Spring 5-19-2014

Why do Undergraduate Women Persist as Stem Majors? A Study at TwoTechnological Universities

Ronald Brandt
ronald.brandt@student.shu.edu

WHY DO UNDERGRADUATE WOMEN PERSIST AS STEM MAJORS? A STUDY AT TWO TECHNOLOGICAL UNIVERSITIES

BY

RONALD E. BRANDT

Submitted in partial fulfillment of the requirements for the degree
Doctor of Philosophy
Department of Education Leadership, Management and Policy
Seton Hall University
May 2014

SETON HALL UNIVERSITY
COLLEGE OF EDUCATION AND HUMAN SERVICES
OFFICE OF GRADUATE STUDIES

APPROVAL FOR SUCCESSFUL DEFENSE

Doctoral Candidate, **Ronald E. Brandt**, has successfully defended and made the required modifications to the text of the doctoral dissertation for the **Ph.D.** during this **Spring Semester 2014**.

DISSERTATION COMMITTEE
(please sign and date beside your name)

Mentor:
Dr. Martin Finkelstein ______ 3/5/2014

Committee Member:
Dr. Elaine Walker Elaine M. Walsh 3/5/2014

Committee Member:
Dr. Eunyoung Kim ______ 3/5/14

The mentor and any other committee members who wish to review revisions will sign and date this document only when revisions have been completed. Please return this form to the Office of Graduate Studies, where it will be placed in the candidate's file and submit a copy with your final dissertation to be bound as page number two.

ABSTRACT

Women continue to be underrepresented in STEM fields despite significant policy efforts to increase the number of qualified women. Prior research focused on access for women into advanced high school mathematics and science courses. Parity has been achieved in academic prerequisites for STEM studies in higher education, yet the number of women majoring in STEM has remained static. Recent research has focused on the socio-cultural obstacles that women face, including a lower self-confidence in their abilities, bias and gender stereotypes.

A survey was undertaken to examine the self-confidence, opinions and backgrounds of female students persisting as STEM majors at two technological institutions. The results confirmed strong academic preparation, but also revealed a high level of self-confidence in their abilities and future outlook, especially in students attracted to STEM at an early age. The results of this study can inform program initiatives to attract more young girls to STEM majors.

DEDICATION

This work is dedicated to my loving family

Lillie

Shari &Brett, Allyssa & David, Rachel & Carl

Alexander, Jacob, Matthew, Madeline, Bridget, Alexis and Kayla

Hessa Kapelusz

In Memory of

Alter & Dora Brandt, Martin Kapelusz

ACKNOWLEDGMENTS

The completion of a doctoral program is not possible without the committed support and guidance of faculty members, family and friends. Above all the support of my wife and BFF (Best Friend Forever) Lillie was instrumental in meeting the countless challenges and time demands of a rigorous program as well as the many sacrifices that were required to complete this chapter of our lives. I have three outstanding daughters, Shari, Allyssa and Rachel as well as their husbands, Brett, David and Carl, who inspire me with their own professional successes, but more importantly, as wonderful individuals leading meritorious lives. Of course, the greatest pleasure is watching grandchildren grow and knowing that they are being raised with values that will guide them well in their lives. Here is a "shout out" to Alexander, Jacob, Matthew, Madeline, Bridget, Alexis and Kayla.

My dissertation committee members are outstanding professionals, both as renowned academic researchers as well as their strong dedication to student success. Dr. Martin Finkelstein has shaped my understanding of the larger purpose of higher education and how it has impacted the society in which we live. As my mentor, Dr. "F." has been there at my side in guiding me in each step of the process. Dr. Elaine Walker transformed the study of statistics from mathematics into a deeper understanding of the underlying policy and social issues that are being examined. Dr. Eunyoung Kim has taught me to better appreciate the modern challenges facing higher education students from all walks of life. A special thanks to Dr. Kim for her extensive support and guidance during Dissertation Seminar and the early steps of establishing this work.

My educational journey at Seton Hall began as a Master's student in the Educational Studies department. I very much appreciated the guidance of Dr. Rosemary Skeele and Dr. Joseph Martinelli for giving me the skills to be a better high school teacher and giving me the encouragement to continue my studies culminating with this dissertation.

I am fortunate to live in a community with wonderful personal friends and a broad network of role models, all striving to make this world a better place. They continue to inspire me to strive onwards.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Background

The underrepresentation of women in STEM fields has been acknowledged as far back as the 1970s and continues to be studied to this day. The National Center for Education Statistics of the US Department of Education (2006) developed a definition of a STEM degree listing degree programs that include science, technology, engineering, or mathematics degrees. While advances have been made in terms of the sheer number of females participating within STEM majors at both undergraduate and graduate school levels and working as STEM graduates in the field, gender gaps in STEM persist (Morganson, V., Jones, M., & Major, D., 2010). Society is missing the benefits of more talented women in these important career fields, and many capable women are missing the professional positions and higher earning opportunities that STEM careers afford. The U.S. Department of Commerce (Beede et al., 2011) noted that although women represent half of the workforce in the US, they hold less than 25% of STEM related positions. This relatively low participation rate of women in STEM has remained unchanged over the past decade, even as the percentage of college educated women in the workforce has continued to rise, reaching 49% in 2009 (US Department of Commerce, 2011). Within STEM fields, women are well represented with a 51% share in biological and medical careers but represent only 13% in engineering disciplines and 26% in math and computer science. With respect to career income potential, women in STEM fields earn 33% more than in non-STEM careers (U.S. Department of Commerce, 2011).

The relatively smaller number of female professionals in STEM careers is a consequence of a narrow education pipeline as fewer women major in STEM fields in higher education (see Figures 1-3). Initiatives over the past decade to encourage more women to consider STEM based careers have had a positive impact, especially in the life sciences, but only limited success in the physical sciences, math, computer science and engineering, as shown in Tables 1and 2.

Table 1 presents the total number of bachelor's degrees earned in the U.S. in 2000, 2009 and 2010 (NSF, 2013). Despite increases in the absolute number of earned STEM degrees, there were no major shifts in the overall distribution across science disciplines during the last 10 years.

Table 1

US Bachelor's Degrees Earned in 2000, 2009 and 2010

	2000	**% of total**	**2009**	**% of total**	**2010**	**% of total**
All Bachelor's	1,254,618		1,619,208		1,688,227	
Engineering	59,487	4.7	70,600	4.4	74,399	4.4
Phys. Sci.	14,578	1.2	17,942	1.1	18,402	0.7
Life Sciences	83,132	6.6	104,726	6.5	110,015	6.5
Math/Comp.	49,233	3.9	54,704	3.4	56,939	3.3

Table 2 describes the gender mix in bachelor's degrees granted during 2000, 2009 and 2010, highlighting the significant gender gap in the respective shares of awarded STEM bachelor's degrees. With the exception of life sciences, females remain significantly underrepresented in STEM disciplines, especially in engineering and math / computer science. Furthermore, there is no clear trend in the mix over the last 10 years, aside from a further decrease in the relative share of females in math and computer sciences. In the widest gap comparison, females earned about 57% of all bachelor's degrees granted, in 2000, 2009 and 2010 but represent only 20% or less, of the engineering degrees earned.

Table 2

U.S. Bachelor's Degrees Earned by Females in 2000, 2009 and 2010

Females	**2000**	**% Of Discipline**	**2009**	**% Of Discipline**	**2010**	**% Of Discipline**
All Bachelor's	718,559	57.3	927,600	57.3	954,891	57.2
Engineering	12,206	20.5	12,750	18.1	13,693	18.4
Phys. Sci.	5,988	41.1	7,451	41.5	7,598	41.3
Life Sciences	46,416	55.8	60,915	58.2	63,587	57.8
Math/Comp.	16,120	32.7	13,865	25.3	14,554	25.6

Doctoral degrees granted to women during the same time frame follow a somewhat more promising trend (see Table 3). Women represented 50% of all doctoral degrees granted in 2009, a significant increase compared with 44% in 2000. At the same time, female life science doctorates increased from 50% to 63% of the total, while the female share of engineering doctorates grew modestly from 15.5% to 21.6% during the decade.

Table 3

Doctoral Degrees Earned by Females in 2000 and 2009

Females	**2000**	**% Of Discipline**	**2009**	**% Of Discipline**
All Degrees	19,883	44.2	31,225	50.6
Engineering	835	15.5	1,712	21.6
Phys. Science	860	25.0	1,385	31.4
Life Sciences	3,711	50.0	9,573	62.7
Math/Co. Sci.	405	21.8	827	26.6

Government policy has responded to the underrepresentation of women entering and persisting in STEM undergraduate higher education studies as part of the $4.35 Billion *Race to the Top* funding initiatives (2009). The White House Council on Women and Girls (2012) spearheaded public awareness by noting President Obama’s challenge in 2011… “and that's why we’re emphasizing math and science. That's why we’re emphasizing teaching girls math and science.” This was followed by the White House creation of the STEM Master Teacher Corp as a new initiative in July 2012. In 2005, a joint report issued by the National Academy of Science, the National Academy of Engineering and the Institute of Medicine as cited in Chen & Weko, 2009 called for an additional investment in STEM education to increase available teaching resources aimed at increasing the numbers of STEM undergraduate majors. However, it is still not well understood exactly what factors affect persistence in undergraduate STEM majors and therefore where the focus should be placed in order to improve persistence. There is a need for further research to help shape policies directed at improving the participation of women in STEM undergraduate studies.

Despite the growth in pathways for women to have access to advanced math and science courses in high school, seen as pre-requisites for success in college level STEM studies, women fail to achieve an equal representation in undergraduate STEM studies and eventually in STEM careers. Researchers have studied a number of contributing factors revolving around the themes of assuring sufficient academic preparation for young women (Ethington & Wolfle, 1988). However, obstacles beyond achieving a high level of academic preparation continue to hinder the participation of female students in STEM studies. Obstacles include perceptions of a lower self-assessment of capabilities for females compared to males (Brainard et al., 1995; Sax, 1994; Correll, 2001, 2004; Betz & Hackett, 1983; Hyde, J., Fennema, E., & Lamon, S., 1990; Feather, 1988), societal stereotypes (Entwisle et al., 1994), a lack of female role models in STEM (Hill, 2010), family and peer influences (Ost, 2010), as well as the cultural environment (Seymour & Hewitt, 1997).

Researchers have also focused on physiological differences between males and females, which may have some limited impact on women's capabilities in certain STEM fields such as engineering, yet exacerbates female perceptions of not being as capable as the men in achieving success (Halpern et al., 2007). Within STEM studies, more women are attracted to life sciences than to physical sciences, math, and engineering. Spelke and

Grace (2007) noted that boys are more inherently attracted to objects while girls are attracted to people.

The existing body of research on why women have a lower persistence in STEM majors has focused on academic preparation and self-confidence, cultural barriers and career / life balance factors.

Academic Preparation & Self-Confidence

Researchers have analyzed longitudinal data drawn from a wide range of national, regional and institutional databases. Not surprisingly, there is a strong correlation between success in college level STEM courses and high school GPA as well as SAT/ACT scores. The key findings suggest that advanced level and AP math and science classes in high school are the most important predictors of success in STEM majors and degree completion (Griffith, 2010). Bettinger (2010) studied the highest ability math students based on ACT scores and found that even at the highest level, women are 9-14% less likely to stay in STEM majors than male counterparts. Tyson, W., Lee, R., Borman, K., & Hanson, M. (2007) longitudinally studied nearly 100,000 high school 11th and 12th graders in Florida public schools in 1996-97 and followed them through their undergraduate studies. Overall, women represented more than 50% of the high school graduates. Of the original cohort of Florida high school graduates, college degrees were earned by 21.5% of the women compared to 14.5% of the men. Yet men outnumbered women by 2:1 in STEM degrees earned. This gender gap in earned college degrees in STEM disciplines has been consistent in the literature (Schneider, B., Swanson, C., & Riegel-Crumb, C., 1997; Huang, G., Taddese, N., & Walter, E., 2000; Chen & Weko, 2009).

Several researchers noted that the platform for succeeding in advanced classes in high school actually begins with taking algebra 1 in the eighth grade prior to entering high school. Tyson et al.'s (2007) analysis found a high correlation between STEM degree completion and having taken advanced levels of high school math and science courses. The middle school years have been shown to be important developmental stepping-stones for potential STEM majors. Halpern (1986) and Fennema, E., & Peterson, P. (1984) reported that differences in math achievement scores between male and female students begin to appear in the 13-16 year age group. Modi, K., Schoenerg, J., & Salmond, K. (2012) surveyed middle school age girls and found that although 81% of the respondents expressed some interest in a STEM career, only 13% selected STEM as their first choice. Of those who did express a strong interest in STEM, 67% selected health care.

NSF-2012 data for the 2009 high school graduating class showed that women are now well represented in advanced math and science courses. Table 4 presents the percentage of male and female high school students that completed advanced math and science courses in the high school graduating class of 2009.

Table 4

Advanced Math & Science Courses for H.S. Graduates, U.S. - 2009

	Male %	Female %
Math		
Pre-calculus	33.9	36.7
Calculus	17.0	16.7
AP / IB Math	15.1	15.2

Science		
Advanced Biology	39.4	49.9
Chemistry	66.7	72.4
Physics	41.5	35.9
Engineering	5.6	1.1
AP / IB Science	13.4	15.2

Yet, despite a significant increase in the number of women taking advanced courses and achieving scores comparable to men (Lubinski & Persson Benbow, 2006), the gender gap in undergraduate STEM studies still remains. Academic achievement in advanced math and science courses in high school has not answered the question of why women do not declare STEM majors and pursue math and science based careers (Bettinger, 2010). Advanced math and science courses in high school are effectively a pre-requisite to succeed as a STEM undergraduate major, but they are no guarantee that a female student will choose to major in a STEM field.

NSF-2012 data provided a comparison of the intended majors of entering college freshman. Women have a lower rate of intended STEM majors compared to males, with the exception of biology. Figures 1-3 show the intended majors by gender of the entering freshman class in 1995 (and compared with degrees awarded in 2000 as a rough approximation of tracking these students), the entering class of 2005 (and similarly compared with degrees awarded in 2009), as well as the latest data for the entering class of 2010.

Figure 1. 1995 Percent Freshman Intended Majors and 2000 Percent Bachelor's Degrees

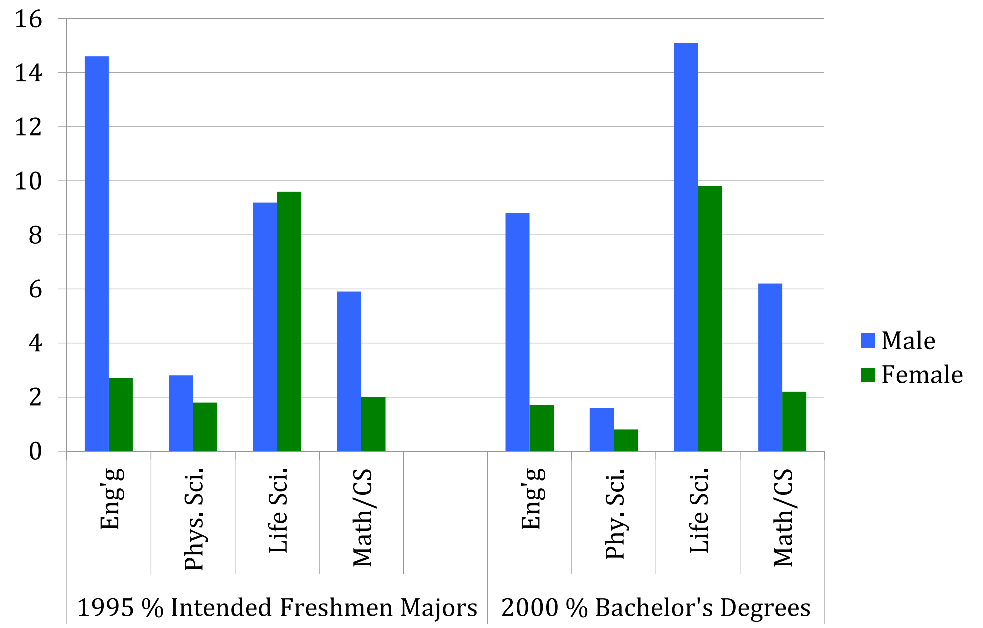
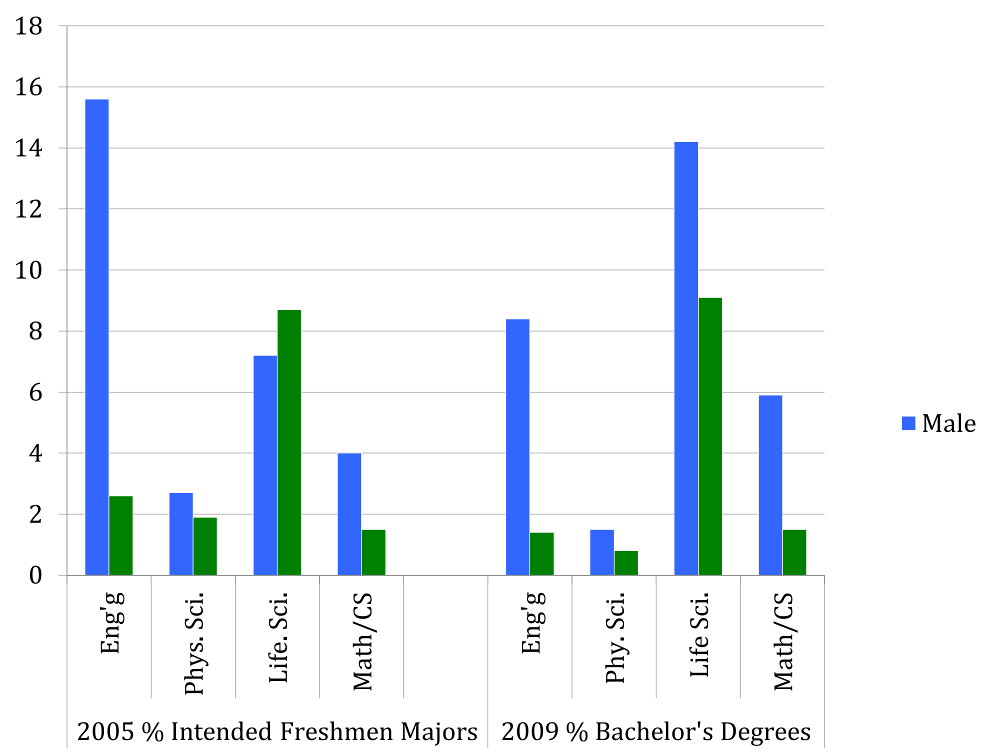
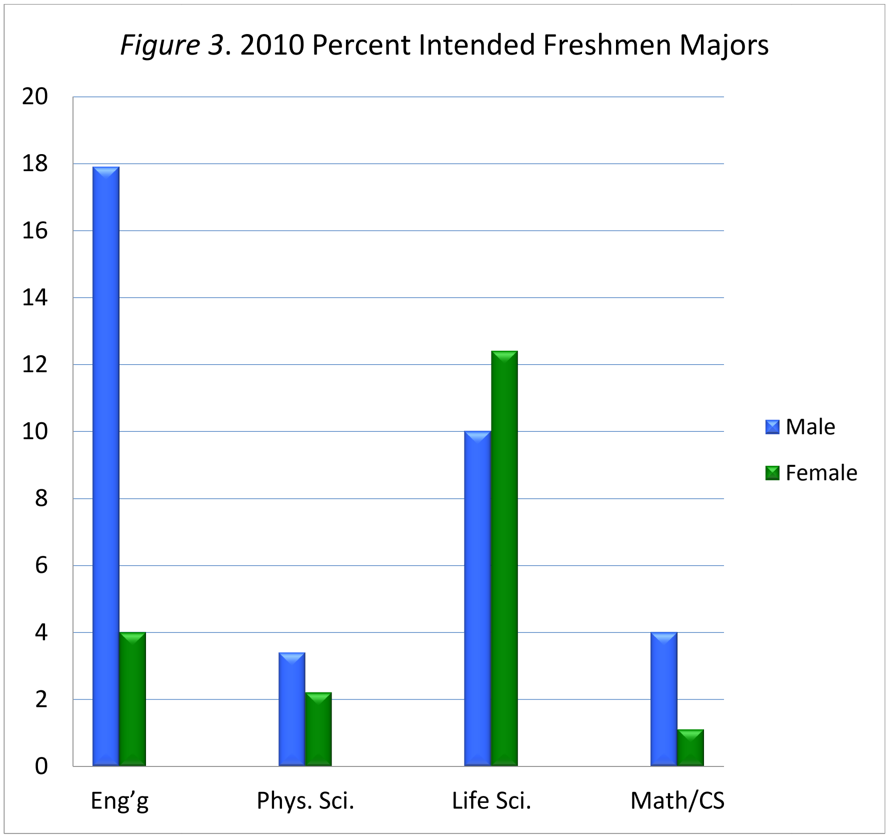


Figure 2. 2005 Percent Intended Freshmen Majors and 2009 Percent Bachelor's Degrees





Some conclusions that can be drawn from Figures 1 – 3 are:

- There is a lack of persistence for all students entering college intended as STEM majors. Only 43% of all students with an initial intention in STEM majors actually go on to major in a STEM field. Bettinger (2010) examined NSF-2004 data and noted that very few students (5%) transfer into STEM majors from non-STEM intentions.

- With the exception of life sciences, female freshmen have a lower rate of intended STEM majors than male freshman. In the 2010 entering class, engineering continued to have the largest gender gap with 17.9% intended male majors compared to 4.0% female.

- The persistence rate of women in STEM studies is less than that of men, tracking from freshman year to degree awarded. This transfer away from STEM is significantly large in engineering disciplines and math / computer sciences. Note that the completion percentage for degrees awarded to females in the life sciences is less than that for male students (9.1% of female bachelor's degrees in the life sciences in 2009 compared to 14.2% for males). This, despite the higher starting rate of female intentions in the life sciences as freshman in 2005 (8.7% female vs. 7.2% male).
- Women of the entering class of 2010 displayed STEM gender gaps which are somewhat smaller compared to prior years, but which are generally comparable to the gender gaps seen in the entering freshman classes of 2000 and 2005. This pattern of female underrepresentation in STEM studies continues despite women having reached parity in advanced math and science courses taken in high school.

Xie and Shauman (2003) and Ohland et al. (2008) considered the lower participation of women in science fields by evaluating the academic pathway from high school through doctoral degrees. Both groups of researchers found that there was no significant difference in high school mathematics and science scores between females and males. Despite similar academic performance in math and science, research has shown that women are more sensitive to the pressures of introductory "weed out" courses than men, and may have to deal with negative, perceived or real, bias from male peers and faculty (Bettinger, E., & Long, B. (2005). Women are more likely than men to switch to a career which offered more humanitarian or personally satisfying work, suggesting that women's early experiences in STEM courses, both grades and classroom experiences, influence their likelihood of persisting in STEM majors (Bettinger & Long, 2005; Seymour & Hewitt, 1977).

Cultural Factors

The dilemma that increasing women's participation and achievement in advanced high school math and science courses has not significantly narrowed the gender gap has led researchers to study the impact of cultural and psychological barriers on female students. The American Association of University Women (Hill, C., Corbett, C., & St. Rose, A., 2010) notes that women undergraduates are much less likely to major in STEM compared to their male counterparts. Hill et al. concluded that barriers are often self perceived and are caused by stereotypes of females not being welcomed in STEM studies and cultural aspects of our society. Leaper, C., Farkas, T., & Spears-Brown, C. (2012) studied high school age girls and examined various social and personal factors differing between males and females. Leaper et al. suggested that social support factors, such as parental influence, teachers and advisors that do not favor math and science courses for girls, will lead to a negative motivation for these subjects. The authors further noted that a girl's personal attitude formed in the middle school years would impact motivational values towards STEM subjects. Parsons, J., Adler, T., & Kaczala, C. (1982) examined the significant influence of parental expectations on math achievement and children's self-perceptions towards math in grades 5-11, while Maple and Stage (1991) reported that school administrators, including teachers, were not influential factors with females with respect to selecting a major.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011) surveyed a selection of female students who entered college-level studies with intended engineering majors at four Massachusetts based institutions (M.I.T., Olin College of Engineering, Smith College, and UMass – Amherst). Cech et al. analyzed persistence in engineering and related STEM majors as well as career interests. The study tested the hypothesis that the primary causes of underrepresentation of women in STEM included women having a lower self-assessment in STEM skills compared to males as well as family planning and work – life balance issues. Cech et al. also established a third category of explanation, a self-assessed "Professional Role Confidence," which they defined as measuring the personal comfort level that a qualified female feels with fitting into engineering as a career, given that engineering is perceived as a male dominated profession. Men reported a significantly higher comfort level compared to women with respect to Professional Role Confidence.

Walton and Spencer (2009) conducted meta-analyses on combined data of nearly 19,000 students spread across five countries. Their hypothesis was that stereotyping of students creates psychological threats, which adversely affect women in quantitative fields. Walton & Spencer's stereotype threat theory implies that women who identify with STEM may feel subjected to self-perceived psychological threats. They concluded that math score differences were not driven by capability, but by social conditioning. Nguyen and Ryan (2008) conducted a similar meta-analysis of data groups from over 100 studies. They noted that stigmatized social groups, (minorities and women), are constantly at the risk of underperformance.

Ost (2010) confirmed that females are more sensitive to grades received in science courses, consistent with theories of stereotype vulnerability. However, Ost noted that the sensitivity to low grades appears only in the physical sciences courses, not in the life sciences. Brainard and Carlin (1997) found that the first 2 undergraduate years and introductory grades were critical in determining whether a student decides to stay in engineering as a major. Rask and Tiefenthaler (2008) and Owen (2010) examined the persistence of undergraduate economics majors and noted that females were more sensitive to course grades in determining persistence as an economics major.

Physiological difference between men and women may manifest themselves as psychological barriers as well. They are an additional source of what may influence female attitudes and perceptions towards their capabilities in STEM studies. Newcombe (2007) emphasized that males are stronger in spatial cognition. This may have only a modest impact on true capabilities, but it begins to create a belief that women are not as capable as men in engineering studies. Lubinski and Persson Benbow (2007), and Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008) noted that although the average mathematical achievement scores of females slightly exceed those of the male population, there is a greater variability in the male scores. Thus the far right tail of math high achievers is male dominated. This may be a basis for the predominance of high achieving male students in advanced math and science courses, which may make some women feel intimidated and isolated.

Differences in cognitive learning between male and female students as a physiological difference begin to emerge in the middle school years. Hines (2007) and Hyde et al. (1990) conducted a meta-analysis of 100 studies. They further referenced studies by Halpern (1986) and Fennema and Peterson (1984) reported that differences between male and female math scores begin to appear in the 13-16-age bracket. Friedman (1989) conducted a meta-analysis and similarly concluded that gender-based differences in math scores are small for young children, with differences beginning to emerge in the junior high school years. Friedman's research, as cited in Carpenter et al., 1980, found that there are gender-based differences in math scores, as it relates to problem solving and applied mathematics. Hilton and Borglund (1974) also observed a divergence in math skills after grade 5.

Career / Life Balance Factors

The prospect that gender influences career choices, especially as it relates to family and life balance issues, was examined through the literature of Eccles (1987, 1994), Farmer (1997), and Fiorentine (1987). For example, Eccles (1987) pointed to the strong influence of cultural stereotyping, often within the family, in steering females away from traditional, male-dominated careers. Eccles (1994) further stated that a woman's educational and career choice is based on two sets of value beliefs: the individual's expectations for success and the importance of personal values. Using a national sample of above-average ability college-age women, Ware and Lee (1988) examined the role of family planning issues in career planning. Those women who placed a high priority on their personal lives and future family planning were less likely to major in a STEM field. Ceci, S., Williams,W., & Barnett, S. (2009) noted that women with high math competency often have high verbal competency as well, allowing for a greater choice in professions and less reluctance to switch from a STEM major to a non-STEM career path.

Kerr et al. (2012) introduced social status and prestige into the discussion. Kerr et al. theorized that a person's self-consciousness of his or her social status and his or her prestige environment (i.e. peer conformity) serve as effective predictors of a woman's persistence in STEM fields. Morganson, V., Jones, M., & Major, D. (2010) examined how well women cope with the *chilly climate* of STEM majors and whether this contributed to attrition of women from this field. *Chilly climate* implies male-dominated classes, and an impersonal and individualistic classroom and work environment (Daempfle, 2003). Women were found to prefer courses offering more discussion and interactive learning. STEM courses are seen as primarily lecture-style instruction with limited classroom dialogue. Milgram (2011) argues for increasing the number of professional STEM women role models that young girls are exposed to, in order to create the cultural message that women can succeed in STEM careers.

Research Problem

The body of research can be summed up as follows: Women now take the same number of rigorous, advanced math and science courses in high school and achieve comparable scores on standardized tests. Yet, with the exception of life sciences, women remain underrepresented in undergraduate STEM majors, especially in engineering, and have a lower persistence rate of staying in STEM during the first 2 years of college level studies. The basis for women that persist in STEM and women who decide to leave remains an open question. Recent research has shifted the focus to find a better understanding of the psychological barriers and cultural factors that women face.

Additional research is needed to help explain women's choices in deciding to persist as STEM majors.

Theoretical Framework

In this study I draw on Eccles' General Expected Values model (1994, 2007). This model focuses on the complex set of values and life balance choices that women consider when choosing an educational track and career. The General Expected Values model is based on the combination of two basic sets of implicit value calculations:

1. The individual's self-assessment of expected success in a given field. An individual's expectations of entering a given career are determined not only by actual achievement in related academic studies, but also by self-assessment of their abilities and chances for success. Prior body of research shows that most women tend to assess their ability in math and sciences less than men.
2. The importance and values hierarchy that the individual places on the opportunities and limitations presented by educational / career options they are considering. The importance and values an individual attaches to educational and career choices are shaped by the social society in which they live. Family, friends, teachers, culturally formed gender roles, and self-perceptions influence individuals in setting their values hierarchy (Leaper et al. 2012). Males may place a higher value priority on achieving career success and achievement of higher income. Females may seek more balance between career and family.

I also draw on Tobin, D., Menon, M., Menon, M., Spatta, B., Hodges, E., & Perry, D. (2010) Gender Self Socialization Model (GSSM) as an auxiliary framework to help explain gender role in the development of women's value based hierarchy. The GSSM model links childhood gender cognition theories into a tripartite classification of three constructs: (a) gender identity: children develop a self-identity as a boy or a girl at a young age; (b) gender stereotype: children's beliefs about what boys and girls are expected to do are influenced by the desire to conform to the collective gender stereotype; (c) self-perception: As children's gender identity strengthens, as they grow older, the more they identify with attributes and activities that fit the gender stereotype.

In the GSSM model, math and science are noted as exemplars of male academic interests, while female academic exemplars are English and language. Tobin et al. (2010) present a "stereotype emulation hypothesis", proposing that the more a child identifies with the collective stereotype of a gender, the more they will view favorably the attributes of that collective stereotype.

Eccles' (1994) framework of General Expected Values and Tobin et al.'s (2010) GSSM are useful in explaining how women's choices of academic majors and persistence are related to their belief about how well they perform the tasks and the extent that they value their success in that task. This valuation is made within the context of their gender identity and the importance an individual places on conformance to a gender stereotype. The frameworks can help explain why some women persist in STEM studies, why women within STEM persist in engineering and the physical sciences, and why women choose STEM based careers.

Purpose of the Study and Research Objectives

The purpose of this study is to examine the reasons and future outlook of those women that entered college with intent to major in STEM studies and persisted into their second, third, and fourth years. I aim to research the extent to which self-assessment of their capabilities and cultural issues influences their choices of persisting in a STEM majors and their future career plans.

A survey of second, third, and fourth year female students was undertaken to analyze their responses to three primary research questions to explain why women persist in STEM studies. The questions are designed to examine the values that women place on STEM as a career choice and on the self-assessment of their capabilities and outlook for success in a STEM career.

This study will add to our understanding of the STEM gender gap by examining the basis for the decisions taken by women that enter college with intentions to major in a STEM field and persist. Seymour & Hewitt (1997) and Rask (2010) noted that women had a higher persistence rate in STEM majors at highly selective colleges. This study will examine responses from students attending two technology-oriented undergraduate institutions, environments in which the overall majority of students are pre-committed to majoring in STEM fields.

Primary and Subsidiary Research Questions

Research Question 1 is: What factors help explain the level of self-confidence of women who have persisted in STEM? The subsidiary questions for Research Question 1 are,

- Do women that have persisted in STEM have a strong academic preparation in math and science?
- Do women's self-assessment of their capabilities in math and science help explain expectation of success in STEM studies?
- Does perception of gender bias in the classroom or concerns of gender bias in the future work environment help explain a lower level of self-confidence by women STEM majors?
- Does the belief that career aspirations can be fulfilled in STEM partly explain a woman's self-confidence?

Research Question 2 is: What factors help explain a woman's decision to remain in a STEM major? The subsidiary questions for Research Question 2 are,

- To what extent do women believe that success in STEM careers requires a trade-off between work and family obligations?
- To what extent do women that have persisted in STEM place value on the importance of achieving a large income compared to raising a family and lifestyle choices?
- To what extent has family, friends, and advisors supported or discouraged a woman's interests in the STEM fields?
- To what extent does the perceived balance of career vs. family help explain their decision to remain as a STEM major?

Research Question 3 is: What factors help explain differences among sub-groups of women persisting in a STEM major? The subsidiary questions for Research Question 3 are,

- To what extent do women who develop a strong interest in STEM studies by their middle school or early high school years (early deciders) exhibit a higher degree of confidence in their capabilities and future outlook in a STEM based career?
- To what extent do women STEM majors, who have experienced classroom bias (either from faculty or other students) feel more isolated, exhibit a lower level of confidence in their career choice and express second thoughts on remaining in a STEM program?
- To what extent do women students at technology based institutions persisting in their initial STEM major exhibit a higher self-assessment of capabilities compared to women that have changed STEM majors (but stayed within STEM)?
- To what extent do women students that struggled in first year STEM courses have a significantly lower level of self-confidence and have second thoughts about their future outlook?
- To what extent do women that have benefited from a strong support structure of family, friends and mentor groups have more self-confidence and a stronger future career outlook?

Summary

The past two decades have seen considerable advance in the realization that the underrepresentation of women in STEM fields, especially in engineering and the physical sciences, is a loss for our society as well as a potential income loss for qualified women.

Programs have been put in place to increase the exposure of young women to advanced math and science classes in school, starting at the middle school level. The participation rate and achievement scores of females in advanced math and science classes at the high school level have increased. More women are now qualified to consider STEM majors as they move to college level studies. Yet the actual completion rate of female degrees in science and math studies has hardly moved. Research is now focused on the sociological / psychological factors that are contributing to this enduring gap. The goal of this study is to add to our understanding of the underlying issues by focusing on the decision-making criteria of women that have persisted as STEM majors. The ultimate goal is to help frame possible solutions to attract more qualified women to major in STEM fields.

CHAPTER 2

REVIEW OF THE LITERATURE AND THEORETICAL FRAMEWORKS

This literature review discusses the three constructs upon which this study is drawn: academic preparation & self-confidence, cultural perspectives, and career/ life balance perspectives. The review also considers Tobin's (2010) Gender Self-Socialization Model and Eccles' (1994, 2007) General Expected Values Model as theoretical frameworks for undergraduate women's decision-making processes with respect to major field of study and career direction. The overall perspective is that the three constructs reflect the influences that shape decisions for women considering majors in STEM fields and entering STEM careers. The considerations of the constructs are viewed within the theoretical framework of gender identity and stereotype. The Expected Values Model provides the framework for integrating these considerations into a decision making process.

Academic Preparation and Self Confidence

Academic preparation and self confidence questions examine the impact of advanced high school math and science courses as well as the self-assessment of women's capabilities in STEM subject areas. It has been well established in a large body of research that a thorough academic preparation in middle school through high school with appropriate advanced math and science courses provides a solid foundation for success as a STEM major in college (Griffith, 2010; Kokkelenberg and Sinha, 2010; Ost, 2010; Price, 2010; Rask, 2010). The number of math and science courses a student takes in high school is a key factor in a student's ability to succeed in a quantitative field of study (Chen & Weko, 2009). In particular, exposure to advanced math classes in high school is a key determinant of math achievement in college. Only 18.1% of students that have taken Algebra 2 as the highest level of mathematics completed in high school entered STEM fields, while 45% of students who completed calculus chose STEM majors (Chen & Weko, 2009), suggesting that the improved odds of entering a STEM major after taking advanced courses in high school.

Women who chose to enter college with the intention to major in STEM studies appear to be academically well prepared. They are as likely as men to have taken demanding pre-requisite courses and appear to have self-confidence in their abilities (Brainard & Carlin, 1998). Maple and Stage (1991) conducted a detailed analysis of STEM indicators among high school students and found that an interest in a STEM major established by the sophomore year in high school and the number of science and math courses taken were the two most important indicators. Tyson et al. (2007) conducted a longitudinal study of high school students in Florida and followed their persistence / attrition from STEM programs. The importance of high school advanced math and science preparation as a key indicator was significant for both men and women in the completion of a STEM related degree. However, recent research has shown that for women, academic preparation in advanced courses is necessary, but not sufficient. For example, the National Science Foundation (2012) reported that in 2010 women achieved equal access and success with advanced math and science courses in high school, yet women continued to be underrepresented in STEM majors. Griffith (2010) confirmed that AP STEM classes in high school and having higher SAT scores enhanced persistence to graduation in STEM field majors. However, several researchers found that advanced high school courses were weak predictors of persistence after controlling for college grades (Kokkelenberg & Sinha, 2010; Ost, 2010; Price, 2010; Rask, 2010). Their conclusions were that the impact of taking AP courses in high school is captured mainly by their improvement in the students' performance in college courses, but does not have an impact on their persistence as STEM majors.

Many leading researchers have made attempts to explain why women score well in advanced high school math and science courses but do not pursue STEM majors and careers. Dweck (2007) presented the notion that women that do well in high school math perceive their talents as a gift and suggested that perhaps high grades in math and science came easily to them in high school. When these women encounter a more rigorous work level in college (e.g. early STEM weed out courses), female students may feel that they have reached the limits of their gift and do not have the confidence to make further efforts to improve their grades and persist in STEM disciplines and are more sensitive to the weed out process than men (Brainard & Carlin, 1998; Manis, 1989).

Although the mean achievement scores for men and women's standardized math scores are reasonably close, the variation in men's scores is much greater and that the tails of the male distribution curve in math scores are wider than that for women, suggesting that the upper, or far right tail in math achievement is richer with males than females (Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C., 2008; Lubinski & Persson-Benbow, 2007). Although this may help explain the larger number of males in STEM careers, there was no conclusive data found as to why women have a higher dropout rate once they intend to major in a STEM field.

In terms of factors that influence student persistence in STEM fields, gender peer effect plays an important role in the first 2 years of STEM courses. Kokkelenberg & Sinha (2010) reported that having more female students in a second year math class improved the confidence of other female students in that class. This positive correlation was also noted for biology but was not evident in non-STEM courses. This study also confirmed the findings of Sax (1994), who noted that the gender gap in mathematical self-confidence was reinforced by the characteristics (i.e. selectivity, size and environmental factors) of the institution attended. Ost (2010) analyzed the grades and gender peer effect at a large, elite, research university, in which the freshman standardized SAT and high school GPA scores were well above the national average (24% of the freshman class at this elite school received college level credit for AP calculus taken in high school). Ost found that students qualified to consider a STEM major were pushed away by low grades in early STEM courses and attracted by higher grades achieved in non - STEM course work.

Despite equal achievement in earned grades, women tend to perceive themselves as less capable in math (Correll, 2004). Female students may hold themselves to a higher standard and thus believe that they are not suited for a STEM major. Concannon and Barrow (2010) surveyed engineering undergraduates at a large research-based university and determined that men's persistence in engineering was strongly associated with their belief in being able to successfully complete the program requirements (with any passing grade) while women's persistence was based on their beliefs in getting good grades (A or B). Concannon and Barrow thus concluded that women hold themselves to a higher academic standard and that women's self-efficacy beliefs significantly predicted their intent to persist. Mara and Bogue (2006) longitudinally surveyed women in engineering programs and found that self-confidence in mathematical abilities increased significantly from the first to third year. They also found an increase in confidence in being able to complete the program. Although there is no comparison with male students in this study, it supports research findings of lower confidence in first and second year female students, leading to transfers away from STEM majors.

Research has shown that higher grades in STEM courses relative to other courses in the first year are positively associated with the probability of continuing in the major. While persistence of all students in a STEM major is affected by low grades in introductory courses, women appear to be more sensitive, especially in physical science courses (Seymour & Hewitt, 1997). Sabot and Wakeman-Linn (1991) examined the impact of grade inflation in non-STEM courses and its impact on course selection. This study also found a positive gender peer effect on women in physical science classes. The need for a female peer support group in some STEM classes was seen to a lesser effect in life science courses. This finding emphasizes the need for women finding a comfort level through peer support in the physical sciences. Women also found a comfort level in STEM majors if there were a significant number of female faculty members instructing the courses (Robst, Keil, & Russo, 1998). Also Bettinger and Long (2005) concluded that female STEM majors have a higher persistence in schools where there are a larger number of female faculty members.

Female self-confidence in math abilities and its impact on persistence in STEM studies seems to be influenced by the type of higher education institution attended. Griffith (2010) reported that female persistence varied depending upon whether the student attended a small liberal arts college, an elite institution, or a research-oriented large university. Rask (2011) found that at a selective northeastern liberal arts college, females' decisions to persist in STEM field majors were less sensitive to grades than male students. However, Ost (2011) found that, at a large, elite, private, research university, females' persistence decisions were more sensitive to grades in the physical sciences than their male counterparts. Seymour and Hewitt (1997) noted that women had a higher persistence rate in STEM majors at highly selective colleges. Strenta, A. C., Elliott, R., Adair, R., Matier, M., & Scott, J. (1994) noted that the gender difference in persistence varied dramatically by type of institution. In highly selective institutions, 61% of men were persistent versus 46% of women. In comparison, on a national average, persistence in STEM studies for men was 39% and 30% for women.

The concept of the type of institution, such as a small, liberal arts college as a natural incubator for science majors including females, was already well documented by Knapp and Goodrich (1952). These studies suggest that the type and size of institution and its peer environment may have a significant impact on female self-assessment of capabilities and thereby their persistence in STEM majors.

Correll (2001) analyzed the NELS-88 database to compare gender-based self-perceptions of mathematical competence versus actual capabilities in determining career decisions. Correll found that men overstated and women understated their own mathematical abilities and concluded that the lowered self-perceptions of capability by female students constrained their career choices. Pajares (2005) found that gender-based differences in self-perception began in middle school and increased as the students advance through high school and college. Brainard and Carlin (1995) focused on women’s lack of self-confidence as a factor is low persistence rates. Feather (1988) studied academic enrollments at an Australian University and found that females placed a lower personal value on mathematics and had lower self-assessment of capabilities. Hutchison, M., Follman, D., Sumpter, M., & Bodner, G. (2006) surveyed first year engineering students with respect to their self-confidence. Seventy two percent of female students compared to fifty five percent of male students expressed concerns about their learning content abilities as needed, to meet the challenges of an introductory engineering course.

Rask (2010) analyzed student persistence in a small, northeast liberal arts college and tracked student cohorts from 2001-2009, following their persistence in math, science and computer science courses through the first 2 years of college. In the largest relative decline in persistence based on gender, women represented 31% of students in introductory computer science classes but only 17% of the initial female cohort remained in this track by the fourth semester course. The largest declines in STEM course participation occurred after the first and second courses. Thus, students that registered for a third semester course and beyond were likely to persist in the major. In contrast to Ost (2010) and his own prior work (Rask & Tiefenthaler, 2008), Rask (2010) found in this study that men exhibited more grade sensitivity than females in deciding to progress to a second STEM course in a subject area.

Huang et al. (2000) analyzed NELS 1988 data and came to a surprising contrary conclusion. They reported that female students in science and engineering programs actually did better than male students in degree completion and program persistence. This finding suggests that although women are less likely than men to enter science and engineering, those women who do enter are as likely to do as well as men. A limitation of this study is that the NELS-88 definition of science and engineering includes some social science majors within the broad field of science and engineering. Social sciences are no longer included in the DOE's definition of STEM (NCES, 2006).

In summary, women have attained equal access to advanced academic preparation in math and science courses to succeed in STEM majors. Equal access and participation of women in advanced courses was a major thrust of policy during the past decades. Academic preparation should no longer be seen as the defining obstacle to entry into STEM disciplines in college, yet the number of women intending to major in STEM fields has not changed and women's persistence remains lower than for men. However, the notion continues to persist that men are mathematically superior and are innately better suited to STEM fields than women (Ethington & Wolfle, 1988).

Research has shown that women have a lower self-assessment of their mathematical capabilities as compared to men (Dweck, C.,2007). This self-confidence gap may start as early as the middle school years. This gap manifests itself by women being more sensitive to grades achieved in early "weed out" STEM courses. Women may drop out of STEM if they have not earned at least a B in introductory courses. The self-confidence gap is exacerbated if there are few peer women students in a class to serve as a mutual support group and few female STEM faculty members to serve as success role models. Interestingly, this confidence gap does not appear as strongly among women attending elite level institutions. What remains unclear through these studies linking female self-confidence and institutional type is the root cause. Is it the characteristics of the institution that shapes the self-confidence of their female students and their higher sensitivity to grades or are self-confident women drawn to the highly competitive and elite college environment? Perhaps women attending elite schools have a stronger self-image and sense of assurance compared to women attending mainstream institutions.

Cultural Factors

The cultural perspectives construct examines the effect of messages that women receive from society, friends, family, friends, and teachers, with respect to what are considered appropriate career fields for women. Women's choice of undergraduate study and career are impacted by images that females receive in early childhood and onwards that certain careers are traditionally appropriate for females while others are typically male dominated. It may begin simply with young boys being encouraged to build model planes and play with trucks, while young girls are encouraged to play with dolls and have tea parties. The question of nature vs. nurture is a factor in broad based studies of male and female behaviors (Ceci, & Williams, 2007). This review is limited to examination of its impact on choice of STEM major and persistence.

The questions can be posed as to what extent is the apparent preference of females for humanities rather than STEM formed by the cultural bias of our society? To what extent is female preference within STEM for majors in the life sciences rather than physical sciences and engineering, a matter of women seeking a career in which they can have greater human contact and fulfill a desire for making a social contribution and nurturing others?

In studies of high mathematics achievers, women were more likely to secure degrees in the humanities, life sciences, and social sciences than in math, computer science, engineering, or the physical sciences (Lubinski & Persson Benbow, 2007). From early adolescence, girls express less interest in math or science careers than boys (Lapan, R. T., Adams, A., Turner, S., & Hinkelman, J. M., 2000). Many girls and young women report that they are not as interested in science and engineering as their counterparts. Betz and Hackett (1981) reported that females had significantly higher levels of self-efficacy in traditional female roles (careers as defined by the U.S. Women's Bureau) and significantly lower self-efficacy when considering non-traditional female careers, including engineering and mathematician. Modi et al. (2012) studied adolescent girls' perceptions of STEM and found a strong interest in science and math in this age group but little interest in STEM as a career. Thus, already by the middle school years, parity in academic capability and interests in math and science does not lead to equivalent interest in these fields as career opportunities.

Blickenstaff (2005) reviewed the complex set of contributing factors attributed to the lower persistence of women enrolled in STEM and focused on the separation of boys and girls by primary grade teachers into culturally defined roles. Blickenstaff cited Thorne (1993) in noting that teacher influences in the primary grades impact children's ideas of appropriate career goals and aspirations. Fennema and Peterson (1990) found that in families and peer groups where mathematics was judged as an inappropriate field for women, a female's positive achievement in mathematics was then viewed as not having adequately fulfilled her sexual role identity.

Dweck (2008) reported that such misconceptions can be overcome when females realize that math and science are learned skills rather than innate to their gender. Drawing upon social psychological theories of vulnerability and ambiguity findings of (Crocker & Major, 1989), Rask and Tiefenthaler's (2008) study indicated that women were more sensitive to college grades as a feedback mechanism than males, and this may contribute to the gender based persistence gap. Their analysis showed that a 1 point increase for females in physical science GPA improved the probability of persistence by 13.4%, whereas the corresponding figure for males was only 10.7%. Social psychological theories of vulnerability and ambiguity are based on the premise that females majoring in the physical sciences may have a particularly large psychological response to grades due to females perceiving that they are a minority group in physical science classes, whereas females majoring in the life sciences do not see themselves as a minority group. Thus females earning a modest grade in a physical science and engineering class, where there are few females peer students to compare against, may feel that they cannot meet the high standards they self impose with respect to their grades, as well as in comparison to high grades earned by males in the same class.

Women appear to be influenced by role models, such as peers, and other female classmates and female faculty more so than their male counterparts. Eagly (1978) found that females were more susceptible to peer influence than males. Bettinger and Long (2005) and Price (2010) found that female instructors had a positive impact on choice of major for female students, supporting a role model influence. Bettinger and Long reported that in quantitative majors (e.g. STEM, economics, etc.), women who had a female faculty member for their introductory course were nearly twice as likely to continue with an additional course. Griffith (2010) found that a higher percentage of female faculty members at a large, research-based institution was associated with a higher persistence rate for women in STEM, highlighting a similar positive relationship linked to a higher number of female graduate students. Robst, Keil, and Russo (1998) similarly found a positive correlation between female STEM persistence and the number of female instructors in math and science. Canes and Rosen (1995), in their study at elite level schools, found no link between the percentage of female faculty and the percentage of STEM majors of female students. In an attempt to examine gender peer effects, Ost (2010) found that female peers had a more positive influence on female students' persistence in physical science courses compared to the impact of male peers had on male students. Rask (2010) and Canes and Rosen (1995) did not find a significant persistence based on female faculty and student role model relationships at the smaller, liberal arts schools. Brainard and Carlin (1998) report an improved persistence rate for women in undergraduate engineering programs after an intervention program for first and second year students based on interaction with local members of the Women In Engineering society, suggesting that role models for women has a positive effect on persistence. Ohland et al. (2008) noted that engineering programs differed from other STEM majors due to the significantly lower number of women in engineering. This implies a direct linkage between a culturally formed perception of minority status and the resultant lack of women intending to declare majors in engineering programs.

Di Fabio, N. M., Brandi, C., & Frehill, L. M. (2008) note that while women occupy 40% of full time faculty positions at degree granting institutions, the female participation rate drops to just 18% in the physical sciences and to 12% for engineering, revealing a lack of academic role models for women in STEM studies. Brainard and Carlin (1995) confirmed in their research that professional female role models influenced a higher persistence rate for female STEM students. Accordingly, Milgram (2011) argued for increasing the number of professional STEM women role models to help strengthen the vision of successful women in STEM careers.

Seymour and Hewitt (1997) presented a basis for explaining some of discrepancies in the impact of faculty gender and peer influence. They report that women attending highly selective colleges have a higher persistence rate within STEM majors as compared to other institutions. The nature of the institution, faculty gender, and the quality of student peer-to-peer relationships apparently has an influence on female persistence at the respective institutions.

Lubinski and Persson Benbow (2007) are among those who argue that women have a strong cultural perspective in their desire to make a social contribution. Women are more likely than men to select a field of study that will enable them to make a contribution to society. Eccles (1994) and Gibbons (2009) explained that even within STEM fields, women are more likely to choose biology, leading to medical studies or environmental engineering, than the physical sciences. Women’s preferences (by a 2:1 margin) for biological studies within STEM as compared to the physical sciences are strongly supported by the data (US Bureau of Labor Statistics, 2009) and (NSF, 2010). From a cultural perspective, female preference for life sciences with STEM can be seen as a fulfillment of a desire to offer nurturing to others through science.

Seymour and Hewitt (1997) reported the effects of sexual stereotyping on choice of field of study are already noted by the ninth grade. The importance of the middle school years in considering a STEM-based career is reinforced by meta-analyses of over 100 studies conducted by Hyde et al. (1990) and Friedman (1989). Entwisle et al. (1994) explained the growing separation between male and female math scores that begin to develop during the middle school years by focusing on the role of cultural factors, such as the neighborhood environment and peer social class. Parsons et al. (1982) examined the influence of parental expectations on math achievement in grades 5-11. As role models, parents imparted their beliefs that math was more important for sons, and that daughters had to work harder to achieve equivalent math scores. This study showed the significant impact of culture on children's self perceptions and attitudes towards math.

At the college level, women are not only more sensitive to grades in early weed-out courses but also have to deal with perceived or real biases from male peers and faculty. Women reported that feelings of psychological alienation or depression played a role in their decision to leave STEM studies. Walton and Spencer (2009) found that pervasive psychological threats from faculty and peer members in academic environments undermined the performances of women. Egan and Perry (2001) confirmed stereotype threats amongst middle-school aged children and examined the relationship between gender identity and psychosocial adjustment. This relationship was divided into evaluation of comfort with one's gender identity, pressure to conform to gender role models from friends and family, and self-perceived gender bias. Egan and Perry sought to understand to what extent adolescent girls felt free to explore career options considered more typical for the opposite gender.

Kerr et al. (2012) introduced social status and prestige into the discussion. Kerr, et al theorized that a person's social status and prestige environment are effective predictors of women's persistence in STEM fields. *Distance From Privilege* (DFP) is a construct that refers to how far removed a student may be from centers of power and the dominant culture that might influence a career decision. Kerr et al. differentiated DFP from classic measurements of race, ethnicity, and SES by giving as an example that a bright, but poor, rural Navaho Indian girl, placed into the right environment (elite college, supportive mentors, access to resources, etc.) had the same chance of success in STEM as a White male student. Their theory is that DFP factors represent barriers for talented women in STEM fields. Kerr et al. proposed *Distance From Privilege* (DFP) as a theoretical model that considers how far removed a student may be from centers of power and the dominant culture, which might influence a career decision. Women that feel themselves removed from the centers of power in STEM studies are less likely to persist. Kerr et al. indicated that social capital (e.g., well connected networking) was as important as financial capital. A strong professional and social network will positively impact persistence in STEM studies. The results highlight the vulnerability that female STEM students may feel if they are not part of the mainstream demographic.

Seymour and Hewitt (1997) observed that men were trained to develop an intrinsic sense of self-worth in their studies and careers, whereas women were trained to develop an extrinsic sense of self-worth. Therefore, women are more likely seek approval and praise from others with respect to their studies as compared to men. Such approval may be difficult for women to find in STEM studies. Ceci et al. (2009) noted that women with high math competency also had high verbal competency. This allowed for a greater choice in major fields of study, enabling the selection of an extrinsic oriented career in the liberal arts as compared to STEM fields.

Morganson et al. (2010) reported that women found a chilly climate in the STEM classroom, while Daempfle (2003) and McShannon and Derlin (2000) found that women had a stronger preference for an interactive learning style, more typically found in non–

STEM courses. Manis (1989) noted that women bring different cultural experiences and patterns of socialization to their studies compared to men and concluded that women are less likely to find satisfactory cultural experiences in STEM studies and that those women reported feelings of psychological alienation or depression. These factors of alienation in STEM classrooms may play a critical role in women's decision to leave STEM. Tamres, L., Janicki, D., & Helgeson, V. (2002) reported that female students are more likely to seek emotional support within their institution as compared to men. Suresh (2006) surveyed female students with respect to how they dealt with first year courses in calculus, chemistry and physics and the support structure they received from the faculty. The findings were that most students utilizing successful coping strategies that were built around support networks with friends. Rosenthal, L., London, B., Levy, S., & Lobel, M. (2011) found that single-sex programs at a co-educational institution strengthened the feeling of women's engagement in STEM studies. However no direct linkage to improved persistence due to improved engagement was reported in this study.

In summary, the focus of the cultural factors construct on female consideration of academic majors and career aspirations deals with the latent messages in our society and the orientation and biases of family, friends, and trusted advisors. Females receive signals, beginning in early childhood that shapes their attitudes towards possible career options. STEM is still considered a male domain, with the exception today of life sciences and medicine. The notion that women are not welcomed in engineering and the physical sciences is well reflected in the findings of Halpern et al. (2007). Their research concluded that cultural, sociologica, and family values influence the decision of even high achieving females against pursuing math and science careers. Academic interests and career decisions for women begin forming during the adolescent years and continue into the university. Academically qualified women arrive at undergraduate studies already pre-disposed against STEM majors and careers.

Career / Life Balance Aspirations

The career / life balance construct examines the real and perceived challenges that a woman may face in balancing family interests with career options. Workplace environment, perceptions of job bias, and family responsibilities all play a role in women's perceptions of STEM as a desirable career field. Hewlett et al. (2008) reported that women cited feelings of isolation, an unsupportive work environment, extreme work schedules, and unclear rules about advancement as major factors in their decision to leave STEM careers. Women who are successful in STEM careers are perceived as male in character and are generally less liked than equivalent male professionals (Heilman, M. E., Wallen, A. S., Fuchs, D., & Tamkins, M. M., 2004). Ceci et al. (2009) reported the perception of female students that women with children have fewer promotion opportunities in math intensive fields. Women physicists reported that one of the obstacles in their career path was the expectation that they would be the primary caregivers for their children (Ivie, Czujko, & Stowe, 2002).

Earnings potential in STEM is an important consideration. Brainard and Carlin (1997) studied 600 women students in six cohorts at the University of Washington. They found that perceived job outlook influenced persistence during the freshman year. Although Federal statistics (U.S. Department of Commerce, 2011) showed that women in STEM careers earn on average 33% more than women in non-STEM fields, Hecker

(1995) reported that women in business and accounting earn more money than students in chemistry, biology, or mathematics.

Xie and Schauman (2003) reported that women considered STEM careers as being more problematic for achieving work and family balance. Women perceive family responsibilities as a possible barrier to advancement in technology based careers (Hewlett et al., 2008). Women considering a STEM career may foresee a "family penalty" in making this career choice. Cech et al. (2011) conducted a longitudinal study of undergraduate women and found that self-confidence in being able to fulfill professional responsibilities was a key factor differentiating women's persistence in engineering studies. Women's relative lack of self-confidence in potential professional success in STEM fields, parallel to a lower self-assessment of math capabilities, leads to a higher rate of female attrition away from STEM studies. Manis (1989) reported that women show a greater concern in wanting to make their education, career goals and personal priorities fit coherently together and that women are more likely than men to switch to a career, which offered more humanitarian or personally satisfying work.

Trower (2008), in a presentation for the American Association of University Women (AAUW), noted that mentoring is crucial for STEM women in academia. Without mentor support women might not be privy to the networking benefits of the good old boys' club. Trower also suggested that the nature of scientific research may make work-family balance particularly challenging for female STEM faculty. Hartung, P. J., Porfeli, E. J., & Vondracek, F. W. (2005) reported that some women develop a belief that they cannot pursue particular occupations because they perceive them as inappropriate for their gender.

Cech et al. (2011) surveyed students at highly selective colleges and found that a lack of self-confidence in finding success in a desired professional role was a primary contributor to women transferring away from STEM. The broader attribute that gender influences career choices, especially as it relates to family and life balance issues, was examined through the literature of Eccles et al. (1987), Farmer (1997), and Fiorentine (1987). Eccles (1987) pointed to the strong influence of cultural stereotyping, often within the family, in steering females away from traditional, male dominated careers. Farmer (1997) conducted a longitudinal study based on male and female students in high school and beyond. Using a social learning theory, Farmer concluded that socialization pressures from parents, teachers, and guidance counselors impacted women, interpreted as an apparent lack of support for women's achievements and career planning. Fiorentine (1987) examined the attrition of women applying to medical school from pre-med undergraduate programs. Although equal numbers of men and women enter into undergraduate pre-med studies, men outnumber women by 2:1 in medical school applications. Fiorentine concluded that this persistence gap is not due to academic performance but rather the cultural barriers hindering women from entering into typical male professions.

Ceci et al. (2009) concluded that biological and sociological factors combine as root causes in female career choices. They reported that females have a stronger innate interest towards people while males are more disposed towards objects (effectively, young girls play with dolls vs. boys playing with blocks). This conclusion is based on sex-based brain development studies. This biological pre-disposition is then coupled with the sociological pressure of negative career - family tradeoffs that women perceive as associated with STEM fields. Ceci et al. also noted that women with high achieving math scores on SAT exams also tend to have high verbal scores. This affords them a broader choice of career options based on majors in the liberal arts. The inherent biological differences in brain development between men and women are exacerbated by the sociological and role expectations of career choices for men and women.

Ware and Lee (1988) studied a national sample of above average ability, college - age women to examine the role of family planning issues. Those women who placed a high priority on their personal lives and future family planning were less likely to major in a STEM field. Burge (2006) focused on women students in the 1970s and 1990s and how societal social pressures shaped their career choices. Burge cited Jacobs (1989, 2003) who noted that women consider work and family balance in gender-specific ways. Burge concludes that women's orientation to family contributes to their stalled progress in establishing STEM based careers. Frome, P., Alfeld, C., Eccles, J., & Barber, B. (2006) longitudinally followed a Michigan cohort of female students during the 1990s and confirmed that they had a lower rate of selecting STEM majors as compared to males and had a higher attrition rate out of STEM majors once in college. Frome et al.'s hypothesis is that this leakage out of the STEM pipeline is due to both the lowered self-assessment in math skills as well as their desire to find an occupation that is more compatible with work and family balance.

In summary, the career / life balance aspirations construct reflects the culturally developed orientation that females do not see STEM careers as an optimal combination of professional self-fulfillment and work - life balance. Women make choices for educational and career pathways based on a different mix of expectations for career success and differentiated personal values as compared to males (Eccles, 1987). It is not clear to what extent the view that STEM careers are unfavorable to family values is reality versus perception. For example, successful attorneys, male and female, tend to work long hours. Marketing and sales managers often have extensive travel commitments. Female faculty members have a similar level of stress to fulfill promotion requirements in non-STEM departments. This dissertation hopes to gain further insight into career / life balance perceptions among undergraduate students.

Theoretical Framework

The constructs chosen for this dissertation reflect three, broad, underlying areas of focus in the decision-making process of women as they consider staying in or leaving STEM studies and careers. The GSSM theoretical model represents gender role and stereotype threats, which influence women's perceptions and attitudes starting in early childhood. The GSSM gender based model acts as a lens through which women view the considerations of the three constructs. The Expected Value Model represents a framework for women's decision-making process, taking both objective factors (skill levels) and subjective factors (core values) into consideration.

Gender Socialization Theoretical Model

The Gender Socialization Theoretical Model integrates women's feelings of lower self-confidence in academic capabilities, cultural messages that steer women away from STEM, and concerns about work / family life balance in STEM careers. Tobin et al.'s (2010) model helps explain that the choices and values that women make are based on gender identity and gender stereotypes that develop at a young age and strengthen as children age. Women will identify with activities and values that society has established as the norm for female behavior. Tobin et al. summarized a body of literature and noted that young children, through parental influence, learn gender behaviors. Young children observe the play of older children and then seek to emulate their activities. Bleeker and Jacobs (2004) found that female self-perceptions about their math abilities were influenced by peers and teachers, but especially by their mother's beliefs, as conveyed during their adolescent years. A similar influence in attitude was observed among high school aged girls in favor of biology compared to physical sciences, based on their mother's preference. Leaper et al. (2012) found that female motivation in math and science was positively correlated with the influence of the mother, peers, and gender-egalitarian beliefs. In a slight contrast, Sjaastad (2010) undertook a similar study in Norway and found that the father was the more influential parent in setting overall academic direction. Martin and Ruble (2010) reported that children form gender identity and labeling by 2 years of age, basic stereotypes by 3 years, and they assign higher status jobs to traditional male roles (e.g. business executive). The range of gender stereotype continues to expand as the child grows to pre-school age and includes descriptions of gender biased school activities and occupations.

Spencer, S., Steele, C., & Quinn, D. (1999) researched gender-based stereotype threats with regard to self-appraisal of female math abilities. Women may feel that they will be judged more negatively than men based on a level of math achievement that may be below expectations. This perceived threat leads to actual lower achievement scores on standardized math tests. Weisgram and Bigler (2007) experimented with groups of adolescent girls to measure interest in science. An experimental group received an intervention consisting of interactions with female scientists as role models and listening to a discussion about gender stereotyping in STEM. The experimental group subsequently scored higher than a control group on a post-test of interest in science.

With regard to the significance of gender identity and stereotyping in a woman's consideration of STEM studies and career, Egan and Perry (2001) concluded that the healthiest environment (most favorable for a woman selecting STEM) is one in which a person feels secure within their own sexual identity but can feel free to explore cross gender role activities when they so desire. This would suggest that women considering STEM career are less likely to be concerned about how others may view their gender self-identity solely based on their choice of major and career.

General Expectancy Value Model

The Expectancy Value Model provides a decision-making platform. Women can evaluate their overall self-assessment and confidence in having acquired the skills to achieve success in a STEM field. This assessment of the chances of success is combined with the importance a woman assigns to gaining that success. Based on prior research by Eccles (1987) and Atkinson (1964), Eccles' (1994) Expectancy Value Theory combines attributes of achievement expectancy and career / life balance choices into a useful decision framework. This model consists of two basic questions that female students considering STEM must evaluate: (a) Do I have the academic and professional capability to be successful in the career I am considering? (b) Based on my personal values, how important is achieving success in this field compared to the life balance trade-offs that may be required versus other career - life balance choices? Eccles'

Expectancy Value Theory can be seen as a model for decision making based on the dual constructs of self –assessment of capability and personal values hierarchy.

Decision-making theory as it applies to women's choices in STEM majors and career options has a well-established body of literature. Eccles (1994) cited Crandall (1969), Weiner (1974), Adler et al. (1983), and Meece and Midgley (1983) among others in building the two constructs of the model. Eccles cited Rokeach (1973) in establishing that males and females have different hierarchies of core personal values.

Correll (2004) postulated that differing self-assessment of competence by men and women would lead to differing career paths. Correll concluded that culturally based beliefs about gender-based capabilities create a bias in men and women's self-assessment of their suitability for a given career. Eccles (1994) noted that individuals make choices and set personal goals, both consciously and unconsciously, which are based on gender differences. For Eccles, the question relating to the female gender gap in STEM is, not why do women make different choices than men, but why do women make the choices that they do.

Manski (1993) presented the economics-based idea that students will choose a specific major if the expected present-value of lifetime utility for choosing that major is higher than the expected value of any other. Similarly, Hecker (1995) concluded that differences in relative earnings and wage growth in a given major provide one key input to student's decision-making. Smart, John C., Kenneth A. Feldman, and Corinna A. Ethington (2006) noted that some students that have shifted away from STEM majors have often gone toward more market-based career choices such as business majors. Jensen and Owen (2001) studied economics majors and reported that students chose their careers based on the combination of interests and abilities. This combination of attributes is the essence of the Expected Value model.

The Eccles (1994) model suggests that students will do well in subjects and careers that they expect to succeed in and which hold a value for them. There is a natural predisposition to succeed in an area that one believes that one has strengths. Expectations and values are driven by a perception of competence integrated with an individual's goals and self-understanding of their values hierarchy. However, expectations and values can easily fall into gender-based stereotypes with women assuming that men are better at math and science and that STEM is a man's domain.

The Expected Values Model itself is logical. It represents the combination of a woman's self-appraisal of her skills and the potential benefits of a STEM career, measured against her personal core values. Tobin's GSSM model helps us understand that gender identification and stereotyping impact women's self-confidence and personal core values. Women's evaluation of the value and importance of achieving fulfillment in a STEM field is further influenced by cultural norms concerning expected female roles.

Overall Conceptual Framework

The purpose of this study is to better understand how self-confidence, cultural issues, and career - life style balance form the foundations of the decisions and choices for women considering a STEM career. The three constructs presented academic preparation and self-confidence, cultural factors, and career life balance factors, flow into the Gender Socialization Model as a method of interpreting the cultural messages and self-assessment of capabilities. Women's feelings and judgments are influenced through the constructs and the gender stereotypes represented in the GSSM model. Women's self-assessment and personal values are then combined in the Expected Values Model as a decision-making template.

Figure 4 presents a flow chart of these connected relationships.

- Academic preparation and self-confidence: High school advanced courses and grades earned in undergraduate STEM classes contribute as objective criteria in a woman's capability assessment. Women will consider whether they have acquired the skills to succeed in a STEM major and profession. The gender stereotype lens of the GSSM model suggests that many women may feel that they have to excel compared to men to succeed in STEM fields. Women may underestimate their own STEM capabilities relative to men. Women's objective assessment of their skills and their self-confidence in achieving success comprises the academic capability and self- confidence construct in the Expected Values Model.
- Cultural factors are viewed through the GSSM model reflecting gender identity and gender stereotype. Women are influenced by society, family and trusted advisors to consider professional roles that have been traditionally assigned to women since early childhood. Women majoring in STEM studies may need to have a strong sense of gender identity in order to consider a career traditionally dominated by males. Gender identity considerations as evaluated through the lens of the GSSM gender model are then evaluated in the Expected Values Model, especially as they relate to women's core personal values.

- Career - life balance factors are judged within a woman's core personal values. Women evaluate the importance of pursuing a STEM career, potentially with higher earning opportunities, compared to alternative career choices, which may result in lower pay, but may offer more flexible work hours. Women's choices in the career - life balance construct are evaluated within the Expected Value Model as part of a woman's decision-making template.

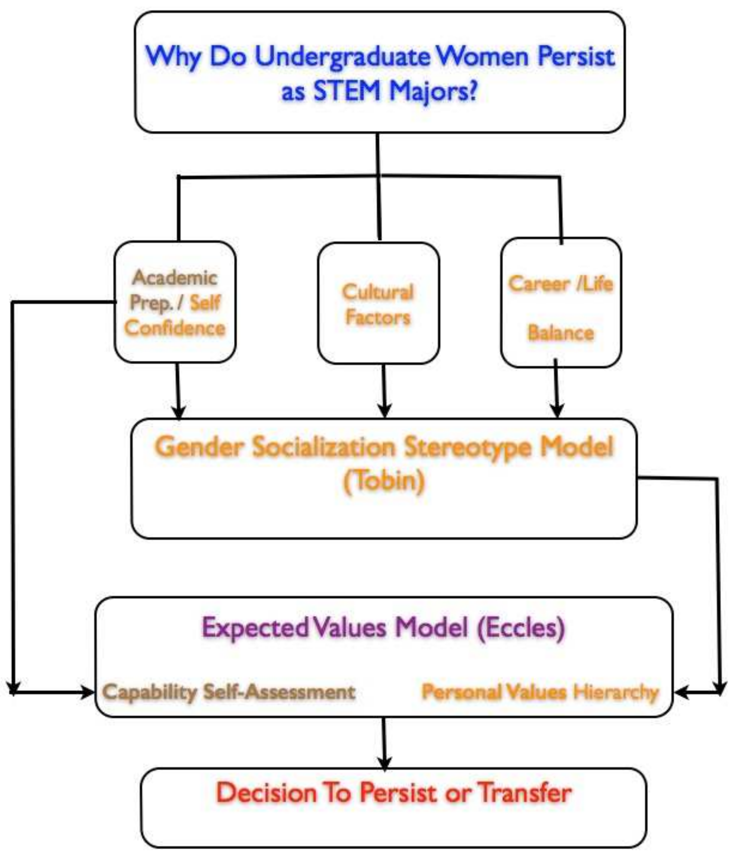


Figure 4. Expected Value Model – Decision Making Template

Conclusion

Government policy has traditionally focused on enabling greater access and participation to young women in advanced math and science courses in high schools. President Obama's challenge in 2011of increasing the number of high school girls taking advanced math and science courses continues to focus federal policy in this direction. However, parity in access and participation has generally been achieved, yet little has changed. This literature review has focused on women's self-assessment of capability, self-confidence, cultural factors, and career - life balance issues which affect women's choices to major and persist in STEM. The goal of this dissertation is to further our understanding of these factors and recommend possible solutions.

CHAPTER 3

METHODOLOGY

Introduction

A cross-sectional online survey was administered to evaluate the academic preparation, self-confidence, and cultural attitudes of undergraduate women who entered college with an intention to major and persist in a STEM field. The objective of the research is to add to the understanding of the underrepresentation of women in STEM by examining the perceptions of those women who are highly committed to a STEM field and are enrolled in a technology based institution. These are female students who entered college with a clear intention to major in a STEM field and are persisting.

Goals of the Survey Analysis

There are two primary goals for analysis of the survey data:

1. A descriptive analysis of women enrolled in a technology based institution majoring in a STEM field. The study profiled their self-assessment of capabilities, self-confidence and values hierarchy with respect to their outlook for a career in a STEM field. This profile of women in a technological institution can be compared to descriptions in the literature of women STEM majors in large, broad based universities and those that have transferred out of STEM.
2. Comparisons within this group of female students that have persisted in STEM studies. The study sought to uncover differences in the level of self-

confidence and future outlook for women in various population subgroups, including; women that were early deciders (by 10th grade) for STEM studies, women that may have experienced gender bias in the classroom, women that have stayed with their original major compared to women that have changed majors (but stayed within STEM) and women that have a strong support network of family and friends.

An on-line written survey was selected for this research as providing the best means of collecting the opinions of undergraduate women attending two technology-based institutions that have persisted in STEM studies. The survey design includes responses to closed-ended questions as well as open-ended responses. The research examined self-confidence in capabilities and the values that women place on STEM as a career choice based on their individual life goals and expectations. Survey design and methodology are based on criteria presented by Babbie (1990) and Creswell (2009).

Primary and Subsidiary Research Questions

The research questions are in response to studies in the literature that focus on a women's self-confidence as a key determinant in persistence in STEM studies. The research study is intended to answer the questions posed by the Expected Values Model as a theoretical framework, which can be summarized as follows:

- Am I confident that I will succeed as a STEM professional?
- Are my personal values fulfilled in a STEM career?

Research Question 1 is: What factors help explain the level of self-confidence of women who have persisted in STEM? The subsidiary questions for Research Question 1 are,

- Do women that have persisted in STEM have a strong academic preparation in math and science?
- Do women's self-assessment of their capabilities in math and science help explain expectation of success in STEM studies?
- Does perception of gender bias in the classroom or concerns of gender bias in the future work environment help explain a lower level of self-confidence by women STEM majors?
- Does the belief that career aspirations can be fulfilled in STEM partly explain a woman's self-confidence?

Research Question 2 is: What factors help explain a woman's decision to remain in a STEM major? The subsidiary questions for Research Question 2 are,

- To what extent do women believe that success in STEM careers requires a trade-off between work and family obligations?
- To what extent do women that have persisted in STEM place value on the importance of achieving a large income compared to raising a family and lifestyle choices?
- To what extent have family, friends, and advisors supported or discouraged a woman's interests in the STEM fields?
- To what extent does the perceived balance of career vs. family help explain their decision to remain as a STEM major?

Research Question 3 is: What factors help explain differences among sub-groups of women persisting in a STEM major? The subsidiary questions for Research Question 3 are,

- To what extent do women who develop a strong interest in STEM studies by their middle school or early high school years (early deciders) exhibit a higher degree of confidence in their capabilities and future outlook in a STEM based career?
- To what extent do women STEM majors, who have experienced classroom bias (either from faculty or other students) feel more isolated, exhibit a lower level of confidence in their career choice and express second thoughts on remaining in a STEM program?
- To what extent do women students at technology based institutions persisting in their initial STEM major exhibit a higher self-assessment of capabilities compared to women that have changed STEM majors (but stayed within STEM)?
- To what extent do women students that struggled in first year STEM courses have a significantly lower level of self-confidence and have second thoughts about their future outlook?
- To what extent do women that have benefited from a strong support structure of family, friends and mentor groups have more self-confidence and a stronger future career outlook?

Survey Variables

The survey variables are intended to measure self-confidence and personal outlook as described in the two research questions.

Independent Variables

1. Academic Preparation: (a) level of H.S. math and science taken and grades achieved, (b) college entry level STEM courses taken and grades achieved, (c) self-assessment of capabilities and comparison to male students, and (d) declared STEM major compared to initial STEM intention.
2. Grade level at which interest in STEM began, Support Network and Perceptions of Gender Bias: (a) grade level when student first intended to pursue STEM studies; (b) level of support from family, friends, teachers, mentors and peers; (c) feelings of isolation in STEM studies, perception of gender bias and seeing STEM as a man's world.
3. Values Hierarchy: (a) whether success in a STEM career requires a sacrifice in family values, (b) importance of earning a higher income in STEM careers and the potential impact the student can make on society as a STEM professional, (c) whether building a family has a higher personal value than a successful career.

Dependent Variables

1. Self-confidence in capabilities to be successful in a STEM based professional career.
2. The outlook of whether a STEM career / life balance is an attractive choice based on personal values.

Demographic Groupings

A descriptive analysis examines the academic background and characteristics of women that have chosen to attend a technology-based institution and persist in STEM studies. Characteristics are examined with respect to year of study in college, academic preparation in high school, reasons for selecting a technological institution, racial / ethnic groupings, declared major, and decisions to change majors within STEM.

Survey Population and Sample Size

The sample population is composed of undergraduate women in their second, third or fourth year of studies that have declared a STEM major and persisted in a technology-based institution. The National Education Longitudinal Study of 1988 (NELS:88) showed that the majority of women that transfer away from STEM majors do so after their freshman year. Therefore, a sample population of sophomore through senior year students should be representative of the target population of women that have persisted in STEM major.

Sampling Procedure

The survey sampled female students at two technology-based institutions in the northeast during the Fall 2013 semester. School A is a public university and school B is a private university. The students were contacted via e-mail through the administrative offices of each school. Accepting and completing the survey represents informed consent of the respondents. Respondents may choose to not answer specific questions or discontinue the survey at any time. All responses remained anonymous.

Descriptive statistics of the two schools are presented in Table 5. The purpose of selecting these particular schools is to enable a generalization of the survey results to a larger population to better understand the perceptions of women that have chosen to attend a technology based school and persist in STEM studies. The administrative members of the two institutions are supportive of this research and have asked to share in the results of the study.

Table 5

Characteristics of the Two Research Sites – 2012

	school A	school B
# Undergrads.	7,111	2,427
% Female	24	25
# B.S. Degrees	1,006	472
% STEM	75	80
75th %tile SAT Math	660	720
% Caucasian	34	58
Carnegie Class.	Research. Univ.	Research. Univ.

Note. Data as per iPEDS http://nces.ed.gov/ipeds/

Student Characteristics at the Two Technological Universities

School A is a public institution with an open style campus in an urban area. The student body is ethnically diverse, with many students drawn from nearby areas, including students commuting from home. Total cost for in-state residents is approximately $35,000 per year, including room and board. Out of state tuition and housing is $48,000. School B is a private institution with a secluded style campus near major urban areas. The student body is majority Caucasian with limited ethnic diversity.

Total cost, including housing, is nearly $60,000 per year. Both schools offer financial aid to a significant percentage of their students as well as internship opportunities.

Students that enter a technology university, including female students, are more predisposed to majoring in a STEM field and persisting through graduation. Students at both school A and school B exhibit a strong persistence rate with relatively few transfers to non-STEM fields. Similarly, the transfer of majors within STEM is relatively limited as well. This is in contrast to the NSF-2012 national data (see Figures 1-3) showing a strong tendency for female students to transfer away from STEM.

A review tracking the progress of an entering cohort of female students at each university displays this pattern.

School A – Entering Class of 2006

The entering freshman class of Fall 2006 included 147 female students, of which 124 (84%) were intended as STEM majors. By the end of the 2012-2013 academic year, 100 of the 2006 female cohort had graduated (68% of the entering class), of which 83 women received a STEM bachelor's degree; representing a 67% persistence rate of the STEM-intended students. Transfers to non-STEM majors, as well as transfers within STEM, were not significantly large in numbers and showed no significant pattern. Female students that transferred within STEM fields generally selected closely aligned majors (e.g. from computer science to information technology). This is in contrast to the national norms (NSF-2012) which show a significant shift of female STEM students transferring from physical sciences and engineering into life science fields.

Table 6 shows the detailed progression of school A 2006 female cohort on a semester basis.

Table 6

School A Fall 2006: Entering Freshman Class of Female Students

	Total	2006 F	2007 S	2007 F	2008 S	2008 F	2009 S
Female students entering A-2006F	147						
Total entering female STEM Majors –2006F	124	124	115	106	98	96	86
			From prior semester				
Transfer into A STEM Major	3		1	-	-	-	1
Transfer within STEM majors	16		2	6	2	8	1
Transfer to non-STEM major	24		1	4	1	1	4
Transfer out of A	21		9	4	2	1	-
Graduated as STEM majors	83		-	-	-	-	4
Cumulative STEM graduates	67%		-	-	-	-	4
Cumulative Years							3

	2009 F	2010 S	2010 F	2011 S	2011 F	2012 S	2012 F	2013 S
Total female STEM majors	86	84	58	46	11	10	4	4
				From prior semester				
Transfer into A STEM major	1	-	-	-	-	1	-	-
Transfer within STEM majors	1	1	2	1	1	-	-	-
Transfer to non-STEM major	4	1	1	1	2	-	-	-
Transfer out of A	-	1	-	1	-	-	-	-
Graduated as STEM majors	-	25	10	35	1	7	-	1
Cum. STEM graduates	4	29	39	74	75	82	82	83
Cumulative Years		4		5		6		7

School B – Entering Class of 2008

The entering freshman class of 2008 included 126 female students containing 106 students with an intended STEM major (84%), either in a specific department or as undecided engineering / technology (see Table 7). By the end of the 2012-2013 academic year, 101 of the original female cohort of 126 students had graduated (80%). Of this group of graduates, 82 female students graduated with STEM degrees; representing 77% persistence of the original STEM intended majors. Transfers from original intended majors to non-STEM fields were nominal and transfers within STEM fields showed no pattern of moving from physical sciences and engineering into the life sciences.

Table 7

School B Fall 2008: Entering Freshman Class of Female Students

	Total	2008 F	2009 S	2009 F	2010 S	2010 F	2011 S
Female students entering “B”-2008 F	126						
Total entering female STEM majors -2008 F	106	106	102	96	92	89	88
			From prior semester				
Transfer into B STEM major	1		-	-	1	-	-
Transfer within STEM majors	18		5	4	3	4	-
Transfer to non-STEM major	9		3	1	2	1	-
Transfer out of B	15		1	5	1	2	1
Graduated as STEM Majors	82		-	-	-	-	-
Cum. STEM Graduates	77%		-	-	-	-	-
Cumulative Years							3 years

	2011 F	2012 S	2012 F	2013 S
Total female STEM majors	87	87	37	37
From prior semester				
Transfer into "B" STEM Major	-	-	-	-
Transfer within STEM majors	-	-	2	-
Transfer to non-STEM major	1	1	-	-
Transfer out of "B"	3	-	2	-
Graduated as STEM Majors	-	48	-	34
Cum. STEM Graduates	-	48	48	82
Cumulative Years		4 years		5 years

The female student STEM intention and persistence rates at the two technological universities make for a good contrast to national norms. At both universities, female students entering as STEM intended majors represented 84% of the total female entering class. This compares with 15% female freshman on a national basis entering college in 2006 with a STEM intended major (NSF, 2012). On a national basis in 2009, 18% of all women's bachelor's degrees were in STEM fields. At A, a comparable statistic is that by 2013, 83% of all women graduating from A from the 2006 entering class had earned a STEM degree and at B 81% of all females from the 2008 entering class had earned a STEM degree.

The survey represents a good opportunity to contrast the opinions and attitudes of females enrolled in a technological university compared to the literature representing national norms in broad based universities.

Survey Limitations and Validity

The selection of students drawn from sophomores through seniors at the two institutions contributes to the representativeness of the survey sample. However, the limitation of surveying students at two northeast technology institutions represents a convenience sample that has a potential sample bias and limits the ability to generalize the results. Students that chose to respond to the survey, as compared to those who declined, may create a bias in the results based on their expressed opinions. A wave analysis was not conducted, based on the early timing of receiving the majority of completed surveys.

Sample Size

The planned sample size for analysis was to receive surveys from a minimum of 135 women, divided between the two schools. Approximately 900 total students were solicited for the on-line survey through an e-mail contact. Sample size determination is based on Green (1991), generating an alpha of 0.05 and a power factor of 0.80.

Survey Instrument Design

The overall survey design is based on obtaining objective information (what advanced high school STEM classes have you taken), as well as subjective opinions on self-assessment and cultural perspectives. The survey instrument includes a mixture of scale types. Objective questions, (which math courses did you take), are presented in a checklist style. Opinion based questions are based on a five point Likert Scale, ranging from *Strongly Disagree* (1) to *Strongly Agree* (5). Some opinion questions are repeated in slightly varied form, as an intentional redundancy, to confirm internal consistency of the responses. Opinion questions are primarily positively worded, interspersed with a few negatively worded questions to avoid acquiescence and response set.

Respondent's opinions with respect to the relative importance of each construct are based on a five point Likert scale, ranging from *Totally Unimportant* (1) to *Very Important* (5). One open-ended question asks the respondents to select the most important construct from their own perspective. Open-ended questions ask respondents for their thoughts on topics that they may feel are important but were not adequately covered by the closed-ended questions in the survey.

The demographics section at the end of the survey is designed to establish a variety of independent variables based on major field of study, type of school attending, years of study in higher education, types of courses taken, and racial / ethnic characterizations. The survey instrument is attached as Appendix A.

Data Collection and Analysis

Data was collected and analyzed using SPSS software. Descriptive statistics and cross tabulations of the sample population are provided and compared to the overall population of female STEM students at the two institutions. ANOVA comparisons distinguished between the responses of women in selected subgroups. The Cronbach Alpha coefficient is used to test reliability. Responses to open-ended questions are clustered by common theme.

Response Coding

- Check box responses are converted to numerical values, e.g. Algebra 2 taken in 9th grade =1, 10th grade =2, and so forth.
- Likert scaled questions are coded from 1-5, representing *Strongly Disagree* to *Strongly Agree*. Negative worded questions are reverse coded.
- Ranking order questions are coded 1-5, representing *Totally Unimportant* to *Very Important*.
- Open-ended questions are group coded by common themes and totaled.
- Demographic data are converted to numerical codes.

Analysis Results

Research question results are presented descriptively for each institution and collectively in table format as shown as per example in Table 8. Significance is established at the $p < 0.05$ level.

Table 8

Descriptive Analysis Examples

	A Respondents %	B Respondents %	Overall Respondents %
Academic prep. & self-assessment questions			
Cultural factors, support network, perceptions of bias			
Career - life balance questions			
School type, intended &			

declared major
Demographic groupings

Research questions 3 are presented in ANOVA format as shown as per example in Table 9. Significance will be established at the $p < 0.05$ level. Post-hoc, Tukey analyses are presented in Appendix B as per example in Table 10.

Table 9

ANOVA Examples

	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups					
Within Groups					
Total					

Table 10

Post-Hoc, Tukey Examples

Multiple Comparisons – Tukey HSD

	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound

Pilot Test

The survey has been designed specifically for this research and was field-tested with 20 students at the end of the spring semester of 2013. All students in the pilot test were graduating female seniors with STEM degrees. The survey questionnaire was analyzed with respect to the parameters of academic preparation, culture and self confidence and career - life balance. Cronbach – alpha test results for all parameters were above 0.7, confirming the validity and reliability of the questionnaire. Pilot reliability results are presented in Table 11. Additionally, written comments to the questionnaire were received from the pilot participants. The comments resulted in adjustment to a few questions for improved clarity.

Table 11

Pilot Test Reliability and Validity Results

Scale	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	*n* of Items
Academic preperation	.792	.795	7
culture & self confidence	.861	.853	16
Career - life balance	.768	.796	12

Summary

An on-line survey was implemented from August through September 2013, based on the goals of this research, which are:

- To study the academic background, self-confidence and future outlook of female, undergraduate STEM majors (sophomore through senior year students) at a public and private technological university in the northeast.
- To examine differences between sub-groups of the student sample population.

The combined population of female STEM majors is approximately 900 students at the two schools, requiring a sample size minimum of 135 responses. A survey pilot test was conducted during June 2013, and confirmed the validity and reliability of the questionnaire.

The survey is composed of check box style questions for demographic information, 5-point Likert questions for opinions, as well as open-ended responses. Survey results are analyzed and presented through descriptive tables and ANOVA tests, which are aligned with the three research questions.

CHAPTER 4

ANALYSIS AND FINDINGS

Survey Results

An online survey of undergraduate (sophomore, junior and senior) female STEM majors at schools A and B was conducted during the start of the 2013-2014 academic year in August and September 2013. The survey asked respondents to report on their academic backgrounds and self-confidence, their perceptions about the role of women in a STEM field, and their personal outlook as a future STEM graduate.

A total of 181 responses were received, representing an 18.4% response rate of the 986 total surveys solicited. Some respondents did not complete the full survey, ending their participation after approximately 75% of the survey was completed (the survey included 70 total questions). Approximately 152 respondents completed the entire survey, representing a 15.4% response of the total population. Responses to each of the 70 questions in the survey included non-responses, either because a question was not applicable to that respondent or the respondent chose not to answer. However, many of the 181 initial respondents answered the majority of key questions addressing their opinions about women in STEM fields. The demographic questions regarding school attended and year of study were located near the end of the survey and were not answered by all respondents. Therefore, there are a higher number of overall responses to questions shown in the following tables compared to categorizing the responses between the two schools. The primary analysis is with the responses of the overall sample population.

The analysis of the survey results in this chapter will be presented in five sections. The first section presents basic demographic characteristics of the survey sample, including school grade distribution and ethnicity data as well as background information describing the factors and opinions that led the sample respondents to first become interested in STEM as a major field of study and attend a technology-based institution. The second section presents the respondent's self-reports about their self-confidence and career outlook within the framework of the research questions.

- Their academic preparation and self-confidence to succeed in STEM studies.
- Their cultural fit as a woman in STEM studies and future career.
- Their work / life balance outlook and priorities in a STEM career.

The third section reports the evaluation of the research questions through ANOVA testing among selected sub groups within the sample population.

- At which grade level did they first become interested in STEM as a field of study and what were the key influence factors?
- Is self-confidence and career outlook affected by perceptions of gender bias in the classroom?
- Do students that are persisting in STEM but have changed majors, or had difficulty in first year courses have a significantly different outlook and level of self-confidence?
- Does self-confidence and future outlook benefit from a strong support structure of family, friends, mentors and peer groups?

The fourth section reports on the open-ended comments and recommendations of the sample respondents on how to increase women's participation in STEM. The fifth section summarizes the analysis and findings.

Demographic Characteristics of the Respondents

Student Grade Level

The number (distribution) of respondents in the sample population from each school corresponds to the school's relative size, with 56% of the responses coming from school A students (5,529 full time undergraduate enrollment in 2012) and 44% from school B (2,527 full time undergraduate enrollment in 2012)[1]. Only 3 of 181 respondents classified themselves as international students and 100% of the respondents are enrolled on a full time basis. Nearly all (96%) of the respondents are age 25 or younger. As these three demographic factors are nearly 100% homogeneous across the survey sample, they are not presented in table form.

Table 12 shows the student grade level distribution of the respondents with the total population of full time female undergraduate STEM majors at the two institutions.

Table 12

Population and survey grade level distributions at the two institutions

	Sophomores	Juniors	Seniors
A – survey respondents	24 (28%)	36 (43%)	25 (29%)
A – total STEM female majors	136 (26%)	201 (39%)	184 (35%)
B – survey respondents	19 (28%)	23 (34%)	25 (38%)

[1] [1]http://nces.ed.gov/ipeds/datacenter

B– total STEM female majors	162 (35%)	109 (23%)	194 (42%)
Survey – total respondents	43 (28%)	59 (39%)	50 (33%)
Combined student body – total female STEM majors	298 (30%)	310 (32%)	378 (38%)

The class distribution mix of the sample population is distributed across three years of study, with 28% of the respondents reporting as sophomores, 38% juniors, and 33% seniors. The grade class distribution of the survey sample is close to that of the overall distribution of full time STEM female majors at the two schools, although the B group is somewhat underrepresented by sophomores and overrepresented by juniors and the A sample is underrepresented by senior year students compared to their student body. As was shown by following previous cohorts at both schools (see Tables 6 and 7), there are only minimal student drops from the programs after the freshman year. Therefore, a slight variation in the mix between sophomores, junior, and senior year respondents should not affect the validity of the sample population.

Ethnic Mix

The ethnic mix of respondents is presented in Table 13. The sample population is composed of 59.7% Caucasian, 25.2% Hispanic, 14.3% Asian, and 7.5% African American students. Multiple responses were allowed. Missing values represent non-respondents.

Table 13

Ethnic mix for respondents and student body by institution (multiple responses allowed)

	A (n=85) % Respondents	A (n=7268) % Student Body	B (n=68) % Respondents	B (n=5784) % Student Body	Overall (n=147) % Respondents	Overall (n=13052) % Student Body
Afr. Amer.	13	10	0	3	7	8
Hispanic	33	20	13	9	25	18
Asian	20	21	16	10	14	20
Caucasian	36	32	81	57	60	44

The overall ethnic mix of the combined sample is generally consistent with the combined undergraduate student body at both institutions. The A sample group is overrepresented with Hispanic respondents and there is an overrepresentation of Caucasian and Asian respondents in the B sample population. All of the limited numbers of African American survey respondents are from A. As will be shown in ANOVA Table 43, the responses of the minority population in the sample are statistically similar with the responses of the total sample population. Therefore the deviations in ethnic mix compared to the general population are not considered to be significant.

Descriptive characterization of the respondents based on their selection of a technological institution

Tables 14 through 19 show the sample respondents by the reasons for their choice of a technology institution, the time frame during their earlier schooling when they first developed a strong interest in pursuing a STEM major, their major field of STEM study and whether they have changed majors during their first 2 years of classes.

Reasons for choosing a technological institution

Attending a technological based institution was attractive to the respondents. As noted in Table 4.3, 79% of respondents chose a technically based school as their first choice for college studies, with 88% of the B sub group making that their first choice. A few respondents transferred from liberal arts colleges hoping to find a more rigorous STEM environment.

Table 14

Reasons for selecting a technological institution by institution (multiple selections allowed)

	A (*n* = 85)	B (*n*=68)	Overall (*n*=179)
	%	%	%
Better atmosphere for STEM studies	68	65	66
A tech. school has students more like me	33	57	40
Better job prospects after graduation	55	92	67
Internships while in school are better	38	74	51
Financial package available to me	62	54	58
School's reputation	38	63	46

The school atmosphere was appealing to 66% of the respondents. Less than a majority, 40%, indicated that they chose a technology institution to find students more like themselves. Additional leading reasons for choosing a technology-based school include better career prospects, both after graduation (67%) as well as internships while in school (51%). The importance of the job outlook after graduation was very pronounced in the B sub group, with 92% selecting this factor. Financial support offered by the schools was an important factor for many of the respondents, most notably for 62% of the respondents at A, a public university, and 54% at B, a private institution. The school's reputation was an important factor for students at B (63%), but less of a factor at A (38%).

Reasons for choosing this particular technological school

The respondents overwhelmingly focused on their particular STEM field of interest in making their school choice, with 78% of all respondents choosing their particular school because it offered the major they were looking for. Respondents also focused a good financial package, 57% overall, with A students again giving a higher response (60%) to this choice.

Table 15

Reasons for choosing this particular school by institution (multiple selections allowed)

	A (*n*=85) %	B (*n*=68) %	Overall (*n*=179) %
Offered the specific major I wanted	81	72	78
Financial package	60	52	57
Convenient to attend	71	37	54
Work / Study internships	26	71	44
School's reputation	40	66	49

The convenience to attend a nearby school was mentioned by 54% of the respondents, especially at A (71%). B is well noted for its work / study internships and this was recognized by 71% of the B respondents. The school's reputation was also an important factor for 66% of B respondents and 49% overall.

When did you develop an interest in STEM?

Respondents generally developed an early interest in STEM, with 41% having decided for STEM studies by middle school. An additional 20% considered a STEM major by the end of the second year of high school.

Table 16

Time frame when an interest in a STEM major and career first developed

	A (*n*=85)	B (*n*=68)	Overall (*n*=181)
	%	%	%
Decided in middle school	41	41	41
Decided during the first 2 years H.S.	20	19	20
Decided during the second 2 years H.S.	26	29	27
Did not decide until entered College	13	11	12

These findings are consistent with those of Maple and Stage (1991): that an interest in a STEM major established by the sophomore year in high school and the number of science and math courses taken, were the two most important indicators of success as a STEM major. Only 12% of respondents decided on a STEM major after entering college.

What is your major?

The major fields of STEM study of the sample group are presented in Table 17. The responses to this question characterize the sample population as well as the overall population at the two technological institutions as not being typical of female STEM student populations throughout the United States, in the respect that 75% of sample respondents are declared or intended as engineering majors.

Table 17

Distribution of major fields of study by institution (some dual majors)[2]

	A (*n*=73) % Respondents	A % Overall	B (*n*=49) % Respondents	B % Overall	Overall (*n*=150) % Respondents
Bio / Life Sciences	27	5	6	3	18
Chem. / Bio Chem.	9	11	6	1	8
Physics	4	5	2	1	3
Math	13	2	2	1	8
Comp. Sci.	9	16	6	9	8
Engineering	61	50	88	67	75

As noted earlier (see Table 2 - 2009 data), less than 11% of female STEM students nationwide are declared as engineering majors. The sample respondents however, are mainstream within these two particular technology institutions, where 50-67% of all undergraduate students are engineering majors. As a further contrast, 71% of nationwide 2009 female STEM students were life science majors, compared with just 18% in the sample population.

Did you change majors?

As Table 18 suggests, most of the respondents (66%) stayed with their original intended major. Within the 34% of the respondents that did change majors, 32% changed majors after the first semester, 26% after the second semester, and an additional 42%

changed by the end of their sophomore year. Just 10% of respondents changed majors more than once. Overall, respondents were generally committed to persisting as a STEM major, with only 22% of respondents expressing having second thoughts about staying with STEM.

Table 18

Reported changes in major field of study, by institution 2013

	A (*n*=83)	B (*n*=68)	Overall (*n*=151)
	%	%	%
Did *not* change major	61	72	66
Did change major	39	28	34
Of those students that changed majors			
Changed major after fresh-1st sem.	28	37	32
Changed major after fresh-2nd sem.	25	26	26
Changed major after sophomore year	41	42	42
Changed major multiple times	13	6	10
Have had second thoughts about majoring in STEM	26	18	22

Table 19 presents the type of change in major (within the 34% sub group that did change major). The majority, (58%) of the student sub group that changed majors, moved to a related field, for example, started with chemical or civil engineering and switched to mechanical engineering.

Table 19

(Within the 34% that changed majors), the type of change the respondents made (Based only on open end responses)

	% Changed to a comparable STEM major in engineering	% Changed from a science major to engineering	% Changed from physical science / engineering to Life Sciences	% Changed from liberal arts into STEM
Combined Responses	58	18	9	4

Contrary to NSF (2012) data, only 9% of respondents changed majors from physical science and engineering to life sciences. Interestingly, 18% of the students that changed majors, switched from pure sciences into engineering. Some commented that they were looking for a more practical application of their science studies.

We may conclude that the respondents that changed majors were looking for a better career fit, rather than moving away from physical science and engineering to life sciences. The persistence to stay in an engineering or physical science discipline, even when changing majors, is in stark contrast to national data as displayed earlier in the NSF 2012 data (see Figures 1-3).

Analysis of respondent opinions based on the research questions

Tables 20 through 27 present the self-reported opinions of the sample respondents to survey questions aligned with the first research question. Research Question 1 is: What factors help explain the level of self-confidence of women who have persisted in STEM? The subsidiary questions for Research Question 1 are,

- Do women that have persisted in STEM have a strong academic preparation in math and science?
- Do women's self-assessment of their capabilities in math and science help explain expectation of success in STEM studies?
- Does perception of gender bias in the classroom or concerns of gender bias in the future work environment help explain a lower level of self-confidence by women STEM majors?
- Does the belief that career aspirations can be fulfilled in STEM partly explain a woman's self-confidence?

Academic Preparation (Tables 20 and 21)

Academic preparation begins with advanced math and science courses in high school. The foundation for advanced courses starts with algebra courses taken at an early age, often in middle school. Most of the respondents (76%) had taken algebra 2 by the 10th grade. A large majority of the respondents (88%) followed algebra classes with pre-calculus. AP calculus was taken in high school by 55% of the respondents and 16-18% had taken a computer science course, AP statistics or both.

Table 20

Percent Reporting Specific Mathematics Preparatory Courses in High School by Institution (includes duplicates)

	A (*n*=71) %	B (*n*=60) %	Overall (*n*=177) %
Algebra 2 by 10th Grade	69	84	76
Took AP Calculus in H.S.	42	71	56
Scored 4-5 on an AP Math exam	60	75	69

The exam scores for respondents that took an AP math exam were well above the national scoring pattern, with 69% of the respondents scoring a 4 or 5. By comparison, the College Board reported that just 42% of students nationally taking the 2013 AP Calculus AB exam scored a 4 or 5 and only 33% taking AP Statistics scored in the 4-5 range.[2]

Academic capability in STEM studies built on a strong foundation of advanced mathematics and science courses during the high school years has been well established by a large body of research (Brainard & Carlin, 1998; Chen & Weko, 2009; Griffith, 2010; Kokkelenberg & Sinha, 2010; Ost, 2010; Price, 2010; Rask, 2010). The findings in the literature are supported by this survey with respect to the courses taken in high school and respondent’s opinions on their preparation for STEM studies.

2

http://www.totalregistration.net/index.php?option=com_content&view=article&id=487&Itemid=118

Science preparation shows a similar depth. Beyond the basic high school science classes, 65% of the respondents had taken AP Bio or AP Environmental Science, 53% AP Chemistry, and 43% AP Physics.

Table 21

Percent Reporting Specific Science Preparatory Courses in High School by Institution (includes multiple courses taken)

	A (*n*=85) %	B (*n*=68) %	Overall (*n*=126) %
AP Bio / Environ. Sci.	33	43	65
AP Chemistry	35	43	53
AP Physics	27	37	43
Other advanced science courses	75	75	75
Scored 4-5 on an AP science exam	54	71	59

AP science exam scores for 59% of respondents were at a 4 or 5. This achievement level compares favorably to the 2013 College Board national statistics, which vary between 31-39% of students scoring a 4 or 5, (depending on the particular AP science exam taken).[3]

The math and science foundation established in high school continued in their college studies with 97% of the students taking college level calculus, 55% taking additional advanced math classes, 92% college level physics, and 72% taking engineering

[3] Note that the comparative trend in national AP math and science scores for 2011 and 2012 (when the sample population students took their tests) were somewhat lower than the 2013 scores, further emphasizing the high achievements of the sample population.

courses. A strong correlation between academic preparation in math / science and persistence in STEM studies is well researched and is confirmed by the sample population in this study.

Self-assessment and Self-Confidence

Table 22 presents the respondents self-reports of their self-confidence in their academic preparation for college level STEM classes.

Table 22

Self-reports of respondent's math and science preparation and experience by institution (% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=166) %
Had sufficient math & science background	70	81	75
Found it difficult to keep pace	14	18	15
Overall college grades confirmed decision for a STEM major	65	68	66
First year STEM classes confirmed decision for a STEM major	59	68	62
STEM classes are more stimulating than liberal arts classes	76	78	76

The respondents expressed their strong confidence regarding their preparedness in math and science with 75% indicating either *agree* or *strongly agree* that they had sufficient background to succeed. Only 15% of respondents selected either *agree* or *strongly agree* (just 3%) to the question that they could not keep pace in class. A large majority (66%) of respondents felt that their decision to major in a STEM program was confirmed by their overall grades in first year courses and 62% felt that their first year STEM classes (sometimes referred to as weed out courses) also confirmed their persistence in STEM. A majority of respondents (76%) found their STEM classes to be more stimulating (42% *strongly agree*) than their liberal arts courses.

Tables 23 and 24 probe into respondent's self-confidence in their overall academic capabilities to succeed in STEM, with 88% affirming that they have the academic confidence to succeed and 95% feeling confident that they have the academic capability to be particularly successful in STEM.

Table 23

Self-reports of respondent's academic confidence by institution

(% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=161) %
Confidence to Succeed in STEM Classes	93	82	88
Feeling They Have Sufficient Overall Academic Capability	94	97	95

Ethington and Wolfle (1988) and many others report that female STEM students have a lower self-assessment of their capabilities compared to men. This gender confidence gap is not evident among the respondents to this survey as seen in Table 24. This series of questions elicited very emotional comments as noted below.

Table 24

Self-reports of respondent's self confidence in math & science capability compared to men, by institution (% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=161) %
I am *not* as strong as male counterparts in STEM	6	13	9
Men are better suited for STEM	0	1	1
Females *not* as capable in STEM	2	6	4
Enjoy competing alongside men in STEM classes	77	71	74
Do *not* mind being one of few women in advanced STEM classes	85	87	86

Less than 10% of the respondents felt that they were not as strong as their male counterparts in their math and science classes and only 1% of respondents believe that men are inherently better suited for STEM studies ("They only BELIEVE they are because that is what they are fed from birth") In a duplicative confirming question within the survey, less than 4% of the respondents responded that females are not inherently as capable as men (one respondent wrote "f*** that!"), while 74% of respondents reported that they enjoyed competing alongside men at the highest levels in their STEM classes. A large majority (86%) do not mind being just one of few women in advanced science and math classes.

Gender Bias

A possible contributing factor to a lack of academic self-confidence may be a perception by female STEM students that discrimination exists in STEM classrooms by professors or fellow male students. Survey questions related to real or perceived bias resulted in the most diverse responses of the sample population. As shown in Table 25, respondents do not feel that male faculty members are biased against female students with 24% responding that male faculty members were biased against female students (with only 6% selecting *strongly agree*). In a related question of possible gender bias by instructors, only 12% agreed that women must work harder than men to achieve the same grade in class.

Table 25

Self-reports of respondent's perception of gender bias in the classroom by institution (% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=161) %
Believe male faculty biased against female STEM students	26	22	24
Believe male students biased against female STEM students	60	53	57
Women must work harder than men for same grade	17	6	12
Personally experienced bias in the STEM classroom	35	39	36

However, the respondents are more critical about their fellow male students with 57% responding that male students are generally biased against females in their class (but only 10% indicated *strongly agree*). Comments accompanying this question reflect the experience that male students are more likely to openly express their bias. A sizable group of 36% of respondents indicated that they have personally experienced some form of bias, whether from other students or faculty (although less than 6% indicated *strongly agree*).

Career Aspirations and Preparation

As shown in Table 26, a high level of confidence of succeeding in a STEM career was already found by the second year. However, senior year students in the sample population demonstrated a strong shift (60%) to the *strongly agree* confidence level.

Table 26

Self-reports of respondents in their confidence to succeed in STEM

	Sophomores (*n*=43)	Juniors (*n*=58)	Seniors (*n*=50)
	%	%	%
Agree	44	53	26
Strongly Agree	40	40	60
Combined	84	93	86

This result is in line with the findings of Mara and Bogue (2006), that an increase in confidence by female STEM students was discernible by class level.

The respondents value their training as STEM majors. As shown in Table 27, 82% of respondents stated that their STEM degree is also a good preparation for a non-STEM career or graduate studies outside of technical fields, yet only 12% intend at this time to pursue a non-technical career or non-STEM graduate degree (e.g. J.D., M.B.A., etc.)

Table 27

Self-reports of respondent's view of STEM education as preparation for a non-STEM Career, by institution (% Agree and Strongly Agree)

	A (*n*=84)	B (*n*=67)	Overall (*n*=154)
	%	%	%
STEM education is a good preparation for non-technical fields or non-STEM graduate study	82	82	82
Intend to pursue a non-technical career or non-STEM graduate studies	14	9	12

Analysis of responses to the first research question confirms the importance of a strong academic preparation as a pre-requisite for success in STEM studies. Not only do female students acquire the skills they will need in their profession but builds self-confidence in their abilities and creates a positive future outlook to succeed in a STEM profession.

Tables 28 through 37 present the self-reported opinions of the sample respondents to survey questions aligned with the second research question. Research Question 2 is: What factors help explain a woman's decision to remain in a STEM major? The subsidiary questions for Research Question 2 are,

- To what extent do women believe that success in STEM careers requires a trade-off between work and family obligations?

- To what extent do women that have persisted in STEM place value on the importance of achieving a large income compared to raising a family and lifestyle choices?
- To what extent have family, friends, and advisors supported or discouraged a woman's interests in the STEM fields?
- To what extent does the perceived balance of career vs. family help explain their decision to remain as a STEM major?

Work / Family Balance – Culturally Based Roles of Women

In contrast to their personal feelings of academic self-confidence and belief in inherent gender equality in STEM capabilities, the sample respondents have a more nuanced view of how society sees the role of women working in STEM fields. Table 28 presents the view of respondents as to how they see society's perception of women working in STEM fields.

Table 28

Self-reported respondent's views on society stereotypes of women in STEM, by institution (% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=161) %
Believe that society sees STEM as a man's world	60	75	66
Believe that society points young girls away from STEM	77	68	72
Female STEM majors are *less*	17	15	16

feminine than L.A. majors

Many of the respondents (50%) agree or (16%) strongly agree with the statement that society believes that STEM is a man's world ("I think that this was a very popular view just a generation or two ago and that, while society as a whole is slowly changing their view, the people within STEM are changing even more slowly, which is part of the difficulty that women have entering the field") and 72% of the respondents believe that society stereotypes point young girls away from STEM careers (but only 19% *strongly agree*). However, the sample group challenges the gender stereotype regarding women engineers. Respondents do not agree (16%) that female STEM majors are less feminine than female liberal arts majors ("I feel like because we work so hard in comparison to others (and therefore look more tired) and sometimes act strongly for our ideas we are perceived as less feminine; but unfortunately being meek and submissive is typically associated with femininity").

The survey respondents are cognizant in Table 29 of the perception that women may have a tougher road than men in advancing to a successful STEM career.

Table 29

Self-reported respondent's perception of women's position in the STEM workplace by institution (% Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=68) %	Overall (*n*=155) %
Believe that women have to be tougher to advance	64	57	61

in a STEM career			
Believe that women *do not* have to work harder for equal recognition in a STEM career	17	24	20
Confident that I will fit in and be accepted in the STEM workplace	61	69	68
Women are more likely than men to feel isolated in STEM careers	65	69	67

Respondents believe (61%) that women have to be tougher than men, to advance in a STEM career. Only a small minority of respondents (20%) do not believe that women have to work harder to get equal recognition in the STEM workplace and 67% expect that women are more likely to feel isolated (but only12% *strongly agree*). As will be reported in ANOVA Table 42, feelings of isolation as a female in STEM are statistically stronger among respondents that have perceived bias in the classroom.

Yet, in contrast to this harsh view of a tough road ahead, 68% feel that they will fit in and be accepted in the workplace (54% *agree* and 14% *strongly agree*). Table 30 notes that just 27% of the sample population considers the stereotype of STEM as a "man's world", as being somewhat or very important.

Table 30

Importance Ranking of Perceptions of STEM as a Man's World

	A (*n*=84)	B (*n*=67)	Overall (*n*=152)
	%	%	%
Not at all important	10	18	13
Somewhat unimportant	30	36	33
Neutral	27	27	27
Somewhat important	29	16	23
Very important	5	3	4

A good work - life balance is important for many women in the sample population as shown in Table 4.2310, yet 13% of the combined sample are concerned whether a STEM career will allow a good balance.

Table 31

Self-report of the importance of a STEM career / life balance, by institution (% Agree & Strongly Agree)

	A (*n*=84)	B (*n*=67)	Overall (*n*=152)
	%	%	%
Work responsibilities in STEM *does not* allow a good work / life balance	10	17	13
A balanced life is more important than maximizing income	69	73	71

Xie and Schauman (2003), as well as Manis (1989), reported on the difficulties women perceive in finding a good work - life balance when considering a STEM career.

Survey responses note that respondents are optimistic in their outlook. Only 13% of respondents *do not* believe that a STEM career allows a good work / life balance. A balanced family life is ranked by 71% as more important that maximizing earning potential (44% *agree* and 27% *strongly agree*).

Higher Income and Prestige Compared to Lifestyle Choices

Table 32 shows that the respondents selected a technological institution partly based on career earnings opportunities as well as paid internships while in school. Survey respondents *agree* / *strongly agree* (87%) that they can earn a higher income in STEM compared to other career choices. Yet, only a slight majority of the B sub group (51%) selected a higher income potential as their top priority while just 35% of A respondents selected higher income potential as their top choice.

Table 32

Higher Income as a STEM Career Consideration (%Agree & Strongly Agree)

	A (*n*=84) %	B (*n*=67) %	Overall (*n*=155) %
Believe I can earn a higher income in STEM compared to other fields	82	93	87
Earning a higher income is at the top of my list in making a career choice	35	51	41

A related cultural influence on work / life balance and career preference is that many female STEM majors focus on life science fields, especially medicine. The literature strongly supports the notion that STEM oriented women are more likely to major in the biological sciences. Lubinski and Persson Benbow (2007) argued that women are seeking to make a social contribution. Eccles (1994) and Gibbons (2009) noted that women are more likely to choose biology, leading to medical studies, or environmental engineering rather than the physical sciences.[4] As shown in Table 33, the respondents at these two technological institutions report a different perspective. A large majority of respondents either *agree* (32%) or *strongly agree* (53%) that engineering and physical science majors are as likely to make a positive contribution to society as biology or life science majors and 90% (40% *agree* and 50% *strongly agree*) believe that they personally can make a positive impact on people's lives as an engineer or physical scientist.

Table 33

Self-reported responses of respondent's views on making an impact in society by engineering and physical sciences majors, by institution (% Agree & Strongly Agree)

	A (*n*=83) %	B (*n*=68) %	Overall (*n*=158) %
Believe that engineering and physical science majors are as likely as biology / life science majors to make a positive impact on society	89	79	85
Believe they can personally make a positive impact as an engineer or physical scientist	89	91	90

Support of Family, Friends and Teachers

[4] Their research is backed by data from the US Bureau of Labor Statistics (2009) and NSF (2010) that show a 2:1 preference for life science majors by women.

Table 34 presents the respondent's opinions regarding the considerations that influenced them to consider a STEM career. The most important consideration (40%) is the influence of family (especially parents), while a nearly equal number of students (35%) indicated that teachers played an important role.

Table 34

Influences on Choosing STEM (open ended responses only, n=161)

% Attracted by Financial Opportunities In STEM	% Enjoy doing "Hands On" Science Activities	% Feel that they are Math & Science Oriented	% Influenced by Family & Friends	% Influenced by Teachers
2	13	32	40	35

An interesting contrast is that only 2% of respondents indicated that a higher financial opportunity was a key influence, yet as noted in Table 14, 67% chose a technology based school based on better job prospects after graduation.

As Table 35 shows, ongoing support from family and friends, especially parents (87%), are the most important external support network for the sample group in terms of influencing persistence as a STEM major (54% *strongly agree*).

Table 35

Self-report by respondents of the importance of ongoing support influence of family, friends and role models, by institution (% Agree & Strongly Agree)

	"A" (*n*=83) %	"B" (*n*=68) %	Overall (*n*=160) %

The importance of family & friends support	82	96	87
The importance of professional role models and mentors	58	66	63
Peer support groups are helpful	19	19	19

Prior research is mixed on the importance of female role models (academic and professional), peer support, and mentors on the persistence of female STEM students. Bettinger and Long (2005) and Price (2010) found that female STEM faculty members had a positive impact on female STEM students, while Canes and Rosen (1995) found no linkage in their study at elite level schools. Respondents in the sample population agreed (63%) that support from professional role models and mentors are an important factor.

The positive support for the influence of mentors leads to an interesting contrast. Less than 20% of the respondents participate in student peer support groups for female STEM majors (e.g. Society of Women Engineers). The open ended comments accompanying this question indicate that respondents felt that either they did not have sufficient time for participation in female student peer support groups or saw no personal benefit in networking with other female STEM students. *(*"Just turns into ranting and complaining so I don't go").

Work - Life Balance

A strong opinion was expressed with respect to the importance of and finding a good career / life balance in STEM. As shown in Table 36, a combined 86% of the respondents believe that their personal career objectives and life / work balance can be fulfilled in STEM, with the largest response segment (52%) valuing this priority as very important.

Table 36

Believing that Personal Career Objectives and Life / Work Balance can be Fulfilled in a STEM Career

	A (*n*=84)	B (*n*=67)	Overall (*n*=152)
	%	%	%
Not at all important	1	2	1
Somewhat unimportant	0	3	1
Neutral	12	12	12
Somewhat important	36	31	34
Very important	51	52	52

Analysis of responses to the second research question confirms the sample population's belief that a good work / life balance is achievable in a STEM profession. Earning a higher income is important, but lifestyle choices available through STEM are more important. Respondent's have a positive view of the impact they can make in society and have a positive outlook about their future role in the profession.

Analysis of differences within the Sample Population

Tables 37 through 43 present a series of ANOVA analyses examining the responses of various sub groups in the sample. All post-hoc comparison tables using the Tukey HSD test are presented in Appendix B. The independent and dependent variables in the ANOVA are aligned with the third research question. Research Question 3 is: What factors help explain differences among sub-groups of women persisting in a STEM major? The subsidiary questions for Research Question 3 are,

- To what extent do women who develop a strong interest in STEM studies by their middle school or early high school years (early deciders) exhibit a higher degree of confidence in their capabilities and future outlook in a STEM based career?
- To what extent do women STEM majors, who have experienced classroom bias (either from faculty or other students) feel more isolated, exhibit a lower level of confidence in their career choice and express second thoughts on remaining in a STEM program?
- To what extent do women students at technology based institutions persisting in their initial STEM major exhibit a higher self-assessment of capabilities compared to women that have changed STEM majors (but stayed within STEM)?
- To what extent do women students that struggled in first year STEM courses have a significantly lower level of self-confidence and have second thoughts about their future outlook?
- To what extent do women that have benefited from a strong support structure of family, friends and mentor groups have more self-confidence and a stronger future career outlook?

Early Deciders

A simple hypothesis would suggest “the earlier, the better” in students developing a deeper commitment to a STEM major and career. The literature supports the importance of developing student interest during their adolescent years. Table 16 showed that 41% of the sample population became interested in STEM during their middle school years, with another 20% during the first 2 years of high school.

A one-way ANOVA between groups, based on the independent variable, age when interest in STEM studies first started (see Tables 37-38), was tested to explore the impact of an earlier development of interest in a STEM major on self-confidence and future outlook of professional image. There was a statistically significant difference at the $p < 0.05$ level for the conditions of [F (3,151) = 3.848, p=0.011] for the self-confidence dependent variable "I am confident I will fit in". Post hoc comparisons using the Tukey HSD test indicated that the mean score for both subgroups of "interested in STEM since middle school or earlier" (M=0.553, SE=0.196, p=0.028) as well as "interested in STEM since 1st two years of high school" (M=0.585, SE=0.289, p=0.041) was significantly different than the sub group "interested in STEM since college." However the sub group "interested in STEM since the 2nd two years of high school" did not significantly differ from the "interested in STEM since college" sub group (M=0.245, SE=0.207, p=0.417).

Table 37

ANOVA testing "Confident that I will fit in" vs. Interest in STEM timing group of "I've wanted to major in STEM since…"

ANOVA					
Q51 I will fit in					
	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	6.725	3	2.242	3.848	.011
Within Groups	87.959	151	.583		
Total	94.684	154			

A one-way ANOVA between the same independent variable of age when interest in STEM studies first started (see Table 38) was conducted to explore the impact on the dependent outlook variable of “I can make a positive impact as an engineer or physical scientist”. There was a statistically significant difference at the $p < 0.05$ level for the conditions of [F (3,150) = 4.401, p=0.005]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the subgroup “interested in STEM since 1st two years of high school” (M=0.760, SE=0.218, p=0.003) was significantly different than the sub group “interested in STEM since college”. The sub groups “interested in STEM since middle school or earlier” (M=0.453, SE=0.195, p=0.097) and “interested in STEM since the 2nd two years of high school” (M=0.318, SE=0.207, p=0.639) did not significantly differ from the “interested in STEM since college” sub group.

Table 38

ANOVA testing “I can make a positive impact as an engineer” vs. career choice timing group of “I’ve wanted to major in STEM since…”

ANOVA

Q44 I can make positive impact eng'g phys. sci.

	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	7.597	3	2.532	4.401	.005
Within Groups	86.305	150	.575		
Total	93.903	153			

Taken together, the ANOVA looking at the independent variable of age when interest in STEM studies first started, confirms the research question and the value of programs that interest young women in STEM studies and careers through the first half of high school. The sub groups of women that developed an earlier interest in STEM better see themselves as fitting into a STEM career and visualizing the impact that they can make as an engineer of scientist.

However, no statistically significant variation was found among the interest in STEM sub groups on questions involving their view of challenges for women in a STEM career. Variables such as the “importance of achieving a good work - life balance,” “STEM perceived as a man’s world,” “women have to work harder than men,” and “women have to be tougher to succeed” showed no significant differences in mean results among the interest in STEM timing sub groups. We can conclude that all of the age groups have statistically similar views of the challenges facing women in a STEM career.

Classroom Bias

Table 25 earlier noted that 36% of the respondents personally experienced some form of bias in the classroom, but more likely from male students rather than faculty. A one-way ANOVA (see Table 39), based on the independent variable of students that have personally experienced bias in the classroom, was conducted to explore the impact of a perception of bias in the classroom on the dependent variable of a respondent’s belief that women will feel isolated in a STEM career. There was a statistically significant difference at the $p < 0.05$ level for the conditions of [F (4,149) = 4.352, p=0.002]. Post hoc comparisons using the Tukey HSD test indicated that the feeling isolated mean score for the subgroup *Strongly Agree* that they personally experienced bias (M=1.303, SE=0.375, p=0.006) was significantly different than the other 4 sub groups expressing a more moderate opinion or having had no experience of bias.

Table 39

ANOVA testing of perception of classroom bias and feeling isolated in a STEM career

ANOVA					
Q42 Women more isolated in STEM					
	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	13.799	4	3.450	4.352	.002
Within Groups	118.104	149	.793		
Total	131.903	153			

The findings presented in Table 39 can only confirm part of the third research question, which deals with the impact of bias on female feelings of isolation in STEM fields. Despite the perception of having experienced bias in the classroom, there was no statistically significant differences in the responses between the subgroups perceiving bias in the classroom and the overall sample with respect to variables "having 2nd thoughts about continuing in STEM," "confidence that they will fit in," "achieving a good work / life balance," and "belief that they are not as strong as their male counterparts." Thus, we cannot confirm the second part of the question that perceptions of bias in the classroom create a statistically significant difference in making a decision to persist with STEM studies, nor with their self-confidence in their abilities and future outlook in this field. This conclusion may derive from our understanding that the primary source of bias experienced was from fellow students and not from faculty. This form of classroom bias may be seen as more of an annoyance rather than having a long-term decision making impact. The modest impact of classroom bias on a female student's decision to remain in a STEM major may also relate to the relative uniqueness of this population of students as female STEM majors at a technological institution.

Although ethnicity and racial composition of the student population are not explicitly covered in the research questions, there is often a connection between minority status and having experienced bias. As reported in Table 13, the non-White population represents 38% of the sample respondents (mixed race selections were combined with non-White for the purposes of this analysis). Examining all of the questions in the survey, only one question demonstrated a statistically significance difference in responses between the non-White sub group compared to the overall population. A one-way ANOVA (see Table 40) examines the impact of the independent variable of ethnic background on the dependent variable of self-confidence compared to male counterparts in math and science. The sub groups show a statistically significant difference at the $p <$ 0.05 level for the conditions of [F (4,144)= 6.983, p=0.009].

Thus, non-White respondents reported a statistically significant lower mean score (reversed scoring) than Whites in believing that they are not as strong in math and science as their male counterparts.

However an ANOVA of responses of ethnicity sub groups on related variables, such as “females are not as capable in STEM,” and “men are better suited for STEM” did not have a significant difference at p <0.05. So it is difficult to judge if the statistical variation in the “self-confidence compared to males” variable (which was a reverse worded question) is actually reporting a meaningful difference.

Table 40

ANOVA testing the impact of ethnic background and future outlook

ANOVA					
Q18 I believe not as strong in M/S as male counterparts					
	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	7.134	1	7.134	6.983	.009
Within Groups	147.112	144	1.022		
Total	154.247	145			

On an overall basis, we can conclude that responses of the non-white sample sub group are similar to the overall sample population.

Changed Majors

As noted in Table 18, 34% of the sample population changed majors during their first two years in college. However, no statistically significant differences could be found between the group that changed majors and the overall sample population in variables dealing with "Self-confidence in academic capabilities," "remaining in a STEM major," "having 2nd thoughts about staying in STEM," "considering a career or graduate study outside of STEM."

Therefore, the third research question that woman students at technology based institutions persisting in their initial STEM major will exhibit a higher self-assessment of capabilities compared to women that have changed STEM majors, cannot be confirmed in this study.

Based on open-ended comments to this question, it can be surmised that for this population of female STEM students at a technology based institution, changing majors indicates seeking a better fit or a better career opportunity within the same broad STEM category, rather than a reduction in self-confidence. The majority of survey respondents that did change majors either stayed within engineering or changed from science to engineering. They were not looking for a clear change in direction.

Struggled with First Year Courses

The impact on self-confidence due to grades received in early STEM (weed out) courses does offer additional insight about self-confidence in persisting in STEM studies. Table 18 showed that 22% of the sample population expressed having second thoughts about staying in STEM. College grades achieved in first year STEM courses may have shaken this subgroup's self-confidence.

A series of one-way between groups ANOVA analysis (see Tables 41-42) was tested to explore the impact on the self-confidence dependent variable "having second thoughts about remaining in STEM" based on the independent variables of "overall grades received in STEM classes," "I believe I am not as strong as male counterparts in math and science," "finding it difficult to keep up in math and science classes," "my first year grades confirmed that I was on the right track," "I am confident to succeed in STEM," and "I can make an impact as an engineer or physical scientist."

All of these independent variables showed a statistically significant impact on the subgroup "having second thoughts." In the self-confidence group of independent variables listed above there was a statistically significant difference at the $p < 0.05$ level for the conditions of [F (4,156)= 7.493, p=0.000], [F (4,153)= 9.456, p=0.000], [F (4,155)= 5.286 p=0.001], and [F (4,155)= 8.457, p=0.000] respectively.

Post hoc comparisons using the Tukey HSD test indicated that the mean score for *Strongly Agree* that they are "not as strong in math and science as male counterparts" was significantly different for the subgroup "having second thoughts" compared to students that expressed *Neutral*, *Disagree* or *Strongly Disagree* opinions (M=-1.294, SE=0.383, p=0.008), (M=-1.207, SE=0.329, p=0.003) and (M=-1.480, SE=0.333, p=0.000) respectively. The *Agree* group was also statistically different compared to the *Disagree* and *Strongly Disagree* groups (M=0.630, SE=0.227, p=0.047) and (M=-0.903, SE=0.232, p=0.001).

The post hoc comparison on the question of "finding it difficult to keep up pace in STEM classes" showed significant differences, with the *Strongly Agree* group compared to *Disagree* and *Strongly Disagree* (M=-1.314, SE=0.321, p=0.001), (M=-1.580, SE=0.325, p=0.000) and the *Agree* group compared to *Disagree* and *Strongly Disagree* (M=-0.753, SE=0.222, p=0.008), (M=-1.018, SE=0.227, p=0.000).

The post hoc comparison on the question of "my overall grades confirmed my choice of STEM studies" showed significant differences with *Strongly Agree* compared to *Neutral*, *Disagree* and *Strongly Disagree* (M=-1.124, SE=0.373, p=0.025), (M=-1.125, SE=0.321, p=0.005), (M=-1.320, SE=0.324, p=0.001). The *Agree* group was significantly different only compared to *Strongly Disagree* (M=-0.635, SE=0.226, p=0.044).

The post hoc comparison on the question of "my first year grades confirmed that I was on the right track" showed significant differences with the *Strongly Agree* group compared to *Neutral*, *Disagree* and *Strongly Disagree* (M=-1.206, SE=0.368, p=0.011), (M=-1.184, SE=0.317, p=0.002), (M=-1.620, SE=0.320, p=0.000). The *Agree* group was significantly different only compared to *Strongly Disagree* (*M*=-0.889, *SE*=0.223, *p*=0.001).

We can conclude from these ANOVA findings, as logically expected, that college course grades, including the first year weed out courses, create uncertainty in remaining with a STEM major, even for those STEM students of this sample population that still remain in the program.

Table 41

ANOVA testing of having second thoughts about remaining in STEM and grades received in STEM courses

ANOVA						
		Sum of Squares	*df*	Mean Square	*F*	Sig.
Q18 I believe not as strong in M/S as male counterparts	Between Groups	27.643	4	6.911	7.493	.000
	Within Groups	143.873	156	.922		
	Total	171.516	160			
Q19 Difficult to keep up M/S	Between Groups	33.100	4	8.275	9.456	.000
	Within Groups	133.887	153	.875		
	Total	166.987	157			
Q20 Overall grades confirmed STEM	Between Groups	18.544	4	4.636	5.286	.001
	Within Groups	135.950	155	.877		
	Total	154.494	159			
Q22 First year on right track	Between Groups	28.859	4	7.215	8.457	.000
	Within Groups	132.241	155	.853		
	Total	161.100	159			

The second series of ANOVA (see Table 42) tested the impact on the self-confidence dependent variable "having second thoughts in STEM" by independent variables dealing with respondent's confidence in their personal future in STEM. The variables "I am confident to succeed in a STEM career," on "having second thoughts," shows a statistically significant difference at the $p < 0.05$ level for the conditions of [F (4,150)= 8.191, p=0.000]. The impact of "I can make an impact as an engineer or physical scientist" on "having second thoughts", shows a statistically significant difference at the $p < 0.05$ level for the conditions of [F (4,149)=6.482, p=0.000].

The post hoc comparison on both questions of "I am confident to succeed in a STEM career" and "I can make an impact as an engineer or physical scientist" showed significant differences only with the *Agree* group compared to *Neutral*, *Disagree* and *Strongly Disagree* (*M*=-0.677, *SE*=0.203, *p*=0.009), (*M*=-0.434, *SE*=0.149, *p*=0.032), and (*M*=-0.812, *SE*=0.152, *p*=0.000) for the first ANOVA and significant differences only with the *Agree* group compared to *Disagree* and *Strongly Disagree* in the second ANOVA (*M*=0.758, *SE*=0.174, *p*=0.000) and (*M*=0.823, *SE*=0.178, *p*=0.000).

Table 42

ANOVA testing of having second thoughts about remaining in STEM and self-confidence in a STEM career and making an impact as an engineer / physical scientist

ANOVA						
		Sum of Squares	*df*	Mean Square	*F*	Sig.
Q43 Confident to succeed in STEM career	Between Groups	12.831	4	3.208	8.191	.000
	Within Groups	58.743	150	.392		
	Total	71.574	154			

Q44 I can make positive impact eng'g phys. sci.	Between Groups	13.919	4	3.480	6.482	.000
	Within Groups	79.983	149	.537		
	Total	93.903	153			

The conclusions of this research question can be considered as logical, that students that have a lower confidence in their ability to succeed or to make an impact with their career would express second thoughts about persisting in the major.

An interesting follow up study could compare differences in the level of “having second thoughts” between students that remain in the program despite uncertainties, with those that changed programs away from STEM. Possibly a threshold level of “having second thoughts” can be established, which leads to transfer out of STEM.

Strong Family Support

A one-way ANOVA between groups (see Table 43), based on the independent variable, agreement with having “family and friends support” was conducted to test the impact of a supportive network of emotional support on a student’s self-confidence and future outlook in a STEM career. There was a statistically significant difference at the $p < 0.05$ level for the dependent variables “I have the confidence to succeed in general” [F (3,158) = 3.949, p=0.010], “I have the confidence to succeed in STEM”, [F (3, 159) = 3.446, p=0.018], “confident to succeed in a STEM career” [F (3, 153) =4.820, p=0.003], “I can make a positive impact as an engineer or physical scientist” [F (3,152) = 3.358, p=0.021] and “I will fit in” [F (3,153) = 4.287, p=0.006].

Post hoc comparisons using the Tukey HSD test indicated that the mean score between the sub groups *Agree* and *Strongly Agree* are significant on all questions with the exception of "I have the confidence to succeed in STEM studies" (M =0.259, SE= 0.123, p=0.157)

Table 43

ANOVA testing of the impact of a strong support structure of family, friends and mentors

ANOVA						
		Sum of Squares	*df*	Mean Square	*F*	Sig.
Q28 I have the confidence to succeed in general	Between Groups	3.377	3	1.126	3.949	.010
	Within Groups	44.183	155	.285		
	Total	47.560	158			
Q29 Confidence to succeed in STEM	Between Groups	5.196	3	1.732	3.446	.018
	Within Groups	78.404	156	.503		
	Total	83.600	159			
Q43 Confident to succeed in STEM career	Between Groups	6.263	3	2.088	4.820	.003
	Within Groups	64.964	150	.433		
	Total	71.227	153			
Q44 I can make positive impact eng'g phys. sci.	Between Groups	5.921	3	1.974	3.358	.021
	Within Groups	87.583	149	.588		
	Total	93.503	152			
Q51 I will fit in	Between Groups	7.432	3	2.477	4.287	.006
	Within Groups	86.679	150	.578		
	Total	94.110	153			

The results indicate a confirmation of the third research question demonstrating the importance of a strong emotional support structure of family members, friends, and mentors in creating an environment of confidence to succeed and developing a positive outlook for the future.

Respondent Open-Ended Recommendations

Tables 44 through 45 present the open-ended recommendations of the respondents on increasing the participation of women in STEM undergraduate programs.

Nearly 50% of the responses shown in Table 44 suggested that focus on STEM for women should begin at an earlier age. This is consistent with Table 16, which showed that 61% of the sample had decided on STEM by the middle of high school. The second most mentioned recommendation (32%) is the need for increasing the confidence levels and support offered to female students. An example of a student comment, which links these two important factors, is as follows:

"Young girls should be shown that they have equal opportunities and that they do NOT need to feel inferior for following their passion in a STEM major. Having them practice their STEM skills with fellow young girls will tell them that they are not alone" and "It is important to show younger generations that the numbers of women and minorities in stem fields is increasing but slowly."

Table 44

Respondents Suggestions for Increasing Women's Participation in STEM (Multiple open-ended responses allowed)

% Increased financial support	% Focus at a younger age	% Increase self confidence and overcome stereotypes	% More hands-on science activities	% More H.S. math and science courses	% Increase peer and mentor support

5	49	32	8	14	18

Respondents were given a chance for their final thoughts in an open-ended question. The coded responses shown in Table 45 were surprising, expressing deep-seated emotions and heavily focused (61%) on the importance of overcoming the stereotypes of women in STEM and improving the social acceptability of women in STEM careers.

Table 45

Respondent's Final Thoughts (Multiple open-ended responses allowed)

% Improve mentor support	% Improve social acceptability of women in STEM	% STEM is a difficult major and career path
11	61	14

Selected comments included:

"Society is misogynistic and wants women to assume passive roles, which usually does not include STEM majors or careers. And even when women pursue STEM majors and careers, we still face criticism for it, where men talk down to us and assume we can't do an equal, if not better, job as men. Even when a woman is better than a man, the career considers her an exception to the rule, as if it's a shock how well she is at her career."

The open-ended comments all display emotional concern about the challenges women face in what may still be seen as a "man's world". "I think that this was a very popular view just a generation or two ago and that, while society as a whole is slowly changing their view, the people within STEM are changing even more slowly, which is part of the difficulty that women have entering the field." The sample population is sensitive to a harder path for women STEM professionals, but is prepared to meet the challenges head on. "We might still have to work harder, though. People don't always want to hire a woman even in today's world, so an equal grade isn't always enough."

Survey Results Overview

The overall summation of responses to the three research questions can be seen in Table 46, which shows the selection of the sample population's most important consideration in pursuing a STEM career.

Table 46

Self-reported respondent's views on the most important factor in considering a STEM career, by institution

	A (*n*=82)	B (*n*=63)	Overall (*n*=146)
	%	%	%
Confidence in my academic ability	30	22	27
The role you will play in society as a STEM professional	30	43	36
Achieving a balance in career & income opportunity / personal family goals	40	35	38

The largest group of the sample population (38%) selected career / life balance as the most important factor, with the role they will play in society as a STEM professional, as a close second (36%). The school subgroups differed on this question. A students chose career - life balance (40%) as top priority while B students selected the role they will play in society (43%), as the highest ranked selection factor.

The responses of the sample population to the research questions confirm the commitment of female students at two technological institutions to STEM studies and careers. The respondents exhibit a high degree of self-confidence in their academic abilities, enjoy competing alongside male students and are not concerned that there are only a few women in their classes (although they wish otherwise). They are aware of the stereotype challenges they will face in the STEM profession and are prepared to meet them.

The respondents have a positive outlook about a career in STEM, both with respect to income potential and career - life balance. Many of the respondents became attracted to STEM by their middle school or early high school years, and took advanced science and math courses in the latter half of high school. The respondents are strongly influenced and emotionally supported by family and friends as well as their teachers, which enables them to pursue their passion in the sciences.

The survey findings are not completely unique, as they are consistent with results in the literature that reported women having a high persistence rate in STEM majors at highly selective colleges (Seymour & Hewitt, 1997). Female STEM undergraduates at technological institutions should be considered as equivalent to STEM students at highly selective universities.

CHAPTER 5

DISCUSSION AND SUMMARY

Study Overview

The significant underrepresentation of women in STEM studies and careers continues to be an important topic for educational planners, economists, and policy leaders. There is a broad range of academic researchers, mainstream journalists, and government planners seeking to identify and respond to the root causes of this underutilized resource for our country's future global competitiveness. Much of the literature has focused on why women undergraduate students drop out of STEM programs or, if they do persist in STEM, why they change majors from the physical sciences and engineering to life sciences.

This study seeks to add to the discussion by looking at a non-typical set of undergraduate students; female STEM majors at two technological universities. These are women that are succeeding in STEM studies, especially in engineering - physical sciences, and selected a technology based institution for their undergraduate work. These students are looking forward to a career in the STEM field. This study seeks to add to our understanding of successful female STEM majors and confirm their academic preparation for these programs; learn about their confidence in themselves; understand the emotional support they've received from family, teachers and friends; as well as their future outlook and comfort level with finding success in what many still perceive as a "man's world."

The study's findings confirm the academic strength and self-confidence of this population. The women respondents to this survey, to a large extent, became committed to a STEM career by the 10th grade. They took advanced math and science courses in high school and scored well on the standardized SAT and AP exams. They have the confidence both to succeed professionally as well as achieve a good work - life balance in a STEM career.

The study surveyed 181 female (sophomore through senior year) STEM majors at a public and private technology institution in the northeast during the Fall 2013 semester. The responses to both the structured questions and their open-ended comments give us a better understanding of programs and initiatives which may positively influence other academically qualified young women to consider a STEM major and career.

Purpose of the Study and Research Objectives

The goals of the study have been met.

- The study examined the reasons and future outlook of women that entered college in a technology institution with an intent to major in STEM studies and then persisted into their second, third and fourth years. The study researched the extent to which a student's self-assessment of their academic capabilities and to which extent cultural and societal issues influenced their choice of persisting in a STEM major.
- The study examined differences in self-confidence and future outlook among subgroups within the sample population. We examined the differences between early deciders (10th grade or earlier) and students that opted for STEM later in their education. We examined the impact of perceived gender bias, family support and grades received in early college courses.

The study has answered the primary and subsidiary research questions.

Research Question 1 is: What factors help explain the level of self-confidence of women who have persisted in STEM?

- Do women that have persisted in STEM have a strong academic preparation in math and science?

  The respondents demonstrate a strong preparation in math and science. A large majority (75%) took AP Calculus in High School. AP science courses ranged from 43% having taken AP Physics to 53% having taken AP Chemistry. As a result of their strong preparation, 75% of respondents felt confident that they had sufficient background in math and science.

- Do women's self-assessment of their capabilities in math and science help explain expectation of success in STEM studies?

  Based on their foundation in math and science courses, 88% agreed or strongly agreed that they had the confidence to succeed in STEM classes.

- Does perception of gender bias in the classroom or concerns of gender bias in the future work environment help explain a lower level of self-confidence by women STEM majors?

  A relatively large sub group of 36% of respondents reported personally experiencing bias in the classroom, although primarily at the hands of male students. This led to increased feelings of isolation but did not dissuade the students from persisting in their STEM major or change their career intentions. There is a clear understanding (69%) that women may have to work harder for equal recognition, but they are confident (68%) that they will fit in.

- Does the belief that career aspirations can be fulfilled in STEM partly explain a woman's self-confidence?

    A positive outlook on career aspirations is reflected through responses to a number of questions and can be best characterized by noting that 90% believe that they can personally make a strong impact as an engineer or physical scientist.

Research Question 2 is: What factors help explain a woman's decision to remain in a STEM major?

- To what extent do women believe that success in STEM careers requires a trade-off between work and family obligations?

    A positive outlook on career aspirations is reflected through responses to a number of questions and can be best characterized by noting that 90% believe that they can personally make a strong impact as an engineer or physical scientist.

- To what extent do women that have persisted in STEM place value on the importance of achieving a large income compared to raising a family and lifestyle choices?

    Respondents are very aware (87%) of the higher income opportunity in a STEM, yet only 41% reported that earning a higher income was their highest priority for a career choice. Consistent with the above trend, 71% of the respondents reported that a balanced life is more important than maximizing income.

- To what extent has family, friends, and advisors supported or discouraged a woman's interests in the STEM fields?

  Open-ended comments to this question indicated the strong importance of parental support and that of respected teachers or other advisers in deciding to pursue STEM studies. The ANOVA of the subgroup that selected *strongly agree* with having the support of family and friends reported a higher level of self-confidence to succeed in general, to succeed in a STEM career as well as a belief that they can make a positive impact as an engineer or physical scientist.

- To what extent does the perceived balance of career vs. family help explain their decision to remain as a STEM major?

  The belief that a good balance of career and personal life can be found with a STEM career is considered as important by 86% of all respondents and was selected as the most important factor in considering a STEM career (38%). Overall, this presents a picture of students that are committed to their future in STEM and look forward to the life style that this career represents.

Research Question 3 is: What factors help explain differences among sub-groups of women persisting in a STEM major?

- To what extent do women who develop a strong interest in STEM studies by their middle school or early high school years (early deciders) exhibit a higher degree of confidence in their capabilities and future outlook in a STEM based career?

This question was confirmed with over 60% of the respondents committing to STEM studies by the 10th grade. These students had a statistically significant higher level of self-confidence in their abilities and future outlook.

- To what extent do women STEM majors, who have experienced classroom bias (either from faculty or other students) feel more isolated, exhibit a lower level of confidence in their career choice and express second thoughts on remaining in a STEM program?

  This question was partly met, with women having experienced bias feeling more isolated. However, experiencing bias (generally from other students) did not statistically lower their self-confidence or lead to thoughts of leaving the program. Perhaps we might conclude that bias from other students is seen as an annoyance by this group of women rather than a decisive factor in determining their future.

- To what extent do women students at technology based institutions persisting in their initial STEM major exhibit a higher self-assessment of capabilities compared to women that have changed STEM majors (but stayed within STEM)?

  This question was only partly confirmed. Changing majors did not have a statistically significant impact on a student's self-confidence or career outlook. To a large extent, the student population in this survey did not change majors. Those that did change majors (34%), tended to stay within the same STEM field, for example from civil to mechanical engineering. Some students changed from science into engineering, seeking a more applied field. Very few changed to life sciences. As seen in Tables 6 and 7, this above average level of persistence represents a consistent pattern with prior cohorts of women STEM students at both institutions.

- To what extent do women students that struggled in first year STEM courses have a significantly lower level of self-confidence and have second thoughts about their future outlook?

  The results confirmed that women that achieve lower grades in first year weed out courses do have a lower level of self-confidence, see themselves as weaker than male students and have second thoughts about continuing in a STEM program. Since these students continue to persist in STEM despite their lowered expectations, there must be a threshold at which female students at a technological institution decide to transfer to a non-STEM program at their institution or transfer to another school.

- To what extent do women that have benefited from a strong support structure of family, friends and mentor groups have more self-confidence and a stronger future career outlook?

  This question was confirmed, as students reported a strong vote of confidence from family, friends and teachers as an important influence factor in considering a STEM career. Respondents reported in open-ended comments that family and friends are proud that they had selected STEM studies and that this emotional support “helps propel me forward.”

Theoretical Frameworks

The sample population’s responses are aligned with the frameworks of the Gender Socialization Theoretical Model (Tobin, et al. 2010) and the Expectancy Value theory (Eccles, 1994). Tobin et al.’s model focuses on gender stereotypes and female responses to societal messages. Respondents are well aware of the negative stereotyping of women in STEM, but are eager to face those challenges head on. Tobin et al. concluded that a woman’s self-perceptions about math and science abilities are influenced by parents, as well as by teachers and friends. Tobin et al.’s conclusion is confirmed in this study with 87% affirming the importance of family, friends, and teachers in their decision to major in STEM. Open-ended comments to these questions emphasized the influence of parents and family members (siblings) that are in the STEM field, as well as the influence exerted by parents that gave a focus to science themes and toys when the students were young.

The Gender Socialization model considers that women may view their gender self-identity based on their choice of major and career. Open-ended comments to questions dealing with the abilities of women as compared to men can be best summarized as anger by respondents that such questions even exist. The respondents acknowledge that society holds stereotype views and agree that society still sees STEM as a man’s world. However, respondents firmly believe that this cultural bias is starting to change.

The Expectancy Value model presents two basic questions that female students considering STEM must evaluate:

1. Do I have the academic and professional capability to be successful in the career I am considering?
2. Based on personal values, how important is achieving success in this field compared to the life balance trade-offs that may be required vs. other career / life balance choices?

These two questions are answered with a strong, affirmative voice. An overwhelming majority (95%) believes that they have the overall academic background to succeed. One respondent to this question commented that achieving a high level of competence in a STEM major was the primary reason she chose to attend a technology-based school. The responses to the second question are nearly as strong, with 86% believing that they can find a good work - family life balance in a STEM career.

The Expectancy Value model is a decision making framework in which females weigh their options regarding a major - career in STEM compared to trade-offs in work - life balance. Respondents are well aware of the higher income potential that a STEM career brings and accept that sacrifices may be required to achieve a success in a career. Nonetheless, respondents agree (85%) that a successful combination of work / life balance can be achieved in a STEM career.

Achieving a positive role in society as engineers and scientists remains an important motivating value as well. Respondents believe (90%) that they can make a positive impact on society and 85% believe that physical sciences and engineering can make as much positive contribution as the life sciences. The open-ended comments to this question indicate that the respondents see themselves as problem solvers and among those that will find sustainable solutions using technology. Having a balanced view of income potential, professional role in society, and family life goals makes the composite of the respondent's opinions stand out as female STEM majors.

Contribution of this study to the body of research

The key findings of this study are aligned with the body of research presented in Chapter 2 and as discussed in Chapter 4. Numerous researchers have reported the lower self-assessment of female STEM students. Research has shown that societal stereotypes as well as lack of a support network of family, friends, and mentors may contribute to a lower self-confidence in female students. The literature has reported the importance of the middle school years in establishing a vision of a STEM career in young girls, based on a career which includes an important social impact as well as a satisfactory work / life balance. This study supports the body of research by examining the opinions and outlook of persisting female STEM majors in two technological institutions. The profiles of these successful students help explain some of the factors that contribute to the challenges female STEM students face and offer implications for possible solutions to improve persistence of female STEM majors.

Limitations of the Study

The uniqueness of the population is a limitation of this study. Seymour and Hewitt (1997) and Strenta, A. C., Elliott, R., Adair, R., Matier, M., & Scott, J (1993) both noted that women STEM majors had a higher persistence rate at small, highly selective colleges. The students at these two technological institutions are comparable to students at small, elite colleges rather than the STEM student population at larger universities. As noted earlier, by examining cohorts of prior students at the two schools, a high level of persistence is typical at both institutions of this study.

The number of respondents is a limitation. Although an 18% response is considered a reasonable rate for e-mail based, anonymous surveys, there are many students that chose not to respond. Only a small number of African American students responded. Respondents are drawn from two mid-sized schools in the northeast. The respondents are, by design of this study, those students that are persisting in a STEM major, that is, these are the women that are staying the course. Even those students that responded having had second thoughts about STEM or concerns about their capabilities are nonetheless, still in the program.

The survey may have been too long. Nearly 85% of the respondents completed the full survey; with the remainder starting the survey but dropping out after approximately 75% of the survey was completed. Some demographic data and additional optional comments may thereby have been lost due to the dropouts not completing the task. Most of the responses were received within the first few days of the request, so no wave analysis was required.

Implications of the Study

The importance of building a solid foundation in math and science courses has been confirmed by many researchers. As shown in NSF (2012), female students have largely achieved parity with male students taking advanced courses in high school. The respondents to this study confirm this academic requirement; with most of the sample population having taken multiple advanced math and science courses in their high school education. National data points to academic preparation as a necessary, but not sufficient, requirement for increased rates of female participation in STEM.

An additional necessary requirement is to develop a strong interest in STEM at an early age. As noted by Maple and Stage (1991), and confirmed by the respondents to this survey, interest in STEM studies needs to be established by the 10th grade. The increased focus on STEM careers for women should begin in the middle school years, with offering Algebra 1 to qualified students by seventh or eighth grade. We need to offer all middle school and high school students a range of lab based science classes as well as exposure to female professional role models and mentors. We need to cultivate a passion in young women for careers in science and to help them develop the self-confidence that they can succeed. We should assist young women in building a vision of what a career / life balance in a STEM field could encompass.

The impact of first year, weed out courses on women needs to be better understood. These courses may deter women from persisting in STEM while men with the same grades in such courses choose to continue. This is not to suggest that standards in first year courses be modified, but rather that a support network be made available to women that are struggling despite having the inherent capability to continue as a STEM major.

The impact of mentors and professional role models was shown to be of significant importance and should be increased. Role models help build a vision of how a meaningful STEM career and life balance is possible. The supporting network recommendation mentioned above and the increase in mentoring with professional role models could be fulfilled within the scope of campus based peer groups. As shown in this study, the current role of peer support groups was found to be ineffective and undesired by most survey participants. A refocus of the mission of peer support groups to include mentoring and tutoring support may be beneficial for wavering female STEM students.

Egalitarian sensitivity training would be appropriate for male STEM students. The impact of gender bias in the classroom is troubling and as shown in this study, is primarily from female classmates. Perhaps male students are not even aware of the impact of their words on female classmates. Female STEM students need to feel welcome in their classes and in the professional field.

Suggestions for Future Research

The student populations at the two technological institutions are relatively homogeneous with a predetermined strong commitment to a STEM career. Future research should compare this population with female STEM majors at large universities, where they may be a larger female STEM student population to draw from, including those having less of a commitment to staying in STEM. Student self-confidence and willingness to persist in engineering or physical science, despite having second thoughts, may be more diverse than reported in this study.

Research focus should be extended to more deeply examine differences in the self-confidence of minority groups compared to Caucasian women. Ethnic variations in survey responses are only casually examined in this study due to a limited survey population.

Comparison of attitudes between male and female students persisting in STEM at both technological schools and large universities would help explain gender gaps in student self-confidence and future career outlook. Examination of grade transcripts of both male and female STEM students could help explain the any gap in self-appraisal of academic capabilities compared to actual grades earned in first year courses.

Research focus should be extended to more deeply examine the source of classroom bias as exhibited by male students. What is the basis of this gender bias and are male students aware of the negative impact their remarks may have on their female classmates.

Qualitative research based on interviews with successful STEM majors at both technology institutions and large universities would generate additional insight into the factors that help explain persistence of female STEM majors. Qualitative interviews with students that transferred away from STEM, or switched to life sciences within STEM, will also deepen our understanding of the motivations and aspirations of female STEM majors.

Final Thoughts

The broader goal remains as stated in the introduction. The United States is competing in a global marketplace for technology-based products and services with both emerging and developed countries. There are many talented and capable women that represent a major underutilized resource in this competitive environment. Secondly, many women are not taking advantage of the higher income and benefits that a STEM career can offer. The goal of this study is to characterize female students that are persisting and better understand which strategies can be implemented to improve the participation of women in STEM.

REFERENCES

Atkinson, J.W. (1964) *An introduction to motivation* Princeton, NJ: Van Nostrand

Babbie, E. (1990). *Survey research methods* (2nd ed.). Belmont, CA: Wadsworth Publishing.

Beede, D., Julian, T., Langdon, D., McKiittrick, G., Kahn, B., & Doms, M. (2011). *Women in STEM: A gender gap to innovation* (Issue Brief No. 04-11). Washington, D.C.: U.S. Department of Commerce.

Bettinger, E. (2010). To be or not to be: Major choices in budding scientists. In C. Clotfelter (Ed.), *American universities in a global Market* (pp. 69-112). Chicago, Il: University of Chicago Press.

Bettinger, E., & Long, B. (2005). Female role models for female college students. *American Economic Review Papers and Proceedings, 95*(2), 152-157.

Betz, N., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28*(5), 399- 410.

Betz, N., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329-345.

Bleeker, M., & Jacobs, J. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96*(1), 97-109.

Blickenstaff, J. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender & Education, 17*(4), 369-386.

Brainard, S. G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, 87*(4), 369-375.

Brainard, S., Laurich-McIntyre, S., & Carlin, L. (1995). Retaining female undergraduate students in engineering and science: 1995 annual report to the Alfred P. Sloan foundation. *Journal of Women and Minorities in Science and Engineering, 2*, 255-267.

Burge, S. (2006). Gendered pathways in higher education: Change and stability in the pursuit of a science degree. Unpublished doctoral dissertation, Florida State University, Tallahassee, Fl.

Canes, B., & Rosen, H. (1995). Following in her footsteps? Faculty gender composition and women's choices of college majors. *Industrial & Labor Relations Review, 48*(3), 486.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional Role Confidence and Gendered Persistence in Engineering. *American Sociological Review, 76*, 641-666.

Ceci, S. & Williams,W. (2007). Are We Moving Closer and Closer Apart? In S. Ceci, & W. Williams (Eds.), Why Aren't More Women in Science? (2nd ed., pp. 213-236). Washington, D.C.: American Psychological Association.

Ceci, S., Williams,W., & Barnett, S. (2009). Women’s underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin, 135*(2), 218-261.

Chen, X., & Weko, T. (2009). Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education (No. NCES 2009-161). Washington, D.C.: U.S. Department of Education.

Committee on Prospering in the Global Economy of the 21st Century. (2007). Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future No. ISBN: 978-0-309- 10039-7). Washington, D.C.: National Academy of Sciences.

Concannon, J., & Barrow, L. (2010). Men's and women's intentions to persist in undergraduate engineering degree programs. *Journal of Science Education & Technology, 199,* 133-145.

Correll, S. J. (2001). Gender and the career choice process: the role of biased self-assessments, *American Journal of Sociology, 106*(6), 1691-1730.

Correll, S. J. (2004). Constraints into Preferences: Gender, status, and emerging career aspirations, *American Sociological Review, 69*, 93-113.

Creswell, J. (2009). *Research design* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Crocker, J., & Major, B. (1989). Social stigma and self-esteem: The self-protective properties of stigma, *Psychological Review, 96*(4), 608-630.

Daempfle, P. (2003). An analysis of the high attrition rates among first year college science, math and engineering majors. *Journal of College Student Retention: Research, Theory, & Practice, 5*(1), 37-52.

Di Fabio, N. M., Brandi, C., & Frehill, L. M. (2008). *Professional women and minorities: A total human resources data compendium*. Washington, D.C.: Commission on Professionals in Science and Technology.

Dweck, C. (2007). Is math a gift? Beliefs that put females at risk. In S. Ceci, & W. Williams (Eds.), W*hy aren't more women in science: Top researchers debate the evidence* (pp. 47-55). Washington, DC: American Psychological Association.

Dweck, C. (2008). Mindsets and math/science achievement. New York: Carnegie Corporation of New York, Institute for Advanced Study, Commission on Mathematics and Science Education.

Eagly, A. (1978). Sex differences in influence ability. *Psychological Bulletin, 85*(1), 86.

Eccles, J. S. (1987). Gender Roles and women's achievement-related decisions. *Psychology of Women Quarterly*, *11*(2), 135-172.

Eccles, J. S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly, 18*(4), 585-609.

Eccles, J. S. (2007). Where are all the women? Gender differences in participation in physical science and engineering. In S. Ceci, & W. Williams (Eds.), *Why aren't more women in science? (*2nd ed., pp. 199-210). Washington, D.C.: American Psychological Association.

Egan, S., & Perry, D. (2001). Gender identity: A multidimensional analysis with implications for psychosocial adjustment. *Developmental Psychology, 37*(4), 451-463.

Ehrenburg, R. (2010). Analyzing the factors that influence persistence rates in STEM field, majors: Introduction to the symposium. *Economics of Education Review, 29*, 888-891.

Entwisle, D., Alexander, K., & Olson, L. (1994). The gender gap in math: Its possible origins in neighborhood effects. *American Sociological Review*, *59*(6), 822-838.

Ethington, C., & Wolfle, L. (1988). Women's selection of quantitative undergraduate fields of study: Direct and indirect influences. *American Educational Research Journal*, 25(2), 157-175.

Farmer, H. (1997). Women's motivation related to mastery, career salience and career aspiration: A multivariate model focusing on the effects of sex role. *Socialization Journal of Career Assessment, 5*, 355-381.

Feather, N. (1988). Values, valences and course enrollment: Testing the role of personal values within an expectancy-valence framework. *Journal of Educational Psychology, 80,* 381-391.

Fennema, E., & Peterson, P. (1984). *Classroom processes, sex differences, and autonomous learning behaviors in mathematics*. Madison, WI: University of Wisconsin-Madison.

Fiorentine, R. (1987). Men, women, and the pre-med persistence gap: A normative alternatives approach. *American Journal of Sociology, 92*, 1118-1139.

Friedman, L. (1989). Mathematics and the gender gap: A meta-analysis of recent studies on sex differences in mathematical tasks. *Review of Educational Research, 59*(2), 185-213.

Frome, P., Alfeld, C., Eccles, J., & Barber, B. (2006). Why don't they want a male-dominated job? An investigation of young women who changed their occupational aspirations. *Educational Research and Evaluation, 12*, 359-372.

Gibbons, M. T. (2009). *Engineering by the numbers: Profiles of engineering and engineering technology colleges*. Washington, D.C.: American Society for Engineering Education.

Green, S. (1991). How many subjects does it take to do a regression analysis? *Multivariate Behavioral Research, 26*(3), 499-510.

Griffith, A. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*, 911-922.

Halpern, D. F. (1986). A different answer to the question, "Do sex-related differences in spatial abilities exist?" *American Psychologist, 41*(9), 1014-1015.

Halpern, D., Benbow, C., Geary, D., Gur, R., Hyde, J., & Gernsbacher, M. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*, 1-51.

Hartung, P. J., Porfeli, E. J., & Vondracek, F. W. (2005). Child vocational development: A review and reconsideration. *Journal of Vocational Behavior, 66*(3), 385-419.

Hecker, D. E. (1995). Earnings of college graduates, 1993. Mo*nthly Labor Review, 118*(3), 3-17.

Heilman, M. E., Wallen, A. S., Fuchs, D., & Tamkins, M. M. (2004). Penalties for success: Reaction to women who succeed in male gender-typed tasks Journal of *Applied Psychology, 89*(3), 416-427.

Hewlett, S., Buck Luce, C., Servon, L., Sherbin, L., Shiller, P. Sosnovich, E., & Sumberg, K. *The Athena factor: Reversing the brain drain in science, engineering, and technology*. Watertown, MA: Harvard Business School, 2008.

Hill, C., Corbett, C., & St. Rose, A. (2010). Why So Few? Women in Science, Technology Engineering and Mathematics. Washington, D.C.: AAUW.

Hilton, T., & Borglund, G. (1974). Sex differences in mathematics achievement: A longitudinal study. *Journal of Educational Research, 67*(5), 231-237.

Hines, M. (2007). Do sex differences in cognition cause the shortage of women in science? In S. Ceci, & W. Williams (Eds.), *Why Aren't More Women in Science?* (2nd ed., pp. 101-112). Washington, D.C.: American Psychological Association.

Huang, G., Taddese, N., & Walter, E. (2000). *Entry and persistence of women and minorities in college science and engineering education* (No. NCES 2000-601). Washington, D.C.: U.S. Department of Education.

Hutchison, M., Follman, D., Sumpter, M., & Bodner, G. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education, 95*(1), 39-46.

Hyde, J. (2007). Women in science: Similarities in abilities and sociocultural forces. In S. Ceci, & W. Williams (Eds.), *Why Aren't More Women in Science?* (2nd ed., pp. 131-146). Washington, D.C.: American Psychological Association.

Hyde, J., Fennema, E., & Lamon, S. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin, 107*(2), 139-155.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*, 494-495.

Ivie, R., Czujko, R., & Stowe, K. (2002). Women physicists speak. Women in Physics: The IUPAP International Conference on Women in Physics, Paris, France.

Jensen, E., & Owen, A. (2001). Pedagogy, gender, and interest in economics. *The Journal of Economic Education*, *32*(4), 323-343.

Kerr, B., Multon, K., Syme, M., Fry, N., Owens, R., Hammond, M., et al. (2012). Development of the distance from privilege measures: A tool for understanding the persistence of talented women in STEM. *Journal of Psychoeducational Assessment, 30*(1), 88-102.

Knapp, R. & Goodrich, H. (1952). *Origins of American scientists*. New York: Russell & Russell.

Kokkelenberg, E. & Sinha, E. (2010). Who succeeds in STEM studies? An analysis of Binghamton University undergraduate students. *Economics of Education Review, 29*, 935-946.

Lapan, R. T., Adams, A., Turner, S., & Hinkelman, J. M. (2000). Seventh graders' vocational interest and efficacy expectation patterns. *Journal of Career Development, 26*(3), 215-219.

Leaper, C., Farkas, T., & Spears-Brown, C. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and english. *Journal of Youth and Adolescence, 41*(3), 268-282.

Lubinski, D., & Persson Benbow, C. (2007). Sex differences in personal attributes for the development of scientific expertise. In S. Ceci, & W. Williams (Eds.), *Why Aren't More Women in Science?* (2nd ed., pp. 79-100). Washington, D.C.: American Psychological Association.

Manis, J. (1989). *An analysis of factors affecting choice of majors in science, mathematics, and engineering at the university of michigan* (No. 23). Ann Arbor, MI: University of Michigan.

Manski, C. F. (1993). Dynamic choice in social settings: Learning from the experiences of others. *Journal of Econometrics, 58*(1–2), 121-136.

Maple, S. & Stage, F. (1991). Influences on the choice of math/science major by gender and ethnicity. *American Educational Research Journal*, *28*(1), 37-60.

Mara, R., & Bogue, B. (2006). Women engineering students' self efficacy–A longitudinal multi-institution study. WEPAN-Women in Engineering Programs and Advocates Network Conference,

Martin, C., & Ruble, D. (2010). Patterns of gender development. *Annual Review of Psychology*, *61*, 353- 381.

McShannon, J., & Derlin, R. (2000). *Retaining minority and women engineering students: How faculty development and research can foster student success*. New Mexico Higher Education Assessment Conference, Las Cruces, NM.

Milgram, D. (2011). How to recruit women and girls to the science, technology, engineering, and math (STEM) classroom. *Technology & Engineering*, *71*(3), 4-11.

Modi, K., Schoenerg, J., & Salmond, K. (2012). *Generation STEM: What girls say about science, technology, engineering, and math*. Girl Scout Research Institute.

Morganson, V., Jones, M., & Major, D. (2010). Understanding women's underrepresentation in science, technology, engineering, and mathematics: The role of social coping. *The Career Development Quarterly*, *59*, 169-179.

National Center for Education Statistics of the US Department of Education (2006)

National Education Longitudinal Study of 1988 (NELS:88), National Center For Educational Statistics. Retrieved March 24, 2013, from http://nces.ed.gov/surveys/nels88/

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital* (No. NSB-10-33). Arlington, Va.: National Science Foundation.

National Science Board. (2004). Science and engineering indicators 2004 (Vol. 1 ed.). Arlington, Va.: National Science Foundation.

National Science Foundation. (2012). *Intention of freshman to major in S&E fields - 2010*. Retrieved from http://www.nsf.gov/statistics/women/

National Science Foundation. (2013) *Data tables.* Retrieved from http://www.nsf.gov/statistics/wmpd/2013/start.cfm

Newcombe, N. (2007). Taking science seriously: Straight thinking about spatial sex differences. In S. Ceci, & W. Williams (Eds.), *Why Aren't More Women in Science?* (2nd ed., pp. 69-78). Washington, D.C.: American Psychological Association.

Nguyen, H., & Ryan, A. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology*, *93*(6), 1314-1334.

Ohland, M., Sheppard, S., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. (2008, July). Persistence, engagement and migration in engineering programs. *Journal of Engineering Education*, 259- 278.

Ost, B. (2010). The role of peers and grades in determining major persistence in the sciences. *Economics of Education Review, 29*, 923-934.

Owen, A. (2010). Grades, gender, and encouragement: A regression discontinuity analysis. *The Journal of Economic Education, 41*(3), 217-234.

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs In A. M. Gallagher, & J. C. Kaufman (Eds.), Gender differences in mathematics: An integrative psychological approach (pp. 294- 315). Boston: Cambridge University Press.

Parsons, J., Adler, T., & Kaczala, C. (1982). Evaluation of achievement attitudes and beliefs: Parental influence. *Child Development*, *53*(2), 310-321.

Price, J. (2010). The effect of instructor race and gender on student persistence in STEM fields. *Economics of Education Review, 29*, 901-910.

Rask, K. (2010). Attrition in STEM fields at a liberal arts college: The importance of grades and pre- collegiate preferences. *Economics of Education Review, 29*, 892-900.

Rask, K. & Tiefenthaler, J. (2008). The role of grade sensitivity in explaining the gender imbalance in undergraduate economics. *Economics of Education Review, 27*, 676-687.

Robst, J., Keil, J., & Russo, D. (1998). The effect of gender composition of faculty on student retention. *Economics of Education Review, 17*(4), 429-439.

Rosenthal, L., London, B., Levy, S., & Lobel, M. (2011). The roles of perceived identity compatibility and social support for women in a single-sex STEM program at a co-educational university. *Sex Roles, 65*(9), 725-736.

Sabot, R., & Wakeman-Linn, J. (1991). Grade inflation and course choice. *Journal of Economic Perspectives, 5*(1), 159-170.

Sax, L. (1994). Mathematical self-concept: How college reinforces the gender gap. *Research in Higher Education, 35*(2), 141-166.

Schneider, B., Swanson, C., & Riegel-Crumb, C. (1997). Opportunities for learning: Course sequences and positional advantages. *Social Psychology of Education, 2*, 25-53.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving. Why undergraduates leave science*. Boulder, Co.: Westview Press

Sjaastad, J. (2010). *The influence of parents, teachers and celebrities in young people's choice of science in higher education*. XIV. IOSTE Symposium, Slovenia.

Smart, John C., Kenneth A. Feldman, and Corinna A. Ethington (2006). *Holland's theory and patterns of college student success*. Commissioned report for the national symposium on postsecondary success: Spearheading a dialogue on student success. Washington DC: The National Postsecondary Education Cooperative.

Spelke, E., & Grace, A. (2007). Sex, Math and Science. In S. Ceci, & W. Williams (Eds.), *Why aren't more women in science?* (2nd. ed., pp. 57-68). Washington, D.C.: American Psychological Association.

Spencer, S., Steele, C., & Quinn, D. (1999) Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*(1), 4-28.

Strenta, A. C., Elliott, R., Adair, R., Matier, M., & Scott, J. (1994). Choosing and leaving science in highly selective institutions. *Research in Higher Education, 35*(5), 513-547.

Suresh, R. (2006). The relationship between barrier courses and persistence in engineering. J*ournal of College Student Retention: Research, Theory, & Practice, 8*(2), 215-239.

Tamres, L., Janicki, D., & Helgeson, V. (2002). Sex differences in coping behavior: A meta-analytic review and an examination of relative coping. *Personality and Social Psychology Review, 6*(1), 2-30.

Tobin, D., Menon, M., Menon, M., Spatta, B., Hodges, E., & Perry, D. (2010). The intrapsychics of gender: A model of self-socialization. *Psychological Review, 117*(2), 601-622.

Trower, C. A. (2008). *Competing on culture: Academia's new strategic imperative*. Unpublished manuscript for the AAUW.

Tyson, W., Lee, R., Borman, K., & Hanson, M. (2007). Science, technology, engineering and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, *12*(3), 243-270.

U.S. Department of Commerce. (2011). *Women in STEM: A gender gap to innovation*. Retrieved from http://www.esa.doc.gov/Reports/women-stem-gender-gap-innovation

U S Department of Labor, (2009) *Women in the labor force.* Retrieved from http://www.bls.gov/cps/wlf-databook2009.htm

Walton, G., & Spencer, S. (2009). Latent ability: Grades and test scores systematically underestimate the intellectual ability of negatively stereotyped students. *Psychological Science*, *20*(9), 1132-1139.

Ware, N., & Lee, V. (1988). Sex differences in choice of college science majors. *American Educational Research Journal, 25*, 593-614.

White House Council on Women and Girls. (2012). Retrieved from http://www.whitehouse.gov/administration/eop/cwg

Wesigram, E. & Bigler, R. (2007). Effects of learning about gender discrimination on adolescent girls' attitudes toward and interest in science. *Psychology of Women Quarterly, 31,* 262-269.

Xie, Y., & Shauman, K. (2003). *Women in science: career processes and outcomes*. Cambridge, MA: Harvard University Press.

APPENDIX A

Survey Instrument

Dear University and College Undergraduate Women,

We are looking for women that entered college with an interest to major in a STEM field (Science, Technology, Engineering and Math) and persisted into their sophomore, junior and senior year by declaring a STEM major. You are very special. Less than 25% of STEM majors nationwide are women. You are to be complimented for having selected a STEM major and possibly a STEM career path. I am a doctoral student at Seton Hall University and this survey is intended as part of my PhD dissertation on encouraging more women to participate in STEM majors and careers.

We need your help! We want to better understand those characteristics that attracted you to major in STEM, attend a technology based institution and consider a technology-based career. We value and want your opinions. A donation in collective honor of the participants will be made to women's life programs at your school.

What aspects of STEM attracted you? What concerns do you have? Do you plan on a STEM career? Your responses to our survey will help inform this question and hopefully the opinions uncovered will help shape solutions to attract and retain more talented women into STEM majors and technology-based careers. You must be at least 18 years of age to complete this survey. You have the right to decline to answer any or all of the questions in the survey, or stop the survey once you have started. All responses are anonymous and the survey will be processed to protect your identity. Please click on the "Continue" below to indicate your consent to participate in this important research study and proceed to the Survey.

Continue

Ronald Brandt Seton Hall University

(Please note that by clicking on the "Continue" link above, you will be taken to the actual online version of the Survey. Below is a MS Word copy of the Survey Instrument)

Undergraduate Women in STEM

This survey seeks your opinions and your perceptions about:

- Your academic preparation to enter a STEM major and your evaluation of your capabilities in math and science courses
- Your opinion about cultural perspectives relating to a career in STEM fields. Do you see STEM as a "man's world" and women having a more difficult time fitting in?
- Your opinion whether you feel there are career / life balance conflicts in STEM professions. Are other professions more family friendly? Is this balance an important consideration for you in selecting a career?

Academic Preparation

We want to first understand what courses you may have taken, why you chose this school and whether you feel well qualified to undertake a STEM major.

Please tell us about your educational background as it relates to Math and Science courses

The high school grade in which I took Algebra 2	☐ 9th ☐ 10th ☐ 11th ☐ 12th
Additional math courses I took in high school (Check all that apply)	☐ Pre-calculus ☐ Calculus ☐ AP Calculus ☐ Other advanced /AP ☐ Computer Sciences ☐ No additional math
On the Math section of the SAT, my score was	☐ 450-550 ☐ 551-659 ☐ 660-739 ☐ 740-800
On an AP Math exam (best score), I achieved	☐ 1-2 ☐ 3 ☐ 4 ☐ 5 ☐ I did not take an AP math course
Science courses I took in high school (Check all that apply)	☐ Biology ☐ Chemistry ☐ Physics ☐ AP Chemistry

	☐ AP Biology ☐ AP Physics ☐ Env. Sci. ☐ Other
On an AP Science exam (best score), I achieved	☐ 1-2 ☐ 3 ☐ 4 ☐ 5 ☐ I did not take an AP science course
The math courses I took in my first 2 years of college (Check all that apply)	☐ Software / computer science ☐ Calculus ☐ Advanced calculus ☐ Basic math classes ☐ Other college level math courses
The average grade I received in my college math courses was	☐ A- to A+ ☐ B- to B+ ☐ C- to C+ ☐ D or less
Science courses I took in my first 2 years of college (Check all that apply)	☐ Biology and related ☐ Chemistry ☐ Physics ☐ Advanced Chemistry ☐ Adv. Bio / Life Sci. ☐ Advanced Physics ☐ Engineering courses ☐ Other ________________
The average grade I received in my science courses was	☐ A- to A+ ☐ B- to B+ ☐ C- to C+ ☐ D or less
My overall college GPA is (on a 4.0 Scale)	☐ 3.6-4.0 ☐ 3.0-3.5 ☐ 2.5-2.9 ☐ 2.4 or less
You are attending a Technology Institute. Whether this particular school was your first choice or not, was attending a technology based school your…	☐ First choice ☐ Second choice ☐ Other _____________
I've wanted to major in a STEM field since …	☐ Middle School ☐ 1st-2nd yr. of H.S. ☐ 3rd-4th yr. of H.S.
I chose this particular school because…	☐ It offers the major I was looking for ☐ Other _____________

(Check all that apply)	☐ It offered the best financial package ☐ Convenient to attend
I chose a technology institute over a broader based University because…. (Check all that apply)	☐ A better atmosphere for technology studies ☐ Internship Opportunities are Better ☐ School Reputation ☐ Student body that is more like me ☐ Other ___________ ☐ Better job prospects graduating from this school

Your Opinions

Please answer the following statements to measure your thoughts about the opportunities and obstacles that students may face when considering a STEM major in college and an eventual career in technology fields.

- Academic Preparation: Did you feel that you had sufficient academic preparation for college level math and the sciences? How do you judge your capabilities in math and science compared to others in your classes?
- Cultural Biases: Do you perceive STEM, especially the physical sciences and engineering, as a man's world? Is there classroom bias against women in STEM courses (both from other students or professors?)
- Career Aspirations: Do you believe that your career objectives and life / work balance can be fulfilled in STEM? Is balancing a demanding career and a family an important basis for your career decision?

Statement – Please mark an 'X' in the box that best describes your response.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
Academic Preparation for STEM					
I had a sufficient background in high school math and science classes to major in STEM.					
I have been interested in math and science as a possible career since at least my middle school years					
I believe I was *not* as strong as my male counterparts in math and science classes					

I felt overwhelmed by the content and pace in my college science courses					
My overall grades in college math and science classes confirmed my decision to continue majoring in STEM					
I found my first two year college math and science classes more challenging than my liberal arts classes					
My first year courses in college math and science convinced me I was on the right track					
I find my math and science courses as stimulating as liberal arts classes					
Cultural Perspectives and Self Confidence					
Men are better suited for science and math studies					
Females are *not* inherently as capable as males in math and science subjects					
Society believes that STEM is a man's world					
Female STEM majors are less feminine than liberal arts majors					
I enjoy competing alongside men at the highest level in STEM classes.					
I have the confidence to succeed at the highest levels in STEM classes					
Women have to work harder than men in STEM classes to achieve an equal grade					
My friends and family gave me support and encouragement to pursue a STEM major					
Engineering and physical science majors are as likely to make a positive contribution to society as biology or life science majors.					
Our society's gender roles values point young girls away from having an interest in STEM careers					
I *do not* mind being just one of a few women in advanced math or science classes					
I feel that male students and faculty may be generally biased against women in STEM classes					
I have personally experienced bias against me as a female in STEM classes					
I have often had second thoughts about majoring in STEM					
Career Aspirations					
Women are more likely than men to feel isolated in STEM careers					
I am confident I have what it takes to succeed in a STEM career					
I can make a positive impact on people's lives as an engineer or in a career in the physical sciences					
I can earn a higher income in a STEM based career compared to other options I have					
Work responsibilities in STEM careers do *not* allow a good career / life balance					
Earning a high income is very high on my list for making					

my career choices					
A balanced family life is more important to me than financial success					
Women have to be tougher than men to advance in a STEM career					
Women *do not* have to work harder than men to achieve equal recognition in a STEM career.					
I am confident that I will "fit in" and be accepted in a STEM career					
A STEM undergraduate degree is a good preparation for a career or graduate studies outside of technical fields					
I intend to pursue a job or graduate studies in a non-technical career field.					

Statement – Please mark an 'X' in the box that best describes your response.	**Not at all Important**	**Somewhat Unimportant**	**Neutral**	**Somewhat Important**	**Very Important**
	1	**2**	**3**	**4**	**5**
How important are the following themes in Evaluating a STEM major / career for you?					
Feeling that you have sufficient academic preparation in math and the sciences to be successful in a STEM career?					
Perceiving that STEM, especially the physical sciences and engineering, is a man's world?					
Believing that your personal career objectives and life / work balance can be fulfilled in STEM					

What do you feel is the most important factor for you in evaluating a STEM career?

____

Please provide three recommendations to increase women's participation in STEM majors and careers:

1. ____

2. ____

3. ____

Any additional thoughts that you feel may be of value in our evaluation?

Demographics

This information is used for statistical analysis only.

Please tell us a few things about yourself with an X in the appropriate box:

What type of college do you attend?

☐ Public University / College ☐ Private University / College

What year of study are you in?

Sophomore ☐ Junior ☐ Senior ☐

What is your major field of study?

☐ Physical sciences ☐ Biology / Pre-med

☐ Engineering ☐ Math

☐ Computer science ☐ Other ______________________ (please specify)

What was your initial field of study when you entered college?

☐ Physical sciences ☐ Biology / Pre-med

☐ Engineering ☐ Math

☐ Computer science ☐ Other _________________________ (please specify)

If you've changed majors, when did you make the change?

After 1st semester ☐ After 2nd semester ☐ Sophomore Year ☐ I've changed more than once ☐	
Age:	☐ 20 or younger ☐ 21 to 25 ☐ 26 to 44 ☐ 45 or older
Race/Ethnicity:	☐ African/African-American ☐ Hispanic/Latino ☐ Asian/Pacific Islander ☐ Caucasian/White ☐ Other ____________ (please specify)
Are you an international student?	☐ Yes ☐ No
Enrollment status:	☐ Full Time ☐ Part Time

Thank you for your participation!

APPENDIX B

POST-HOC, TUKEY HSD COMPARISON

Table B1

ANOVA testing "Confident that I will fit in" vs. Interest in STEM timing group of "I've wanted to major in STEM since…"

Multiple Comparisons

Dependent Variable: Q51 I will fit in
Tukey HSD

(I) Q15 I've wanted to major in a STEM field since …	(J) Q15 I've wanted to major in a STEM field since …	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 Middle school or earlier	2 1st two years of high school	-.032	.168	.997	-.47	.40
	3 2nd two years of high school	.308	.153	.185	-.09	.70
	4 Not until college	.553*	.196	.028	.04	1.06
2 1st two years of high school	1 Middle school or earlier	.032	.168	.997	-.40	.47
	3 2nd two years of high school	.340	.181	.240	-.13	.81
	4 Not until college	.585*	.219	.041	.02	1.15
3 2nd two years of high school	1 Middle school or earlier	-.308	.153	.185	-.70	.09
	2 1st two years of high school	-.340	.181	.240	-.81	.13
	4 Not until college	.245	.207	.639	-.29	.78
4 Not until college	1 Middle school or earlier	-.553*	.196	.028	-1.06	-.04
	2 1st two years of high school	-.585*	.219	.041	-1.15	-.02

	3 2nd two years of high school	-.245	.207	.639	-.78	.29

Table B2

ANOVA testing "I can make a positive impact as an engineer" vs. career choice timing group of "I've wanted to major in STEM since…"

Multiple Comparisons

Dependent Variable: Q44 I can make positive impact eng'g phys. sci.
Tukey HSD

(I) Q15 I've wanted to major in a STEM field since …	(J) Q15 I've wanted to major in a STEM field since …	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 Middle school or earlier	2 1st two years of high school	-.306	.167	.260	-.74	.13
	3 2nd two years of high school	.135	.153	.813	-.26	.53
	4 Not until college	.453	.195	.097	-.05	.96
2 1st two years of high school	1 Middle school or earlier	.306	.167	.260	-.13	.74
	3 2nd two years of high school	.441	.181	.073	-.03	.91
	4 Not until college	.760*	.218	.003	.19	1.32
3 2nd two years of high school	1 Middle school or earlier	-.135	.153	.813	-.53	.26
	2 1st two years of high school	-.441	.181	.073	-.91	.03
	4 Not until college	.318	.207	.417	-.22	.86
4 Not until college	1 Middle school or earlier	-.453	.195	.097	-.96	.05
	2 1st two years of high school	-.760*	.218	.003	-1.32	-.19
	3 2nd two years of high school	-.318	.207	.417	-.86	.22

*. The mean difference is significant at the 0.05 level.

Table B3

ANOVA testing of perception of classroom bias and feeling isolated in a STEM career

Multiple Comparisons

Dependent Variable: Q42 Women more isolated in STEM
Tukey HSD

(I) Q40 Personally experienced bias	(J) Q40 Personally experienced bias	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 Strongly Agree	2 Agree	-.484	.341	.615	-1.42	.46
	3 Neutral	-.750	.357	.225	-1.74	.24
	4 Disagree	-.519	.338	.541	-1.45	.41
	5 Strongly Disagree	-1.303*	.375	.006	-2.34	-.27
2 Agree	1 Strongly Agree	.484	.341	.615	-.46	1.42
	3 Neutral	-.266	.213	.721	-.85	.32
	4 Disagree	-.035	.179	1.000	-.53	.46
	5 Strongly Disagree	-.819*	.242	.008	-1.49	-.15
3 Neutral	1 Strongly Agree	.750	.357	.225	-.24	1.74
	2 Agree	.266	.213	.721	-.32	.85
	4 Disagree	.231	.209	.803	-.35	.81
	5 Strongly Disagree	-.553	.265	.231	-1.28	.18
4 Disagree	1 Strongly Agree	.519	.338	.541	-.41	1.45
	2 Agree	.035	.179	1.000	-.46	.53
	3 Neutral	-.231	.209	.803	-.81	.35
	5 Strongly Disagree	-.783*	.239	.011	-1.44	-.12
5 Strongly Disagree	1 Strongly Agree	1.303*	.375	.006	.27	2.34
	2 Agree	.819*	.242	.008	.15	1.49
	3 Neutral	.553	.265	.231	-.18	1.28
	4 Disagree	.783*	.239	.011	.12	1.44

*. The mean difference is significant at the 0.05 level.

Table B4

ANOVA testing of having second thoughts about remaining in STEM and grades received in STEM courses

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Q41 2nd thoughts about STEM	(J) Q41 2nd thoughts about STEM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Q18 I believe not as strong in M/S as male counterparts	1 Strongly Agree	2 Agree	-.577	.357	.490	-1.56	.41
		3 Neutral	-1.294*	.383	.008	-2.35	-.24
		4 Disagree	-1.207*	.329	.003	-2.11	-.30
		5 Strongly Disagree	-1.480*	.333	.000	-2.40	-.56
	2 Agree	1 Strongly Agree	.577	.357	.490	-.41	1.56
		3 Neutral	-.717	.300	.122	-1.54	.11
		4 Disagree	-.630*	.227	.047	-1.26	.00
		5 Strongly Disagree	-.903*	.232	.001	-1.54	-.26
	3 Neutral	1 Strongly Agree	1.294*	.383	.008	.24	2.35
		2 Agree	.717	.300	.122	-.11	1.54
		4 Disagree	.087	.265	.997	-.64	.82
		5 Strongly Disagree	-.186	.270	.959	-.93	.56
	4 Disagree	1 Strongly Agree	1.207*	.329	.003	.30	2.11
		2 Agree	.630*	.227	.047	.00	1.26
		3 Neutral	-.087	.265	.997	-.82	.64
		5 Strongly Disagree	-.273	.185	.581	-.78	.24
	5 Strongly Disagree	1 Strongly Agree	1.480*	.333	.000	.56	2.40
		2 Agree	.903*	.232	.001	.26	1.54
		3 Neutral	.186	.270	.959	-.56	.93
		4 Disagree	.273	.185	.581	-.24	.78

Q19 Difficult to keep up M/S	1 Strongly Agree	2 Agree	-.562	.348	.491	-1.52	.40
		3 Neutral	-1.012	.373	.056	-2.04	.02
		4 Disagree	-1.314*	.321	.001	-2.20	-.43
		5 Strongly Disagree	-1.580*	.325	.000	-2.48	-.68
	2 Agree	1 Strongly Agree	.562	.348	.491	-.40	1.52
		3 Neutral	-.450	.292	.536	-1.26	.36
		4 Disagree	-.753*	.222	.008	-1.37	-.14
		5 Strongly Disagree	-1.018*	.227	.000	-1.64	-.39
	3 Neutral	1 Strongly Agree	1.012	.373	.056	-.02	2.04
		2 Agree	.450	.292	.536	-.36	1.26
		4 Disagree	-.303	.259	.770	-1.02	.41
		5 Strongly Disagree	-.568	.263	.202	-1.29	.16
	4 Disagree	1 Strongly Agree	1.314*	.321	.001	.43	2.20
		2 Agree	.753*	.222	.008	.14	1.37
		3 Neutral	.303	.259	.770	-.41	1.02
		5 Strongly Disagree	-.265	.183	.597	-.77	.24
	5 Strongly Disagree	1 Strongly Agree	1.580*	.325	.000	.68	2.48
		2 Agree	1.018*	.227	.000	.39	1.64
		3 Neutral	.568	.263	.202	-.16	1.29
		4 Disagree	.265	.183	.597	-.24	.77
Q20 Overall grades confirmed STEM	1 Strongly Agree	2 Agree	-.685	.348	.288	-1.65	.28
		3 Neutral	-1.124*	.373	.025	-2.15	-.09
		4 Disagree	-1.125*	.321	.005	-2.01	-.24
		5 Strongly Disagree	-1.320*	.324	.001	-2.22	-.42
	2 Agree	1 Strongly Agree	.685	.348	.288	-.28	1.65
		3 Neutral	-.439	.292	.562	-1.25	.37
		4 Disagree	-.440	.222	.278	-1.05	.17
		5 Strongly Disagree	-.635*	.226	.044	-1.26	-.01

	3 Neutral	1 Strongly Agree	1.124*	.373	.025	.09	2.15
		2 Agree	.439	.292	.562	-.37	1.25
		4 Disagree	-.001	.259	1.000	-.72	.71
		5 Strongly Disagree	-.196	.263	.945	-.92	.53
	4 Disagree	1 Strongly Agree	1.125*	.321	.005	.24	2.01
		2 Agree	.440	.222	.278	-.17	1.05
		3 Neutral	.001	.259	1.000	-.71	.72
		5 Strongly Disagree	-.195	.181	.818	-.70	.31
	5 Strongly Disagree	1 Strongly Agree	1.320*	.324	.001	.42	2.22
		2 Agree	.635*	.226	.044	.01	1.26
		3 Neutral	.196	.263	.945	-.53	.92
		4 Disagree	.195	.181	.818	-.31	.70
Q22 First year on right track	1 Strongly Agree	2 Agree	-.731	.344	.214	-1.68	.22
		3 Neutral	-1.206*	.368	.011	-2.22	-.19
		4 Disagree	-1.184*	.317	.002	-2.06	-.31
		5 Strongly Disagree	-1.620*	.320	.000	-2.50	-.74
	2 Agree	1 Strongly Agree	.731	.344	.214	-.22	1.68
		3 Neutral	-.475	.288	.469	-1.27	.32
		4 Disagree	-.453	.219	.236	-1.06	.15
		5 Strongly Disagree	-.889*	.223	.001	-1.51	-.27
	3 Neutral	1 Strongly Agree	1.206*	.368	.011	.19	2.22
		2 Agree	.475	.288	.469	-.32	1.27
		4 Disagree	.022	.255	1.000	-.68	.73
		5 Strongly Disagree	-.414	.259	.502	-1.13	.30
	4 Disagree	1 Strongly Agree	1.184*	.317	.002	.31	2.06
		2 Agree	.453	.219	.236	-.15	1.06
		3 Neutral	-.022	.255	1.000	-.73	.68
		5 Strongly Disagree	-.436	.179	.112	-.93	.06

	5 Strongly Disagree	1 Strongly Agree	1.620*	.320	.000	.74	2.50
		2 Agree	.889*	.223	.001	.27	1.51
		3 Neutral	.414	.259	.502	-.30	1.13
		4 Disagree	.436	.179	.112	-.06	.93

*. The mean difference is significant at the 0.05 level.

Table B5

ANOVA testing of having second thoughts about remaining in STEM and self-confidence in a STEM career and making an impact as an engineer / physical scientist

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Q41 2nd thoughts about STEM	(J) Q41 2nd thoughts about STEM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Q43 Confident to succeed in STEM career	Strongly Agree	Agree	.188	.242	.937	-.48	.86
		Neutral	-.489	.264	.347	-1.22	.24
		Disagree	-.246	.225	.809	-.87	.37
		Strongly Disagree	-.624	.227	.052	-1.25	.00
	Agree	Strongly Agree	-.188	.242	.937	-.86	.48
		Neutral	-.677*	.203	.009	-1.24	-.12
		Disagree	-.434*	.149	.032	-.84	-.02
		Strongly Disagree	-.812*	.152	.000	-1.23	-.39
	Neutral	Strongly Agree	.489	.264	.347	-.24	1.22
		Agree	.677*	.203	.009	.12	1.24
		Disagree	.243	.182	.670	-.26	.75
		Strongly Disagree	-.135	.185	.949	-.64	.38
	Disagree	Strongly Agree	.246	.225	.809	-.37	.87
		Agree	.434*	.149	.032	.02	.84
		Neutral	-.243	.182	.670	-.75	.26

		Strongly Disagree	-.378*	.122	.020	-.72	-.04
	Strongly Disagree	Strongly Agree	.624	.227	.052	.00	1.25
		Agree	.812*	.152	.000	.39	1.23
		Neutral	.135	.185	.949	-.38	.64
		Disagree	.378*	.122	.020	.04	.72
	Strongly Agree	Agree	.342	.283	.748	-.44	1.12
		Neutral	-.156	.309	.987	-1.01	.70
		Disagree	-.416	.263	.513	-1.14	.31
		Strongly Disagree	-.481	.266	.372	-1.21	.25
	Agree	Strongly Agree	-.342	.283	.748	-1.12	.44
		Neutral	-.497	.238	.228	-1.15	.16
		Disagree	-.758*	.174	.000	-1.24	-.28
		Strongly Disagree	-.823*	.178	.000	-1.31	-.33
Q44 I can make positive impact eng'g phys. sci.	Neutral	Strongly Agree	.156	.309	.987	-.70	1.01
		Agree	.497	.238	.228	-.16	1.15
		Disagree	-.261	.213	.739	-.85	.33
		Strongly Disagree	-.325	.216	.562	-.92	.27
	Disagree	Strongly Agree	.416	.263	.513	-.31	1.14
		Agree	.758*	.174	.000	.28	1.24
		Neutral	.261	.213	.739	-.33	.85
		Strongly Disagree	-.065	.144	.992	-.46	.33
	Strongly Disagree	Strongly Agree	.481	.266	.372	-.25	1.21
		Agree	.823*	.178	.000	.33	1.31
		Neutral	.325	.216	.562	-.27	.92
		Disagree	.065	.144	.992	-.33	.46

*. The mean difference is significant at the 0.05 level.

Table B6

ANOVA testing of the impact of a strong support structure of family, friends and mentors

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Q32 Friends and family support	(J) Q32 Friends and family support	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Q28 I have the confidence to succeed in general	Disagree	Neutral	.238	.261	.797	-.44	.91
		Agree	.315	.230	.520	-.28	.91
		Strongly Agree	.008	.226	1.000	-.58	.59
	Neutral	Disagree	-.238	.261	.797	-.91	.44
		Agree	.077	.160	.964	-.34	.49
		Strongly Agree	-.230	.154	.443	-.63	.17
	Agree	Disagree	-.315	.230	.520	-.91	.28
		Neutral	-.077	.160	.964	-.49	.34
		Strongly Agree	-.307*	.093	.006	-.55	-.07
	Strongly Agree	Disagree	-.008	.226	1.000	-.59	.58
		Neutral	.230	.154	.443	-.17	.63
		Agree	.307*	.093	.006	.07	.55
Q29 Confidence to succeed in STEM	Disagree	Neutral	.833	.346	.080	-.07	1.73
		Agree	.685	.305	.116	-.11	1.48
		Strongly Agree	.426	.299	.486	-.35	1.20
	Neutral	Disagree	-.833	.346	.080	-1.73	.07
		Agree	-.148	.213	.898	-.70	.40
		Strongly Agree	-.407	.204	.195	-.94	.12
	Agree	Disagree	-.685	.305	.116	-1.48	.11
		Neutral	.148	.213	.898	-.40	.70
		Strongly Agree	-.259	.123	.157	-.58	.06
	Strongly Agree	Disagree	-.426	.299	.486	-1.20	.35
		Neutral	.407	.204	.195	-.12	.94
		Agree	.259	.123	.157	-.06	.58
Q43 Confident to succeed in STEM career	Disagree	Neutral	.192	.325	.934	-.65	1.04
		Agree	.349	.283	.608	-.39	1.09
		Strongly Agree	-.085	.278	.990	-.81	.64
	Neutral	Disagree	-.192	.325	.934	-1.04	.65
		Agree	.157	.204	.868	-.37	.69
		Strongly Agree	-.278	.196	.493	-.79	.23
	Agree	Disagree	-.349	.283	.608	-1.09	.39
		Neutral	-.157	.204	.868	-.69	.37
		Strongly Agree	-.434*	.116	.001	-.74	-.13

	Strongly Agree	Disagree	.085	.278	.990	-.64	.81
		Neutral	.278	.196	.493	-.23	.79
		Agree	.434*	.116	.001	.13	.74
Q44 I can make positive impact eng'g phys. sci.	Disagree	Neutral	.423	.378	.679	-.56	1.41
		Agree	.346	.331	.722	-.51	1.21
		Strongly Agree	-.037	.324	.999	-.88	.81
	Neutral	Disagree	-.423	.378	.679	-1.41	.56
		Agree	-.077	.238	.988	-.69	.54
		Strongly Agree	-.460	.229	.190	-1.05	.14
	Agree	Disagree	-.346	.331	.722	-1.21	.51
		Neutral	.077	.238	.988	-.54	.69
		Strongly Agree	-.383*	.136	.028	-.74	-.03
	Strongly Agree	Disagree	.037	.324	.999	-.81	.88
		Neutral	.460	.229	.190	-.14	1.05
		Agree	.383*	.136	.028	.03	.74
Q51 I will fit in	Disagree	Neutral	-.462	.375	.609	-1.44	.51
		Agree	-.660	.327	.186	-1.51	.19
		Strongly Agree	-.927*	.321	.023	-1.76	-.09
	Neutral	Disagree	.462	.375	.609	-.51	1.44
		Agree	-.199	.235	.833	-.81	.41
		Strongly Agree	-.465	.227	.174	-1.05	.12
	Agree	Disagree	.660	.327	.186	-.19	1.51
		Neutral	.199	.235	.833	-.41	.81
		Strongly Agree	-.266	.134	.197	-.61	.08
	Strongly Agree	Disagree	.927*	.321	.023	.09	1.76
		Neutral	.465	.227	.174	-.12	1.05
		Agree	.266	.134	.197	-.08	.61

*. The mean difference is significant at the 0.05 level.

AUTHOR'S BIOGRAPHY

Ronald Brandt teaches physical science at the high school level, emphasizing Project Based Learning and inquiry based lab activities. Brandt seeks to inspire his students, especially young women, to develop a passion for STEM studies and consider a career in science and technology. Prior to entering the education profession, Ronald Brandt was an executive in the chemical industry serving as senior vice president at two multinational firms as well as President & CEO of an emerging biotech pharmaceutical services company. Ronald Brandt also served as President of the Drug, Chemical and Allied Technologies Association (DCAT).

Ronald Brandt earned a Bachelors of Engineering (Chemical Engineering) from The Cooper Union, a Masters of Business Administration from Rutgers University and a Masters of Arts (Ed.) from Seton Hall University. Brandt is a member of the Beta Gamma Sigma and Kappa Delta Pi honor societies. The American Chemical Society selected Ronald Brandt as a Hach Scientific Foundation Scholar for his work as a high school chemistry teacher.