displays influential pre-collegiate activities shared by undergraduate females.

One participant described her STEM experiences outside of the classroom as,

> We [science class] took a field trip to the [science] lab. We listened to five different people who work in different parts in that lab. They do something with blood and our science teacher took us there so we could see different opportunities and if we would like to work there. It was interesting to learn about career opportunities out there and how you can apply science.

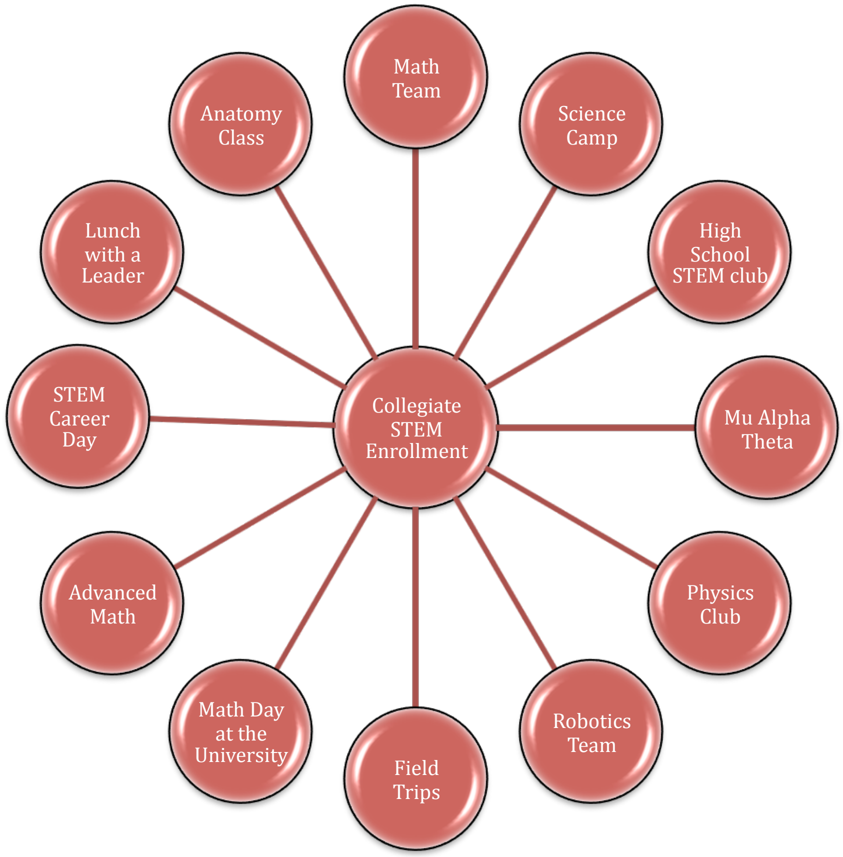



*Figure 6.* Influential pre-collegiate activities for female undergraduates. This figure illustrates the pre-collegiate STEM experiences that were influential as reported by undergraduate females.

Another focus group participant described the competitive nature of her class assignment and how it engaged both girls and boys. "In anatomy class for dissecting cats, we had a race. There was a group of girls and a group of boys. Sometimes the girls would win and sometimes the boys would win." The female student reflected on how the teacher's integration of a competitive activity in the anatomy class stood out as a moment that influenced her decision to enroll in a collegiate STEM degree program.

***Career pathways***. Overwhelmingly, participants called for educators to talk about careers in STEM – for example, how taking an advanced calculus course can lead to a career in architectural engineering where you are designing the acoustics of a skyscraper in Dubai. Focus group participants were asked what educators could do to increase the number of girls going into STEM programs. The participants responded that there needs to be both early exposure to career opportunities and linking of the coursework with a career path. One participant commented,

> When we're young, you learn about, this is what a doctor does, or you can be a writer. No one ever says anything about engineering. Match the person to what their job is. The doctor you line them up to the hospital. From a very young age, you see fire trucks, you see firemen, you see all of these different things, but you don't see engineers in there.

Multiple participants remarked on the benefit of having guest speakers from diverse careers visit class, as these speakers provide a link between coursework and career options. One participant explained, "the only reason I went into engineering is because our physics teacher had a lot of speakers come in. [Explaining] here is what our engineering students do on a day-to-day basis." Another participant recommended that elementary age students be exposed to STEM activities, as they would benefit from engaging in these experiences at an earlier age.

> I guess they [educators] told us what it [career options] was when we were younger, saying 'I want to be a doctor'…maybe if there were more awareness, every little kid knows what a doctor is. But there are not many kids who know what an engineer is. I think if we knew what it was when we were younger and it was an option for years before. I probably said I wanted to be a doctor at some point. What little kid doesn't? If engineering was an option like that, I think we [females] would look into it. I think if they targeted the all-girls schools. I'm the only person from my class, there were only 74, but I'm the only person that went into a math or science field. I don't know if the statistics are like that for the other schools.

Another participant reflected,

> At my high school they took us to a career fair at [university] and it was really helpful because there were a lot of jobs that were what people in our high school wanted to do.  It wasn't just, be an English major, you can be a writer. It was this is a contractor, this is an engineer, real tangible jobs you can see yourself doing. The fact that they took us there, they didn't have people come into talk to us, but it was more of you had to go and learn to talk to the people and get ahead in what you wanted to do.

Multiple students mentioned the benefit of having an understanding of the application of their current course work. One participant noted that "if they [teachers] would just explain what you would use this information for, how you can apply it." Another participant voiced the benefit of attending a school that pushed the female students into collegiate STEM degree programs: "I went to an all-girls school and every single person in my physics class either went into math, computers, or science. Our physics teacher…really pushed us into engineering or some kind of science field."

Yet another participant commented,

> There was an architectural engineering subgroup in camp. That was junior year going into my senior year when I was just starting to look into it [college majors]. It definitely helped me to get a clear picture of what I would be doing. Beforehand, searching any kind of engineering I was hazy on what they [engineers] would actually do. It gave a description, but it wasn't a very clear view of it. So, the summer camp definitely helped put things into order of what I would be doing. Otherwise in school I took a lot of construction and drafting classes, which helped as well.

Multiple participants communicated how they were exposed to STEM careers. Participants commented: "at my high school they took us to a career fair and [I] was exposed to actual careers," "at our school we had Lunch with a Leader," and "once a month we have [alumni] come in and talk about a wide variety of different careers that they were doing." Another participant shared that her high school hosted a robotics competition.

> They [high school] have competitions and you build a robot. There's some new task; one year you had football-shaped balls and several different shapes and you had to get them all over the wall. Another year you had to score in goals and things like that. It was really cool. I would hear about robots being used in other places. At one point I was really interested in being an archeologist as they use robots in archeology.

**Phase III: Quantitative**

**Sample Population.** As reported in Table 14, *Sample Population's Demographics*, a total of 276 upper-class undergraduate female students enrolled in a collegiate STEM degree program during the fall and winter 2012 completed the survey. The average grade point average (GPA) of the sample population was 3.53 with a range of 2.0 – 4.0. The ACT assessment test score ranges from 1 – 36. The sample population reported scores that ranged from 24 to 36, with the majority (n = 146) reporting a 30 or above composite score.

Table 14

Sample Population's Demographics

| | | |
|---|---|---|
| Class | | |
| | Sophomores | 31% |
| | Juniors | 30% |
| | Seniors | 39% |
| State of Residence | | |
| | Nebraska | 75% |
| | Iowa | 2.5% |
| | Minnesota | 3% |
| | Other | 19.5% |
| Ethnicity | | |
| | White | 84% |
| | Asian | 9% |
| | Hispanic/Latino | 3% |
| | African American | 2% |
| | Multiracial | 1% |
| | Other | 1% |

*Note.* Two hundred and seventy-six undergraduate females enrolled in a collegiate STEM program completed the survey. Demographic information for this sample population is shared.

**Research Questions.**

1) What are the primary influences for female students to enroll in collegiate STEM degree programs?
2) Do females enrolled in a collegiate STEM degree program report high levels of self-confidence as it relates to their expected success in the degree program?
3) What are the primary influences that keep female students motivated in a collegiate STEM degree program?
4) What is the primary factor that influenced female students in their decision to enroll in a collegiate STEM degree program?
5) Does it matter to females enrolled in a STEM degree program if they are making a difference in the lives of others?
6) Are grades of greater importance to females than their male peers?

**Findings.** The following section addresses the six research questions that drove the collection of the quantitative data.

1) What are the primary influences for female students to enroll in collegiate STEM degree programs?

The sample population was asked to rate the factors on a 7-point Likert scale, with 7= very true of me and 1= not at all true of me, that influenced their decision to enroll. As reported on the next page in Table 15, *Factors that Influence STEM Enrollment*, survey respondents ($n = 287$) rated the statement *this field interests them* ($M = 6.37$) as the most influential factor. While *wanting to help others* was reported as a strong contributor to influencing enrollment decision (*M* = 6.21), there were three factors that were rated in close proximity to each other: being *good at math and science* (*M* = 6.11), confidence in personal capabilities (*M* = 6.09), and having a desire to pursue a STEM major (*M* = 6.07). Factors such as career (*M* = 6.00) and salary (*M* = 5.72) were not as highly rated, but were still above the average rating of 3.5.

Table 15

Factors that Influence STEM Enrollment

| Factor | Mean |
|---|---|
| This field interests me | 6.37 |
| I want to help others | 6.21 |
| I was good at math and science | 6.11 |
| Confidence in personal capabilities | 6.09 |
| Desire to pursue this major | 6.07 |
| I see great career opportunities | 6.00 |
| Preparedness to succeed | 5.92 |
| I enjoy science | 5.84 |
| I appreciate the job security | 5.77 |
| I think that there are great salary opportunities | 5.72 |
| I enjoy math | 5.57 |

2) Do females enrolled in a collegiate STEM degree program report high levels of self-confidence as it relates to their expected success in the degree program?

The sample population (*n* = 294) was asked to rate their level of confidence as it relates to statements regarding their expected success as a collegiate STEM major, as reported in Table 16, *Undergraduate Female Self-confidence as it Relates to STEM Major*. The average rating was 5.61 on a 7-point Likert scale, with 7 representing very true of me and 1 representing not at all true of me. The statement *I'm confident I can understand the basic concepts taught in my STEM major* had a mean rating of 6.33. The sample population rated the statement *I'm certain I can master the skills being taught in my STEM major* with a mean rating of 5.88. For the statement *I am confident I can understand the most complex material presented by the faculty in my STEM major*, the sample population gave their confidence for their level of success a mean rating of 4.98.

Table 16

Undergraduate Female Self-confidence as it Relates to STEM Major

| Statement | Mean |
|---|---|
| I'm confident I can understand the basic concepts taught in my STEM major. | 6.33 |
| I expect to do well in my STEM major. | 5.92 |
| I'm certain I can master the skills being taught in my STEM major. | 5.88 |
| Considering the difficulty of the courses, the teachers, and my skills, I think I will do well in my STEM major. | 5.80 |
| I believe I will receive an excellent GPA in my STEM major. | 5.49 |
| I'm confident I can do an excellent job on the assignments and tests in my STEM major. | 5.44 |
| I'm certain I can understand the most difficult material presented in the readings for my STEM major. | 5.06 |
| I am confident I can understand the most complex material presented by the faculty in my STEM major. | 4.98 |

3) What are the primary influences that keep female students motivated in a collegiate STEM degree program?

When the sample population was asked to rate the primary factors that keep them motivated in their major despite obstacles faced, respondents ($n$ = 279) overwhelmingly replied that career goals ($M$ = 6.20) were an influential factor. Female collegiate STEM majors at MU rated the factor *desire to purse this major* with a mean score of 6.11 on a 7-point Likert scale, followed by *personal motivators* ($M$ = 6.09) and *parents/family* ($M$ = 5.45), when asked to rate the factors that kept them motivated in their degree program.

The factors *friends* and *faculty* were ranked the lowest at ($M$ = 4.77) and ($M$ = 4.69), respectively, as illustrated in Table 17, *Undergraduate Females' Motivation Factors*.

Table 17

Undergraduate Females' Motivation Factors

| Factors | Mean |
|---|---|
| Career goals | 6.20 |
| Desire to pursue this major | 6.11 |
| Personal Motivators | 6.09 |
| Parents/Family | 5.45 |
| Challenging major | 5.34 |
| Friends | 4.77 |
| Faculty | 4.69 |

4) What is the primary factor that influenced female students in their decision to enroll in a collegiate STEM degree program?

In order to determine the primary factor that influenced a female student to enroll in a collegiate STEM major, the sample population was asked to choose the factor that most influenced their decision. More than half (51%) of respondents ($n$ = 279) reported being *good at math and science* as the primary factor that influenced them to enroll in a collegiate STEM degree program. Approximately one-quarter of the respondents (26%) reported wanting *career options* as the primary factor that influenced their decision. The remaining 25% of the population reported receiving encouragement from a school teacher (8%), participating in math- and science-focused extra-curricular activities (5%), having a parent who works in a STEM field (4%), attending a pre-engineering and technology high school (3%), attending a science summer camp (2%), and receiving encouragement from a school counselor (2%) as primary factors that influenced their decision to enroll in a collegiate STEM degree program, which is reflected in Table 18, *Primary Factors that Influence STEM Enrollment*.

Table 18

Primary Factors that Influence STEM Enrollment

| Factor | Response |
|---|---|
| I am good at math and science | 51% |
| I wanted career options | 26% |
| My high school teacher encouraged me | 8% |
| I participated in math- and science-focused extra-curricular activities | 5% |
| My mother or father work in a STEM field | 4% |
| I attended a pre-engineering and technology high school | 3% |
| I attended a science summer camp and I really liked it | 2% |
| My school counselor encouraged me | 2% |

5) Does it matter to females enrolled in a STEM degree program if they are making a difference in the lives of others?

Having a career that positively affects the lives of others was a theme that emerged in the first phase of the research study, qualitative data collection, during focus group sessions with the first-year female freshmen. In order to validate this theme, the sample population was asked if it mattered to them if they had a career that made a difference in the lives of others, which is noted in Table 19, *Role of Altruism: Undergraduate Female*

*STEM Majors*. Overwhelmingly (93%), female respondents (*n* = 279) reported that having a career that positively impacts society matters to them.

Table 19

Role of Altruism: Undergraduate Female STEM Majors

| Response | % |
|---|---|
| Yes | 93% |
| No | 7% |

6) Are grades of greater importance to females than their male peers?

In order to better understand if grades matter more to females than males, the sample population was asked (1) ‘Do grades matter to you?’ and (2) ‘Do you feel grades matter more to your male peers than they do to you?’. Table 20, *Importance of Grades: Undergraduate Female STEM Majors,* shows that almost all respondents in the sample population (97%) reported that grades matter to them. Ninety-one percent of the sample population reported that they do not believe grades matter more to their male peers than they do to them.

Table 20

Importance of Grades: Undergraduate Female STEM Majors

| | | |
|---|---|---|
| Do Grades Matter to You? | | |
| | Yes | 97% |
| | No | 3% |
| Do you feel grades matter more to your male peers than they do to you? | | |
| | Yes | 9% |
| | No | 91% |

# CHAPTER 5: DISCUSSION AND RECOMMENDATIONS

## Research Study

There continues to be an inadequate amount of females enrolling in and graduating from collegiate science, technology, engineering, and mathematics (STEM) degree programs. In 2011, Beede et al. reported that "women hold a disproportionately low share of STEM undergraduate degrees, particularly in engineering" (p. 1). The insufficient amount of females graduating from these collegiate degree programs is resulting in workforce demands not being met and a lack of diversity in the workforce. The American College Testing (ACT) organization reported that "over the past ten years, the percentage of ACT-tested students who said they were interested in majoring in engineering [STEM fields] has dropped steadily from 7.6 percent to 4.9 percent" (2006, p. 1). In this research study, a mixed methods research design was used to address the concern that too few females are enrolling in collegiate STEM degree programs. The research design provided an opportunity for the researcher to collect, analyze, and combine both qualitative and quantitative data during the research process within a single study. This chapter includes a discussion of what was learned from the findings and recommendations for future studies that will further the research in determining which factors influence and motivate female students to enroll and persist in collegiate STEM programs.

## Project Overview

**Mixed methods research design.** An exploratory mixed methods research design was chosen as the methodology for this research study, as it allows for the collection of both qualitative and quantitative data, providing for additional means for addressing the research question. The collection of qualitative data focused on investigating the participants' phenomenological understanding of the experiences that influenced their enrollment in collegiate STEM degree programs. The themes and factors from Phase I were used to develop a survey instrument that was constructed to address the research question. The themes from the qualitative phase formed the basis of domains in the survey instrument. The purpose of the quantitative phase of the research study was to (a) increase the sample population, which provided an opportunity to generalize the results; and (b) verify the findings from the qualitative phase of the research study.

## Discussion of Findings

**Phase I: Qualitative summary.** In Phase I, qualitative data collection, 13 first-year female freshmen who were enrolled in a STEM degree program participated in the focus group session during fall and winter 2012. Provided below are findings as they relate to the research questions.

***Research Questions.***

1) Which pre-collegiate experiences influenced females to enroll in a collegiate STEM degree program?

This study considered a number of influential pre-collegiate STEM experiences as they were shared by first-year female freshmen in a focus group session. Female focus group participants reported that both formal and informal pre-collegiate exposure influenced them to enroll in a collegiate STEM degree program.

The formal experience was described as having attended an engineering summer camp that exposed the student to academic and career opportunities. For some undergraduate females, having participated in an after-school robotics club that involved hands-on activities and competitions got the students excited about STEM.

The informal experiences were described as reading about engineering on the Internet, as the field seemed interesting, or having a conversation with mom or dad, because they were engineers. Undergraduate females recalled participating on a *math team*, attending *science campus,* and competing on a *robotics team* as experiences that influenced their choice of collegiate major. Participants told stories of visiting a *university research lab* and experiencing what it would be like to work in that type of environment. One student's high school hosted a monthly *Lunch with a Leader event* that introduced female students to alumni from a range of professions.

Female focus group participants expressed how they were appreciative of having had exposure to these fields, as they would not have known that these were degree options had it not been for these opportunities.

2) Which stakeholders influence collegiate females in their decision-making process?

Females who participated in the focus groups discussed who exposed them to STEM degree opportunities and influenced their collegiate enrollment decision. Focus group participants narrowed in on two influential stakeholders who played a significant role in their decision to enroll in a collegiate STEM degree program. The first influential stakeholder was a *parent* who (a) had a career in STEM to which the female could relate, or (b) encouraged his/her daughter to pursue a career in STEM. The second influential stakeholder was a *teacher* who (a) was enthusiastic about math and science and engaged students, and/or (b) provided positive reinforcement for being successful in math and science by encouraging them to persist in these areas.

*Parent.* The majority of the focus group participants reported that either their mother or father worked in a STEM field and that having access to information about these careers influenced their decision to enroll.

*Teacher.* The female students in the focus group discussed how having a teacher who was excited about math and science increased their level of excitement for these disciplines. One student recalled how her chemistry teacher was inspirational and made her love chemistry because of the excitement she showed when teaching the class.

Influential stakeholders who are able to connect how academic fields like math and science can lead to careers in which you are helping people and making a difference, and may further pique female student interest in STEM degree programs.

3) Does entering a career that helps others matter to female students?

In response to the third research question, overwhelmingly, focus group participants expressed how having a career that helps others was of utmost importance to them. Participants called for educators to provide pre-collegiate students with more information about how a career in STEM helps others, as it is not always apparent. Focus group participants communicated how they wanted a career that positively impacts the lives of others. Influential stakeholders who are able to connect how a career in STEM involves much work that affects the lives of others may lead to more females considering it as a degree and career option.

4) How can confidence be instilled in females so that they can persist in collegiate STEM programs?

Focus group participants vocalized how their passion for having a career in STEM, and the support that they received from encouraging stakeholders, motivated them to persist through obstacles faced as a collegiate STEM major. Undergraduate females discussed how their commitment to having a career in STEM kept them focused despite obstacles faced. The confidence to enroll and persist in collegiate STEM degree programs was described as both (a) an internal drive, and (b) external support received from others. Female focus group participants reported how they knew that they could be successful in their advanced math and sciences courses despite receiving a bad grade or being the only female in a class of males, as they were confident in their ability to be successful. Support received from influential stakeholders helped female students to persevere regardless of obstacles faced, as they provided encouraging feedback.

5) What can educators do to recruit more females to STEM degree programs?

When focus group participants were asked what can educators do to recruit more females to STEM degree programs, they called for (a) a better connection of academic courses to career paths (i.e., how advanced calculus relates to a collegiate degree in civil engineering and a career in developing new and maintaining old infrastructure), and (b) more exposure to careers in STEM at earlier ages. Focus group participants spoke of participating in Lunch with a Leader Day or attending a STEM career day in middle and high school when speakers would visit their class to share stories of their career path as experiences that influenced their enrollment decision.

**Phase II: Instrument Development Summary.** This section provides a summary of the instrument development process. In general, the steps for developing the survey instrument involved combining (a) the Motivated Student Learning Questionnaire, (b) the questions developed from the findings from the qualitative phase, and (c) a demographic section. The survey administered to the participants consisted of 15 questions. The survey was electronically distributed via the web-based survey tool, Qualtrics.

**Phase III: Quantitative Summary.** Phase III, the quantitative phase, included administering an electronic online survey to undergraduate (sophomore, junior, and senior status) female students enrolled in a collegiate STEM degree program during the fall and winter 2012 semesters. Analysis of the data answered the following research questions.

***Research questions.***

1) What are the primary influences for female students to enroll in collegiate STEM degree programs?
2) Do females enrolled in a collegiate STEM degree program report high levels of self-confidence as it relates to their expected success in the degree program?
3) What are the primary influences that keep female students motivated in a collegiate STEM degree program?
4) What is the primary factor that influenced female students in their decision to enroll in a collegiate STEM degree program?
5) Does it matter to females enrolled in a STEM degree program if they are making a difference in the lives of others?

6) Are grades of greater importance to females than their male peers?

Two hundred and seventy-six undergraduate females completed the survey, providing the researcher with an opportunity to confirm the themes heard in the qualitative phase and to gain a better understanding of the factors that influence and motivate female students to enroll and persist in collegiate STEM programs.

Females enroll in collegiate STEM degree programs because they are interested in STEM fields, they are good at math and science, they are encouraged by a high school teacher, they want career options, and they want a career where they can impact the lives of others. Grades matter to females enrolled in collegiate STEM degree programs; however, 91% of the sample population reported that they do not believe grades matter more to their male peers than they do to them.

Survey respondents rated their level of confidence in their ability to be successful as a collegiate STEM major as high, with an overall average rating of 5.61 on a 7-point Likert scale, with 7= very true of me and 1= not at all true of me. Overwhelmingly, the female students conveyed that they were confident that they could understand the basic concepts taught in their STEM major. Undergraduate female STEM majors persisted in their degree programs because they were focused on obtaining their career goals, they had a strong desire to pursue their major, and they had parents and teachers who encouraged them to persist.

**Phase IV: Synthesis.** In what ways do the quantitative results support the qualitative findings and the qualitative findings support the quantitative results?

For this research study, data were collected according to a sequential research design model. On the next page in Table 21, *Phase IV: Synthesis How the Quantitative Results Support the Qualitative Findings*, illustrates the themes from Phase I, variables from Phase III, and interpretation from Phase IV, demonstrating how the quantitative results support the qualitative findings and vice versa. The qualitative study data were collected and analyzed before the design and construction of the survey instrument. The quantitative results were then used to confirm and prioritize the recommendations from the qualitative phase. The results from Phase IV of the study confirm the findings from Phase I of the study. In summary, the findings from both the qualitative and quantitative phases provide insight into the factors that influence and motivate female students to enroll and persist in a collegiate STEM degree program.

**Recommendations**

The findings from this study illustrate the role of K-12 STEM educators, pre-collegiate STEM outreach programs, and STEM education policymakers in influencing and motivating female students to enroll and persist in collegiate STEM degree programs.

**K-12 educators.** Undergraduate female STEM majors who participated in this study recalled the impact of having an enthusiastic math and science teacher, experiencing a field trip to a STEM lab, and participating in a STEM after school club as experiences that influenced their decision to enroll in a collegiate STEM degree program.

Table 21

Phase IV: Synthesis Findings

| Phase I Qualitative Themes | Phase II Survey Development | Phase III Quantitative Variables | Phase IV Synthesis |
|---|---|---|---|
| Altruistic | Is it important to you to have a career that positively impacts society? | Altruism | Yes, it important to you to have a career that positively impacts society |
| Influential Stakeholder | What are the reasons for why you chose this major? | Self-confidence and motivation, Desire to succeed, Career Path | Influential stakeholders |
| Grades | Do grades matter to you?<br>Do you feel grades matter more to your male peers than they do to you? | Grade Perception<br>Gender | Almost all respondents in the sample population (97%) reported that grades matter to them. Ninety-one percent of the sample population reported that they do not feel grades matter more to their male peers than they do to them. |
| How to Influence Females into STEM | What is the primary factor that influenced you to enroll in a collegiate STEM major? | Pre-collegiate STEM exposure<br>Influential Stakeholder | When asked to choose the primary factor that influenced her decision to enroll, the female respondents shared:<br>I am good at math and science; I wanted career options; and, My high school teacher encouraged me. |
| Self-confidence to Enroll and Persist | What influences keep you motivated in this major? | Self-confidence and motivation | Undergraduate female STEM majors persist in their degree programs because they are focused on obtaining their career goals, they have a strong desire to pursue their major, and they have parents and teachers who encourage them to persist |

*Note.* The themes from Phase I, variables from Phase III, and interpretation from Phase IV, demonstrate how the quantitative results support the qualitative findings and vice versa.

Teachers who show enthusiasm for math and science nurture students who demonstrate a greater interest in these fields. Greater emphasis needs to be placed on exposing K-12 math and science teachers to STEM collegiate programs and career opportunities, as they are influential stakeholders in the collegiate degree decision-making process. The more informed the K-12 teacher, the better informed the student. Additionally, it was found that educators who show enthusiasm for math and science impact students' interest and excitement for the topic.

**STEM outreach.** Pre-collegiate STEM experiences are a great way to get students excited about STEM. Undergraduate females enrolled in STEM collegiate programs recounted how they learned about careers in STEM fields from either their parents or teachers. For some females, their mother or father had a career in a STEM field and exposed them to this career opportunity. Some females in the research study shared how they had the opportunity to participate in a STEM field trip to a lab or to meet with a professional with a career in STEM, which provided them with more information about STEM career pathways at younger ages, and increased their knowledge of potential opportunities and their likelihood of developing an interest in these fields.

When research study participants discussed pre-collegiate experiences that influenced their decision to enroll in a collegiate STEM degree program, they spoke of participating in a robotics team, joining math and science club, and attending a STEM summer camp. STEM educators are encouraged to increase female student exposure to STEM-related activities in an after-school setting as it results in an increased interest, complements the math and science classes that they are taking (as it demonstrates the application side of these courses), and provides additional exposure to STEM opportunities.

**STEM education policy.** Research study participants reflected on the pre-collegiate experiences that influenced their decision to enroll in and persist through a collegiate STEM degree program. STEM education policymakers can increase the pipeline of students who have an interest in these fields by (a) exposing elementary, middle, and secondary school teachers to hands-on programs that will make them confident in delivering a STEM education program to their students, (b) increasing the number of K-12 schools that offer students a pre-engineering and technology curriculum, and (c) providing pre-collegiate students with access to information regarding STEM career pathways and opportunities.

## Limitations

Upon review of data collected, it became apparent that there were four limitations of this study. The first limitation was not having a control group to compare the findings against. The data collected represents only the voices and experiences of undergraduate females enrolled in a collegiate STEM degree program at Midwestern university. The second limitation had to do with the number of kindergarten through twelfth grade STEM pathway schools in the state in which Midwestern university is located. Currently, there are 16 high schools, one middle school, and one elementary school in the state that provide students with an engineering and technology-focused curriculum program like Project Lead The Way. The majority of students enrolled at Midwestern university are in-state residents, so there is limited access to a focused STEM curriculum program in the early childhood years. The third limitation had to do with the small sample sizes. First, the focus group sample size was small. A total of 265 first-year freshmen women enrolled in a collegiate STEM degree program were invited to participate and approximately 5% ($N = 13$) took part in the focus group session. In addition, 800 female upperclassmen received an email to complete the survey and approximately 35% ($N = 278$) completed it. The final limitation had to do with the data results, which were of insufficient quantity to be able to conduct a large-scale statistical analysis.

**Future Research**

There are several opportunities to extend this dissertation into further studies aimed at identifying the factors that influence and motivate female students to enroll and persist in collegiate STEM programs. The researcher suggested that through increased pre-collegiate exposure to STEM curriculum programs in both formal and informal settings, more females would enroll and persist in collegiate STEM degree programs. The findings from this research study provide STEM educators and policy makers with a better understanding of the factors that influence undergraduate female students to enroll in collegiate STEM degree programs. With this in mind, in order to fully understand why some females choose STEM programs over other collegiate academic majors, additional research needs to be conducted. The researcher suggests the following future studies be conducted so that additional knowledge of influential factors can be determined.

The most likely next step is to expand the size of the research study so that a larger sample population can be engaged, more voices can be heard, and a greater understanding of solutions for the problem can be gained. In addition to increasing the size of the sample population, it is recommended that future research studies (1) be expanded to include varying types of higher education institutions (e.g., land grant institutions, private institutions, public research institutions, etc.) from across the country and (2) collect data about the type of pre-collegiate institutions the students attended (e.g., STEM magnet school, Project Lead The Way school, etc.).

An additional suggested study involves females who earn high scores on the ACT and/or SAT in mathematics and have the capacity to be successful in STEM, but choose to enroll in a non-STEM collegiate major. By engaging undergraduate females who choose a non-STEM collegiate major but are successful in math and science, researchers can determine why they choose not to enroll.

The third suggested study that would extend the findings would be to explore the implications of expanding the acronym STEM, which reflects the fields of science, technology, engineering and mathematics, to include the arts, resulting in the acronym STEAM. At this time, there is not much research on the effects of expanding STEM to STEAM and how this expansion may affect enrollment trends within collegiate science, technology, engineering and math degree programs. Dave et al. (2012) observed the experiences had tenth and eleventh grade girls who were asked to re-engineer an existing product. The participants were given a pair of blue jeans and asked to create a new product from them – a blue jean bag. The researchers purposefully developed the curriculum so that it would be multidisciplinary and had acknowledged that the project called for the girls to use creativity along with engineering and technology in designing their projects. By collecting data on how a multidisciplinary approach to teaching science, technology, engineering and mathematics affects student enrollment trends, more specifically female interest in these fields, educators and policymakers will benefit from gaining a better understanding how to engage students in these fields.

Another potential study involves the simultaneous collection of data from undergraduate males and females enrolled in collegiate STEM degree programs. By engaging males in an identical research study as females, researchers will gain a better understanding of how males and females differ in terms of the factors that influence their decision to enroll and persist in a collegiate STEM degree program.

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# APPENDIX A

**Pilot study: Graduate Student Recruitment Email**

Dear Graduate Student,
You have been selected to participate in a study at UNL that is aimed at gaining a better understanding of why some female students enroll in STEM programs and others do not. I am interested in your pre-college math and science experiences and I invite you to join a focus group on **Wednesday, October 17**, at **5:00** pm. The discussion group will last approximately 60 minutes and will be held in **room 100A at the Peter Kiewit Institute**.

Pizza will be provided! Please RSVP by **Monday, October 15** so that I will be able to save a spot for you.

You, the student, may refuse to participate without any loss of benefit, which you are otherwise entitled to. You may also refuse to answer some or all the questions if you don't feel comfortable with those questions. All responses will be kept confidential.

If additional information regarding the focus group is needed, please contact me.

I look forward to hearing from you.

Best,
Rosemary

# APPENDIX B

# Undergraduate Student Survey



**Motivated Student Learning Questionaire**

**Please rate the following based on your experiences. Your rating should be on a 7-point scale where 1= not at all true of me to 7=very true of me**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| I believe I will receive an excellent GPA in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I'm certain I can understand the most difficult material presented in the readings for my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I'm confident I can understand the basic concepts taught in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I am confident I can understand the most complex material presented by the faculty in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I'm confident I can do an excellent job on the assignments and tests in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I expect to do well in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I'm certain I can master the skills being taught in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Considering the difficulty of the courses, the teachers, and my skills, I think I will do well in my STEM major. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**Block 1**

**What are the reasons for why you choose this major? Your rating should be on a 7-point scale where 1= not at all true of me to 7=very true of me**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I enjoy math | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I enjoy science | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I see great career opportunities | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I want to help others | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I think that there are great salary opportunities | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I appreciate the job security | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| This field interests me | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I was good at math and science | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Personal capabilities | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Preparedness to succeed | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Desire to pursue this major | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**What influences keep you motivated in this major? Your rating should be on a 7-point scale where 1= not at all true of me to 7=very true of me**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Career goals | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Parents/Family | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Faculty | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Challenging major | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Friends | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Personal Motivators | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Desire to pursue this major | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**What is the primary factor that influenced you to enroll in a collegiate science, technology, engineering, or mathematics (STEM) major?**

- ○ I am good at math and science
- ○ My mother or father work in a STEM field
- ○ I attended a science summer camp and I really liked it
- ○ I attended a pre-engineering and technology high school
- ○ I participated in math and science focused extra-curricular activities
- ○ I wanted career options
- ○ My school counselor encouraged me

- My high school teacher encouraged me

**Is it important to you to have a career that positively impacts society?**

- Yes
- No

**Do grades matter to you?**

- Yes
- No

**Do you feel grades matter more to your male peers than they do to you?**

- Yes
- No

**What is your major?**

**What was your composite ACT score?**

- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 32
- 33
- 34
- 35

- 36

**Class Level (choice one)**

**What is your GPA?**

**Race / Ethnicity (check all that apply)**

- White
- African American/Black
- Hispanic/Latino
- Asian
- Multiracial
- Other

**High School State**

**What is the highest level of education completed by someone in your immediate family ?**

- Some high school
- High school graduate
- Some college, but did not finish
- Two-year college degree
- Four-year college degree
- Some graduate or professional degree
- Graduate or professional degree
- Doctorate or PhD

**What is the highest level of education completed by your parents? Please indicate below.**

| | Mother's Highest Level of Education | Father's Highest Level of Education |
|---|---|---|
| Unknown | ☐ | ☐ |
| No High School | ☐ | ☐ |
| Some High School | ☐ | ☐ |
| High School Graduate | ☐ | ☐ |
| Some Technical Education | ☐ | ☐ |
| Licensed/Certified | ☐ | ☐ |
| Some College | ☐ | ☐ |
| College Graduate | ☐ | ☐ |
| Graduate/Professional School | ☐ | ☐ |

# APPENDIX C

**Focus group: Undergraduate Student Recruitment Email**

Dear Student –

Once again, congratulations on your admission to the University of Nebraska – Lincoln! Last week you received an email requesting that you participate in an individual interview to discuss your math and science experiences in high school.

You have been selected to participate in a study at UNL that is aimed gaining a better understanding of why some students enroll in STEM programs and others do not. I am interested in your pre-college math and science experiences and I invite you to join a focus group on **DATE**, at **TIME** pm. The discussion group will last approximately 60 minutes and will be held in **ROOM LOCATION**. This will be a great opportunity for you to meet with other students in STEM fields across the University.

Pizza will be provided! Please RSVP by **DEADLINE DATE** so that I will be able to save a spot for you.

You, the student, may refuse to participate without any loss of benefit, which you are otherwise entitled to. You may also refuse to answer some or all the questions if you don't feel comfortable with those questions. All responses will be kept confidential.

If additional information regarding the focus group is needed, please contact me at redzie2@unl.edu.

Best,

Rosemary

# APPENDIX D

**Participant Demographic Worksheet**

Please answer the following questions as honestly as possible. If you are uncomfortable answering any of the questions, you can choose to leave the question blank.

Name: ___________________________________________

Pseudonym: ___________________________________________
(Name to be utilized in the documentation of the research)

---

Program of Study: ___________________________________________

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**Please circle the appropriate response for the following questions:**

1. **Gender:** F M

2. **Race/Ethnicity (Check all that apply and identify):**

| | |
|---|---|
| White (Identify): | |
| African American/Black (Identify): | |
| Hispanic/Latino (Identify): | |
| Asian (Identify): | |
| Multiracial (Identify): | |
| Other (Identify): | |

3. **High School (city, state/country):** ___________________________________________

4. **What is the highest level of education completed by someone in your immediate family?**
    - Some high school
    - High school graduate
    - Some college, but did not finish
    - Two-year college degree
    - Four-year college degree
    - Some graduate or professional school
    - Graduate or professional degree
    - Doctorate or PhD

**5. Self-identified Socioeconomic Status:**

| Lower | Lower-middle | Middle | Upper-middle | Upper |
|---|---|---|---|---|
| | | | | |

**6. Please indicate the highest education experience for your Mother and/or Father**

| | Mother's highest Education | Father's highest Education |
|---|---|---|
| Unknown | | |
| No High School | | |
| Some high school | | |
| High school graduate | | |
| Licensed/certified | | |
| Some college | | |
| College graduate | | |
| Graduate /Professional school | | |

# APPENDIX E

**Transcriber Confidentiality Agreement**

I, the undersigned, agree to the following:

All data at the individual record level obtained or acquired as Notetaker during undergraduate student focus group meetings, and given to Rosemary L. Edzie of the Department of Education Administration at the University of Nebraska-Lincoln, will be coded or de-identified. Under no circumstances will the identifiers be made available to individuals University of Nebraska - Lincoln. Any breach or suspected breach of data confidentiality shall be reported immediately to the University of Nebraska – Lincoln Institutional Research Board.

In addition any breach or suspected breach of data confidentiality shall be reported immediately. Any intentional violation of this agreement shall be the basis for dismissal for cause.

______________________________
(Signature)

_______________
Date

______________________________
(Print Name)

University of Nebraska – Lincoln
Department of Education Administration the University
Rosemary L. Edzie
redzie2@unl.edu

# APPENDIX F

**Qualitative Categories and Themes**

| Category | Themes |
|---|---|
| MAKING A DIFFERENCE | Altruistic |
| HELPING OTHERS | Altruistic |
| HELPING OTHERS, UNIVERSITY INFLUENCE | Altruistic, Persist |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
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| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK | Career Security |
| ECONOMIC OUTLOOK, HELPING OTHERS | Career Security, Altruistic |
| ECONOMIC OUTLOOK, TEACHER INFLUENCE | Career Security, Influential Stakeholder |
| OVERCOME OBSTACLES | Confidence to Enroll and Persist |
| CONFIDENT | Confidence to Enroll and Persist |
| CONFIDENT | Confidence to Enroll and Persist |
| POSITIVE REINFORCEMENT, CONFIDENT | Confidence to Enroll and Persist |
| GRADES MATTER REGARDLESS OF GENDER | Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist<br>Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist<br>Pre-Collegiate STEM exposure |
| OVERCOME OBSTABCLES1<br>PRE-COLLEGIATE STEM EXPOSURE2 | Confidence to Enroll and Persist<br>Pre-Collegiate STEM exposure |

| Category | Themes |
|---|---|
| CONFIDENT | Confidence to Enroll and Persist |
| CONFIDENT | Confidence to Enroll and Persist |
| IT IS INTERESTING, ECONOMIC OUTLOOK, CONFIDENCE | Confidence to Enroll and Persist, Career Security |
| CONFIDENT, TEACHER INFLUENCE, PARENT INFLUENCE, CONFIDENT | Confidence to Enroll and Persist, Influential Stakeholder |
| CONFIDENT, SECONDARY SCHOOL INFLUENCE, ENCOURAGEMENT TO SUCCEED | Confidence to Enroll and Persist, Influential Stakeholder, Encouraged |
| CONFIDENCE, PASSIONATE, PRE-COLLEGIATE STEM EXPOSURE1<br>PARENT INFLUENCE2<br>ECONOMIC CONCERN3 | Confidence to Enroll and Persist, Passionate about math, Pre-Collegiate STEM Exposure1<br>Influential Stakeholder 2<br>Economic Outlook3 |
| CONFIDENT, POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| CONFIDENT, POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| CONFIDENT, POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENCE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENCE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENCE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENCE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENCE | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE, STRUGGLED, CONFIDENT | Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |
| CONFIDENT1<br>PARENT INFLUENCE2<br>ECONOMIC OUTLOOK3 | Confidence to Enroll and Persist1<br>Influential Stakeholder 2<br>Career Security 3 |

| Category | Themes |
|---|---|
| CONFIDENT1<br>POSITIVE REINFORCEMENT,<br>TEACHER INFLUENCE2 | Confidence to Enroll and Persist1<br>Pre-Collegiate STEM Exposure2,<br>Influential Stakeholder 2 |
| CONFIDENT1, 2<br>TEACHER INFLUENCE2 | Confidence to Enroll and Persit1,<br>Influential Decision amker2 |
| ECONOMIC OUTLOOK | Cost of Education |
| ECONOMIC OUTLOOK | Cost of Education<br>Career Security |
| HELPING OTHERS | Altruistic |
| HELPING OTHERS, MOTIVATED TO MAKE A DIFFERENCE | Altruistic |
| PARENT INFLUENCE | Influential Stakeholder, Confidence to Enroll and Persist |
| STAKEHOLDER | Influential Stakeholder, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PASSIONATE TEACHER | Influential Stakeholder, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PASSIONATE TEACHER | Influential Stakeholder, Confidence to Enroll and Persist |
| PARENT INFLUENCE | Influential Stakeholder, Confidence to Enroll and Persist |
| PARENT INFLUENCE | Influential Stakeholder, Confidence to Enroll and Persist |
| PARENT INFLUENCE, ECONOMIC OUTLOOK | Influential Stakeholder, Confidence to Enroll and Persist, Career Security |
| PARENT INFLUENCE, ECONOMIC OUTLOOK | Influential Stakeholder, Confidence to Enroll and Persist, Career Security |
| PARENT INFLUENCE, ECONOMIC OUTLOOK | Influential Stakeholder, Confidence to Enroll and Persist, Career Security |
| PARENT INFLUENCE, ECONOMIC OUTLOOK | Influential Stakeholder, Confidence to Enroll and Persist, Career Security |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, CONFIDENT TO PERSIST, PASSIONATE, ENCOURAGING OF FEMALES IN STEM | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, CONFIDENT TO PERSIST, PASSIONATE, ENCOURAGING OF FEMALES IN STEM | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |

| Category | Themes |
|---|---|
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE | Influential Stakeholder, Passionate Teacher, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, POSITIVE REINFORCEMENT, CONFIDENCE, PRE-COLLEGIATE STEM EXPOSURE | Influential Stakeholder, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, CONFIDENT, POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Influential Stakeholder, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PASSIONATE, TEACHER INFLUENCE, ENGAGED, PRE-COLLEGIATE STEM EXPOSURE | Influential Stakeholder, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| TEACHER INFLUENCE, PASSIONATE, LOGIC | Influential Stakeholder, Pre-Collegiate STEM Exposure, Passionate |
| TEACHER INFLUENCE, PASSIONATE, LOGIC | Influential Stakeholder, Pre-Collegiate STEM Exposure, Passionate Teacher, |
| FEMALE IN STEM, PASSIONATE TEACHER, TEACHER INFLUENCE, LOGIC, ECONOMIC OUTLOOK | Influential Stakeholder, Prestige of Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PARENT INFLUENCE1<br>ECONOMIC OUTLOOK2 | Influential Stakeholder 1<br>Societal Expectatoins2 |
| TEACHER INFLUENCE1<br>CONFIDENT2 | Influential Stakeholder 1<br>Confidence to Enroll and Persist2 |
| INFLUENTIAL DECISIONMAKER1<br>PRE-COLLEGIATE STEM EXPOSURE2 | Influential Stakeholder 1<br>Pre-Collegiate STEM exposure2 |
| INFLUENTIAL DECISIONMAKER1<br>PRE-COLLEGIATE EXPOSURE TO STEM2 | Influential Stakeholder 1<br>Pre-Collegiate STEM exposure2 |
| PARENT INFLUENCE1<br>PRE-COLLEGIATE STEM EXPOSURE2 | Influential Stakeholder 1<br>Pre-Collegiate STEM exposure2 |

| Category | Themes |
|---|---|
| INFLUENTIAL STAKEHOLDER 1<br>POSITIVE REINFORCEMENT | Influential Stakeholder 1<br>Pre-Collegiate STEM Exposure2 |
| TEACHER INFLUENCE1, PASSIONATE ABOUT MATH AND SCIENCE2, PRE-COLLEGIATE STEM EXPOSURE3 | Influential Stakeholder 1, Passionate about STEM2, and Pre-Collegiate STEM Exposure3 |
| PARENT INFLUENCE1<br>TEACHER INFLUENCE2<br>PASSIONATE ABOUT STEM3 | Influential Stakeholder 1, 2 & Passionate about STEM, Pre-Collegiate STEM Exposure3 |
| TEACHER INFLUENCE1<br>CONFIDENT2<br>PRE-COLLEGIATE EXPOSURE3 | Influential decisionmaker1<br>Confidence to enroll and persist2<br>Pre-Collegiate STEM exposure3 |
| MALES HAVE ECONOMIC CONCERNS | Males want Career Security |
| DISCOURAGING INTERACTIONS, CONFIDENCE | Overcoming discouraging interactions, STEM Outlier, Confidence to Enroll and Persist |
| PRESTIGE OF FEMALE IN STEM, DISCOURAGING INTERACTIONS, CONFIDENCE | Overcoming discouraging interactions, STEM Outlier, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE<br>POSITIVE REINFORCEMENT | Pre-Collegiate STEM Exposure |
| POSITIVE REINFORCEMENT1<br>LOGIC2 | Pre-Collegiate STEM Exposure |
| LOGIC | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
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| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, |

| Category | Themes |
| --- | --- |
| | Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| PRE-COLLEGIATE STEM EXPOSURE | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |

| Category | Themes |
|---|---|
| PRE-COLLEGIATE STEM EXPOSURE, CONFIDENT1<br>PARENT INFLUENCE2 | Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist1<br>Influential Stakeholder 2 |
| PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| LINKING CAREER WITH MAJOR, PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| LINKING CAREER WITH MAJOR, PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| LINKING CAREER WITH MAJOR, PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| LINKING CAREER WITH MAJOR, PRE-COLLEGIATE STEM EXPOSURE, TEACHER INFLUENCE | Pre-Collegiate STEM Exposure, Influential Stakeholder |
| PRE-COLLEGIATE STEM EXPOSURE, PASSIONATE ABOUT MATH, GOOD FIT | Pre-collegiate STEM Exposure, Passionate about STEM |
| PRESTIGE OF FEMALE IN STEM, CONFIDENCE | Prestige of being an Prestige STEM Outlier, Confidence to Enroll and Persist |
| PRESTIGE OF FEMALE IN STEM, CONFIDENCE | Prestige of being an Prestige STEM Outlier, Confidence to Enroll and Persist |
| FEELING LIKE THE ONLY FEMALE | Prestige STEM Outlier |
| PRESTIGE, AFFECTING OTHERS | Prestige STEM Outlier, Altruistic |
| FEMALE IN STEM, INFLUENTIAL TEACHER, CONFIDENT, POSITIVE REINFORCEMENT, PRE-COLLEGIATE STEM EXPOSURE | Prestige STEM Outlier, Influential Stakeholder, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| CONFIDENT, PRE-COLLEGIATE STEM EXPOSURE, FEELING LIKE THE ONLY FEMALE, DISCOURAGED BY TEACHING STYLE | Prestige STEM Outlier, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist |
| FEMALE IN STEM, IT IS INTERESTING, TEACHER INFLUENCE, PASSIONATE, ENGAGING, PRE-COLLEGIATE STEM EXPOSURE, | Prestige STEM Outlier, Pre-Collegiate STEM Exposure, Confidence to Enroll and Persist. Passionate Teacher, |
| FEMALE IN STEM, CONFIDENCE, | Prestige STEM Prestige STEM Outlier, |

| Category | Themes |
| --- | --- |
| POSITIVE REINFORCEMENT | Confidence to Enroll and Persist |
| GOOD FIT | Self-Confidence |
| GUYS MANAGE STRESS | Societal Expectations |
| PRESTIGE OF FEMALE IN STEM, CONFIDENCE, PRE-COLLEGIATE STEM EXPOSURE | Prestige STEM Outlier, Confidence to Enroll and Persist, Pre-Collegiate STEM Exposure |

# APPENDIX G

**Undergraduate Survey: Female Student Recruitment Email**

Dear Student -

You have been selected to participate in a study at UNL that is aimed at gaining a better understanding of the experiences of undergraduate female students in science, technology, engineering, and mathematics fields.

I ask for your help in completing this survey so that a better understanding of your math and science experiences can be gained. It should take only about ten minutes to answer the survey questions; your input will be very helpful.

Participants that complete the survey will be entered into a raffle to win a $30 iTunes gift card. Only one iTunes gift card will be provided. The winner will be notified via email.

If additional information regarding the survey is needed, please contact me at redzie2@unl.edu.

Best,

Rosemary

**Follow this link to the Survey:** ${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser: ${l://SurveyURL}

*You, the student, may refuse to participate without any loss of benefit, which you are otherwise entitled to. You may also refuse to answer some or all the questions if you don't feel comfortable with those questions. All responses will be kept confidential.

** The overall odds of winning are dependent on the number of people who participate, but they have at least a 1 in 1000 odds of winning.

# APPENDIX H

## IRB Approved Certificate

University of Nebraska Lincoln

IRB# 20121012911 EP
Date Approved: 08/20/2013
Valid Until: 10/08/2014

**Title of study:** Exploring the Factors that Influence and Motivate Female Students to Enroll in Collegiate STEM Degree Programs: A Mixed Methods Study

**Principal investigator**: Rosemary L. Edzie

**Advisor:** Dr. James O'Hanlon, 402-472-3041, johanlon1@unl.edu

**Institute:** Department of Education Administration, University of Nebraska – Lincoln

**Introduction:** The following research study addresses the national concern surrounding the low enrollment of females in STEM (science, technology, engineering, and mathematics) collegiate programs. In order to address this problem, freshman females declared as STEM majors are invited to participate in a focus group meeting to share their STEM experiences.

**Background information:** The following research addresses the national concern surrounding the low enrollment of females in STEM programs. The primary significance of this study would lead to increased interest and persistence had by females in STEM collegiate programs.

**Purpose of this research study:** The purpose of the study is to explore the factors that influence and motivate female students to enroll in collegiate STEM degree programs.

**Procedures:** Participation in the study will require approximately 60 minutes of your time and will consist of a focus group discussion about your experiences in K-12 math and science programs and reasons for enrolling in a STEM program at the post-secondary level. A note taker will attend the focus group meeting to transcribe what was discussed and the meetings will be audio taped. All responses will remain confidential. Focus groups will be held on both the Lincoln and Omaha campuses. Participants will be asked to complete a demographic sheet.

**Risks and/or Discomforts:** There are no known risks or discomforts associated with this research.

**Benefits:** In order to increase the enrollment of females in STEM programs, there needs to be an empirical understanding of the factors that affect the decision making process. The results of this research study will influence and benefit education policymakers, engineering colleges, and secondary school curriculum specialist on STEM related curriculum decisions and student programming.

**Right of refusal to participate and withdrawal**: You, the student, are free to decide not to participate in this study. You can also withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln.

**Confidentiality:** The information provided by you will remain confidential. Nobody except principal investigator will have an access to it. Your name and identity will also not be disclosed at any time. However the data may be seen by an ethical review committee and may be published in journal and elsewhere without giving your name or disclosing your identity.

**Available Sources of Information:** If you have additional questions you may contact Principal Investigator Rosemary Edzie, Department of Education Administration the University of Nebraska - Lincoln via email, redzie2@unl.edu. If you have any questions or concerns about the research, you should contact the IRB Office at 402-472-6965 or irb@unl.edu.

**Consent, Right to Receive a Copy:** You are voluntarily making a decision whether or not to participate in this study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

**Participant Name (Printed)** **Participant (Signature)** **Date**

**Principal Investigator (Signature)** **Date**

☐ By checking this box I indicate that I agree to be audio taped.