WOMEN'S DECISION TO MAJOR IN STEM FIELDS

by

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Abstract

This paper explores the lived experiences of high school female students who choose to enter into STEM fields, and describes the influencing factors which steered these women towards majors in computer science, engineering and biology. Utilizing phenomenological methodology, this study seeks to understand the essence of women's decisions to enter into STEM fields and further describe how the decision-making process varies for women in high female enrollment fields, like biology, as compared with low enrollment fields like, computer science and engineering. Using Bloom's 3-Stage Theory, this study analyzes how relationships, experiences and barriers influenced women towards, and possibly away, from STEM fields.

An analysis of women's experiences highlight that support of family, sustained experience in a STEM program during high school as well as the presence of an influential teacher were all salient factors in steering women towards STEM fields. Participants explained that influential teacher worked individually with them, modified and extended assignments and also steered participants towards coursework and experiences. This study also identifies factors, like guidance counselors as well as personal challenges, which inhibited participant's path to STEM fields. Further, through analyzing all six participants' experiences, it is clear that a linear model, like Bloom's 3-Stage Model, with limited ability to include potential barriers inhibited the ability to capture the essence of each participant's decision-making process. Therefore, a revised model with no linear progression which allows for emerging factors, like personal challenges, has been proposed; this model focuses on how interest in STEM fields begins to develop and is honed and then mastered.

This study also sought to identify key differences in the paths of female students pursuing different majors. The findings of this study suggest that the path to computer science and engineering is limited. Computer science majors faced few, if any, challenges, hoped to use computers as a tool to innovate and also participated in the same computer science program. For female engineering students, the essence of their experience focused on interaction at a young age with an expert in an engineering-related field as well as a strong desire to help solve world problems using engineering. These participants were able to articulate clearly future careers. In contrast, biology majors, faced more challenges and were undecided about their future career goals. These results suggest that a longitudinal study focused on women pursuing engineering and computer science fields is warranted; this will hopefully allow these findings to be substantiated and also for refinement of the revised theoretical model.

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Chapter 1

In an Executive Report (2010) presented to President Barack Obama, titled "Prepared and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future," experts in STEM fields, policy, and education linked the future success of America as a worldwide leader, to the advancements made within STEM education. "STEM education will determine whether the United States will remain a leader among nations and whether we will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security" (p. v). STEM education influences almost every sector of public and private life. As a result, individuals with knowledge and educational backgrounds in STEM fields will be eligible for the most needed, challenging, and successful jobs in America. STEM fields, in this present report, refer to physical, biological, and agricultural sciences as well as computer science, engineering, engineering technologies and mathematics (Hill, Corbett, & St Rose, 2010). Currently, men inhabit a wide majority of these STEM-related jobs in America, mainly because a majority of women do not pursue educational majors in these STEM fields.

Recent research in this field provides a host of information about why women leave STEM fields; however, there is a need for more research investigating how and why few women choose to enter into STEM fields, particularly in engineering and computer science. Data from a National Science Foundation report (2013) titled, “Women, Minorities, and Persons with Disabilities in Science and Engineering,” delineates the low enrollment of women in STEM fields. Although women represent a majority of students participating in and receiving undergraduate degrees, women do not equally represent (or outnumber) the enrollment of male students in all STEM fields but biological sciences. The percentage of bachelor degree completion rates in 2010 for women in STEM fields were the following: computer science (18.2%), engineering (18.4%), physical sciences (40.8%), mathematics (47.8%) and biological sciences (55.8%). These statistics show that disparities exist between male and female students' enrollment in STEM fields, like computer science, engineering, physical science and mathematics; the rates of completion in computer science and engineering fields are particularly striking. Furthermore, when we consider completion rates for women in STEM fields ten years prior, in 2000, it is clear that little progress and perhaps even regression has been made in female students' completion of STEM degrees.

The National Science Foundation report (2013) shows that in fields like biological science and mathematics, women have made positive progress in completing degrees over from 2000 to 2010, 2% and 4.7%, respectively. However, in physical science degrees, the completion of degrees by female students has not increased, and in engineering and computer science there seem to be *fewer* women completing degrees in the past ten years, -2.1% and -9.8%, respectively. The decreased representation of women in engineering and computer science is especially troubling as jobs in these fields have *grown* between 2000 and 2010 and will continue to grow. In fact, the United States Department of Education predicts that from 2010 to 2020 there will be 14% job growth in STEM fields, and an even higher growth in areas like computer systems analysts (22%) and software developers (36%) (Department of Education, 2014).

Another area of concern in the recruitment and retention of women in STEM fields is the low rate of enrollment, in these fields, for African American and Hispanic women.

These minority women have earned bachelor's degrees in STEM fields at a rate of almost half of what White and Asian women have earned. In 2010, the NSF (2013) report highlights that minority women earned 10.6% of bachelor degrees in STEM fields, and only 3.9% of doctoral degrees (NSF, 2013). Recently, scholars like Riegle-Crumb et al. (2011) have linked interest and academic achievement with minority women's enrollment in STEM fields (Espinosa, 2011; Riegle-Crumb et al., 2011). However, few research studies have delved into the reasons for the disparity among these female sub-groups.

The Decision-Making Process for Women to Study STEM

A majority of the research on women in STEM fields focuses on two major areas: factors that are linked to female students' successes in STEM fields and potential barriers that impede female students' progress in STEM fields. However the decision-making process is also a crucial factor when considering the involvement of women in STEM. In a longitudinal analysis, Espinosa (2011) found that one factor—academic achievement—is directly linked to female students' decisions to enter STEM fields. Espinosa's (2011) analysis provides critical information to the field of women in STEM, but fails to consider *how* academic achievement steers women towards STEM majors. Similar studies from Riegle-Crumb et. al (2011) as well as Rask (2010) focus on quantitative methodology, which fail to consider the intricate and complex nature of choosing one's academic path. Meanwhile, other authors focus on barriers for women to enter STEM fields, and offer possible solutions to breaking these down. A recent report by Hill, Corbett and Rose (2010), which reviewed a host of research on stereotype threat, suggests that women may fail to pursue and also persist in STEM fields because of perceived negative beliefs about women's roles in STEM fields and also their ability to succeed in these fields. These authors discuss specific suggestions as to alleviate stereotype threat, and focus on the role of instructor as critical. Whereas, other research studies consider female students' experiences once enrolled in STEM fields. Although results of these studies provide critical knowledge about which statistical factors correlate with female students' decision to study STEM fields, few studies seek to understand the essence of each individual's experience in the complex process to decide to major in a STEM field.

Once the experiences of women in specific majors are understood, parallels and differences between majors can be extrapolated. The data which shows women's low enrollment and completion of STEM fields, particularly engineering and computer science justify a study, which provides an in-depth look at women's experiences in differing fields, e.g. engineering versus biological sciences. This may provide more evidence about how and why women choose certain STEM fields as compared with others. Further, for women who do choose less popular STEM fields, like engineering and computer science, common themes may emerge among these women's experiences. This may lead to a stronger understanding of strategies, which effectively led them into their current majors, and could also be used as a model to increase future enrollment of women in these fields. Besides understanding the experiences of women in STEM fields, this study also seeks to understand how best to analyze the development of women's talent in STEM fields. One method, which has been utilized by scholars is Bloom's 3 Stage model; a discussion of this model, and how this present study can be utilized to extend this theoretical frame is provided next.

Extending Bloom's 3 Stage Model

Bloom's Talent Development study (1985) sought to understand how talent developed in exceptional individuals in fields like ballet, sculpture, tennis and, relevant to this study, mathematics and neuroscience. Utilizing qualitative methodologies, Bloom and his team interviewed 120 exceptional individuals (along with their family members, coaches and mentors) to understand each individual's path towards excellence in their field. Key results from this study suggest that individuals develop or grow talent through the interaction and support of family and mentors during three unique phases of education: early stage, middle stage and late stage. These three phases span a time period of approximately fifteen years, and although each individuals' experiences varied, common themes emerged amongst all individuals in the study, and more specifically for mathematicians and neuroscientists.

The early stage, typically in elementary school, is highlighted by the fostering of an individual's curiosity in mathematics and also science; typically, this interest is nurtured by a family member or teacher who engages the individual in hands-on learning. During the middle stage, individuals report that a specialized teacher, often a math or science teacher in middle school, or a unique experience in mathematics or science, spurred on their interest in these fields. Lastly, during the later stage, as high school students, individuals in Bloom's study (1985) begin to master their field and seek out the help of a master teacher who can support and push them in learning more complex topics. These three stages form a theoretical framework called Bloom's 3 Stage Model, which recent researchers have utilized as a lens to analyze students' experiences in developing talent in many fields, especially STEM fields (Subotnik et al., 2010; van Rossum, 2001).

Despite the strengths of this framework, one major issue exists with this methodology of Bloom's (1985) study: the absence of female voice as mathematicians and neuroscientists. Bloom (1985) states that, "there is one female in the group of accomplished mathematicians. In order to avoid making her conspicuous, all references to the mathematicians will be masculine" (p. 271); there were no females in the neurologist group. Hence, within Bloom's 3 Stage Model, the perspective of female mathematicians as well as neuroscientists is actively disregarded. This brings into question how, and if, scholars, like Subotnik et al. (2010), can utilize Bloom's 3 Stage Model to understand female STEM students' experiences. This present study seeks to address the female perspective of talent development as described through Bloom's 3 Stage Model.

Research Questions

The current study focuses on the factors which influence women's decision-making process to study (and persist) in STEM fields. The research design of this study utilized a phenomenological approach to analyze the decision-making process of high school female students, within months of graduation, who recently decided to study STEM in college. The participants of this study, six individuals in total, are female high school students who expressed an interest in studying STEM fields at a 4-year school, and who attended public high schools; these include low and high SES SES (socio-economic status) schools as well as urban and suburban. The data collected for this study included one in-person participant interview, a writing prompt, and completion of a timeline. Analysis of this data relies on the theoretical frame, Bloom's 3-Stage Model, as well as Moustakas' (1994) structured method with modifications from Creswell (2007).

This study is guided by two major research questions as well as sub-questions, which frame the methodology and analysis of study. The first question seeks to understand how mentors play a role in women's decision to enroll in STEM using Bloom's 3-Stage model as a framework. Further, the second major question asks how the decision-making experience to study a STEM field varies for women of different majors.

1) How do experiences and relationships influence female students' decision to major in a STEM field?

a. How do experiences in elementary, middle and high school play a role in female students' decision to study a STEM field?

b. How do relationships in elementary, middle and high school affect female students' interest in STEM fields?

c. Are there barriers during elementary, middle and high school which women overcome to decide to major in a STEM field? If so, what are these barriers and how do women overcome these?

2) How do the decision-making experiences of female students majoring in STEM fields differ (i.e. computer science versus mathematics or engineering versus chemistry)?

Finally, to understand these research questions, the following key definitions have been provided below.

> Mentor: an individual who "provides an advocate as well as useful information about how to operate in particular environment; and mentoring can offer social and emotional support" (Cohoon & Aspray, 2008).

Experience: opportunities, both in school and out of school, which provide students with a chance to learn about STEM fields; this may include curriculum, extra-curricular opportunities, summer or after-school programs as well as in-school programs or courses.

Barrier: a factor or individual which limits or decreases student interest or access to or into STEM fields.

Chapter 2: Literature Review

Introduction

This chapter will review scholarly research relating to female students in STEM fields. More specifically, it analyzes research that unravels the complex decision-making process of women who choose to study a STEM field. A central theme of this review focuses on the experiences and influences of young women, which research has shown can improve the enrollment and retention rates of female students in STEM fields. This review will also highlight the high school years, which are of critical importance to the development and decision-making process of female students (Maltese & Tai, 2011). Overall, this chapter is divided into five distinct sections: Factors that steer women away from STEM fields; Academic factors that steer women towards STEM fields; Influential factors for women: Pedagogy, Curriculum and Experiences. These sections are followed by a description of the theoretical framework, Bloom's 3-Stage Study.

The first section of this review will define major impediments that steer women away from STEM. Almost half a century ago, scholars surmised that lower achievement scores for women, and biological differences between the sexes, were the root cause of low female enrollment in STEM fields. Literature presented in the first section of this chapter will show that both of these assumptions are inaccurate. However, factors like stereotypes, threats, and perceptions about the connection between masculinity and science, have been associated with steering women away from STEM majors. A research-based analysis at the end of this chapter will explain how these barriers can be overcome by the inclusion of positive influences in young women's lives. These positive influences will be identified in the second and third section of this review as well.

Numerous factors can guide women towards STEM degrees. The second section of this chapter will analyze factors such as academic achievement; mathematics achievement and coursework; and interest in STEM subjects. Macro-level factors, like curriculum, pedagogy and extracurricular experiences will then be analyzed as tools to engage more women in STEM fields. The third section of this paper will focus on the importance of mentors—trusted and experienced advisors—in female students' decisions to study STEM fields.

The term "mentor" can be defined in a variety of ways but this study will utilize a definition proposed by Cohoon and Aspray (2008), who both focus their research on women in computing. They define mentoring as, "an active process of sponsorship by experienced members towards less experienced entrants or trainees" (p. 160). This definition highlights a two-person relationship where one person has more knowledge of a field and is actively helping or sponsoring a less knowledgeable individual. Cohoon and Aspray (2008) further delineate that a mentor, "provides an advocate as well as useful information about how to operate in particular environment; and mentoring can offer social and emotional support" (p.

160). This definition of mentor coincides with descriptions by scholars (i.e. Herzig, 2004), who recognize the importance that mentors can play in integrating women into male-dominated fields. Further, Bloom's stages fail to provide a definition of mentors but rather, refers to these individuals as teachers, faculty or parents; this study purposefully seeks to utilize a broader term for the word mentor in order to capture all relationships that have affected female students' decision to major in a STEM field. Further, this study also recognizes that a mentor is an advocate, as described by Cohoon and Aspray (2008), and encourages female students towards STEM fields; throughout this study, individuals who do not support female students' decision to study a STEM field will be highlighted but will not be referred to as mentors.

The relationships that will be analyzed using quantitative and qualitative research include (a) female student and K-12 teachers; (b) female student and university or college professors; (c) female student and family member. This analysis will highlight the critical role of mentors in encouraging women to first choose a STEM major, and then persist through this major once in college. Research will also highlight how barriers, like a hostile learning environment for women, may impede on female students' abilities to complete a STEM major (Herzig, 2004). The third section will also show that the decision to major in a STEM field is a lengthy process, which is influenced by a host of mentors, a notion that is strongly supported by the theoretical framework for this study.

The last section of this study will describe the theoretical framework for this study, Bloom's 3-Stage Model, which provides a lens to view three distinct stages of development of talent. An examination of the study leading to Bloom's (1985) theoretical frame will be presented, as well as a thorough analysis of each of the three stages of development: early years; middle years; and the later years. The limitation of this theoretical frame, more specifically, the absence of gender as a key social structure in the study, will be discussed. Finally, a review of relevant research, which utilizes Bloom's 3-Stage Theory will be provided. Overall, in this literature review, the best-known literature and research about women's decisions to study STEM fields will be presented. This will provide a background to answer the question for this study: *How do experiences and relationships influence female students' decisions to study a STEM field?*

Factors that Steer Women Away from STEM Fields

Research suggests that women and men have few biological and academic achievement differences but factors like stereotype threat and gender biases may play a role in steering women away from women's STEM fields. Female students have lower rates of initial enrollment in STEM fields than their males peers, and those women who do enroll are at a higher risk of dropping out of a STEM major than males (Chen & Thomas, 2009). Kokkelenberg and Sinha (2011) analyzed the records of 44,000 students from 1997 to 2007 at Binghamton University in New York. They used a fixed effects model to determine the factors that influence students' decisions to major and persist in STEM fields. Initial data gathered for this study suggests that women, particularly in fields like engineering, are under represented and are more likely to dropout than their male peers. Female engineers comprise 13% of the department at Binghamton University, despite the fact that women make-up 54% of total the school enrollment. Meanwhile, women are equally represented in other STEM fields in comparison to their male peers.

In the past fifty years, research has sought to answer why there are so few women in STEM fields, particularly in fields like engineering and computer science. Scantlebury and Baker (2007) sought to answer this question with a meta-analysis of research from the 1960s to the late 2000s. Prior to the 21st century, scholars explored if academic achievement and biological differences were the reason for the disparity between men and women in STEM enrollment. Forty years ago, male students outperformed female students in math and science achievement tests (Scantlebury & Baker, 2007). During this time, scholars argued that innate biological differences between the sexes were the reason for higher achievement scores by male students. By the 1990s, scholars like Kahle and Meece (1994) acknowledged that women had a lack of spatial ability in comparison to men. However, this analysis concluded that, rather than spatial ability (which will be further explained later in this section), experiences like course enrollment and extracurricular activities were the reason for achievement score disparity. The most recent research analyzing both achievement and biological differences between the sexes in STEM fields suggests that women have caught up to men in terms of academics.

Recent data analyzing achievement between men and women shows women have made significant improvements. Though the TIMSS (1999) study found that internationally, female students still score lower than their male peers in science, women have made significant gains in mathematics. The improvements are more impressive when looking at specific regions. For example, in the United Kingdom, girls outperform their male peers in both math and science (Scantlebury & Baker, 2007). Other recent data from the National Center for Education Statistics (2007) shows that American female students are earning more credits in math and science in high school, and are outperforming their male peers in these courses. Overall, most research suggests that academic achievement for male and female students is equitable (Hill, Corbett & St Rose, 2010). Researchers have also concluded that overall, men and women have similar cognitive abilities. However, there is one area where men still drastically outperform women: Spatial skills.

Spatial ability—a skill set that allows an individual to mentally manipulate objects—is considered a critical skill for the science and engineering fields. There was once a notion that spatial skills were a given natural set of abilities, which individuals were born with (i.e. skills that could not be improved). This idea added to the concept that men were naturally better equipped than women to pursue STEM fields. However, research suggests that significant gains in spatial ability can be made with minimal training. "Individuals' spatial skills consistently improve dramatically in a short time with a simple training course. If girls grow up in an environment that enhances their success in science and math with spatial skills training, they are more likely to develop their skills as well as their confidence and consider a future in a STEM field" (Hill, Corbett & St Rose, 2010, p. xv).

Similarly, a meta-analysis completed by Ceci et al. (2009) recognized that although male and female biology are dissimilar, the hormonal and brain differences between the sexes could not be linked to the underrepresentation of women in STEM fields. Hence, many scholars now believe that achievement and biological factors are not a reason for the low-enrollment of women in STEM, but that social issues relating to gender may play a more critical role.

Research from the past thirty years supports the theory that gender as a social structure is crucial to understanding the low enrollment of women in STEM. In 1978, Kelly (1978) compared three hypotheses in a quantitative analysis of international data, which sought to compare how culture, school, and attitude affected male and female student achievement. The results showed that societal and cultural expectations contributed to the difference between male and female achievement scores. They also found that school experiences could limit this difference (Scantlebury & Baker, 2007). More recently, in LeBeau et al.'s (2012) study, the authors looked at 3,500 students and compared their rates of completing a STEM major in college to their GPA, years of math completed, ACT scores, percentile rank, gender, and race. Using a linear mixed model, the authors found that three student factors were significant predictors of students' completing a STEM major: ACT mathematics scores, high-school mathematics GPA, and gender. The results of the study show that male students are six and a half times more likely to complete a degree in math or engineering than female students. This study shows that student mathematical ability and gender are the two key factors in predicting success in math and engineering fields in college. Hence, this study indicates that academic achievement and gender must play significant roles in female students' decisions to study a STEM field. Further research completed by Riegle-Crumb et al. (2012), which will be described further, supports the notion that prior academic achievement does not account for female students' low enrollment in STEM fields and suggests that the role of gender is extremely strong in women's decision-making processes.

In the Riegle-Crumb et al. (2012) study, the authors utilized a set of three longitudinal studies (National Center for Educational Statistics the High School and Beyond: Sophomore

Cohort, the NELS: 88, and the Educational Longitudinal Study of 2002) to understand how and if prior achievement accounts for the difference between male and female students' enrollment in STEM majors. A series of multivariate models were created with variables like students' GPA, major, gender, race/ethnicity, students' parental level of graduation, family income, and if students enrolled in college in the fall subsequent to high school graduation. The results of this study dispel the myth that women are underrepresented in STEM fields as a result of deficits in prior achievement. This research highlights that academic preparedness may not be a limiting factor for women in pursuing STEM fields, but rather, gender, as a social structure, plays a critical role in the decision to major in STEM and to persist in these fields. Riegle-Crumb et al. (2012) argue that it's critical for girls to know that an achievement gap does not exist between male and female students in science and math. By promoting this, the authors believe that gender stereotypes can be broken down. They are not the only scholars who support this concept (Hill, Corbett & St Rose, 2010).

In an important report from the American Association of University Women, *Why So Few? Women in Science, Technology, Engineering, and Mathematics* (Hill, Corbett & St Rose, 2010), scholars report that negative stereotypes about women in mathematics and science are still prevalent, and can negatively impact female students' decisions to study STEM fields. In this report, Hill, Corbett and St Rose (2010), explain that two major stereotypes exist. One is a general belief that girls are not as good in math as boys, and secondly, that science is better suited to boys than girls (p. 38). When women are exposed to these negative beliefs, their performance on academic measures and also aspirations to study STEM fields are affected. This phenomenon is referred to as stereotype threat. As a result of stereotype threat, female students may perform poorly on tests or may limit themselves from considering a career in a STEM field. "Stereotype threat may also help explain why fewer girls than boys express interest in and aspirations for careers in mathematically demanding fields. Girls may attempt to reduce the likelihood that they will be judged through the lens of negative stereotypes by saying they are not interested and by avoiding these fields" (Hill, Corbett & St Rose, 2010, p. 38). Research suggests that even the most academically strong females can be affected by stereotype threat, and may therefore be steered away from STEM fields. Scientific evidence has proven this theory as well.

In a relevant study on stereotype threat, Good et al. (2010) used a two way ANOVA analysis to compare gender differences between graduate record exam (GRE) mathematics scores while pairing each students' GRE math scores to their current calculus grades. The researchers utilized an experimental study model in which one group of students received instructions stating that male and female students both scored equally on this assessment. The other group did not receive these directions. The results of the study showed that female students with directions that included information about gender equity outscored their male peers on the assessment. The female students who were not exposed, scored lower than their male peers. These findings were significant because the participants in this study represented the brightest high school scholars, and those students who would most likely pursue a STEM degree. Good et al. (2010) link stereotype threat as not only a barrier to female students pursuing a STEM field, but also as a reason for females leaving a STEM field. Good et al. (2010) explain that, "stereotypes can cause individuals enough discomfort to lead them to drop out of the domain and redefine their professional identities. When the domain is something as fundamental as mathematics, domain avoidance essentially shuts the door to potentially lucrative careers in science, engineering, and technology" (p. 27). Despite the serious consequences of stereotype threat, research from a plethora of scholars suggests that there are concrete ways to curb this phenomenon.

Along with Good et al.'s (2010) suggestion of active discussions with women about stereotype threat and the assurance that tests are not gender biased, Steele, Spencer and Aronson (2002) explain that the influence of a role model is another strategy to combat stereotype threat. Aronson, in an interview for the Hill, Corbett and St Rose (2010) reports that women's test scores can be increased by "exposing students to role models who can help students see their struggles as a normal part of the learning process rather than as a signal of low ability" (p. 41). This implies that role models can help to break down barriers for female students in order to pursue STEM fields and to spark female students' interests in these fields. The importance of the role model influence in order to get past stereotype threat and to promote female interest in STEM is tremendously important and will be addressed in future sections of this chapter. However, the issue of female interest in STEM is a large and important problem that needs to first be addressed independently.

Often in the debate about the low enrollment of women in STEM, individuals hypothesize that women may simply not be interested in STEM fields such as computer science and engineering. In a recent poll, high school students between the ages of 13 and 17 reported on their belief that computer science would be a good college major. Male students responded affirmatively at a rate of 74% while only 32% of female students responded positively (WGBH Education Foundation & Association for Computing Machinery, 2009).

In their analysis of recent research, Hill, Corbett and St Rose (2010) suggest that women do, overall, have a lower rate of interest than men in STEM fields, particularly in engineering and computer science. The reasons for this disparity are complex and highly debated.

Some researchers believe more women do not have an interest in STEM fields because they are drawn to academic fields that aim to work with and help people. Education researcher Camilla Benbow further explains this theory by stating, “what we are measuring here is related to one of the biggest differences between genders, namely that of ‘people versus things’ … Females tend to be interested in the former and males in the latter” (as cited in Wyer et al., 2008, p. 82). Benbow's rationale suggests fields like biology and chemistry, where women have high enrollments, are more closely linked with people, whereas the engineering and computer science fields may be more representative of "things" and often do not seem to directly benefit society (National Academy of Engineering, 2008). In a 2008 report titled, "Changing the Conversation: Messages for Improving Public Understanding of Engineering," the authors suggest that in order to increase women and minority students' interests in engineering, a new view of engineering needs to be presented. This new perspective will highlight the engineers who are shaping society, contributing solutions to real-world challenges, and helping to improve the health, happiness and safety of all. This 2008 report argues that this new framing of engineering may increase female enrollment in STEM fields. However, there are other ways to influence female interest as well.

Research suggests that female student interest can be changed with interventions and exposure to opportunities in STEM fields. A 2009 study by Plant et al. demonstrates that attitudes and performance of female students can potentially be changed during critical middle school years. In this experimental study, 166 male and female middle school students participated in a regularly scheduled computer session and interacted with either a male or female computer agent, or no agent at all. Students then answered questions about their attitudes, stereotypes, and self-efficacy relating to engineering. The ANOVA analysis for this study showed that performance and career interest in engineering increased particularly for female students who were exposed to the female computer agent. The results of the study specifically link a rise in self-efficacy with an increase in female students' interests in engineering. Despite these findings, results of the study also showed that the computer agents did not have any impact on changing female students' beliefs about engineering as a male-dominated field. The authors hypothesized that the reason for this may be because "the messages that young girls receive over time, indicating the lower expectations people hold for their abilities in these fields are so salient for them that a single persuasive communication is not enough to counteract previous messages" (Plant et al., 2009, p. 214). Plant et al. (2009)'s research suggests that there are a multitude of factors that can influence female perceptions about STEM as a male dominated field, and that more encouragement needs to be given to girls about the ability of women to study and work in these fields.

While this section defined some of the barriers that contribute to the lack of female representation in STEM fields, this research also provides strong and reasonable strategies to break down these barriers. In STEM fields like engineering and computer science, there is a belief that male students are academically and biologically superior to women. Research now shows that women and men score similarly on achievement tests, while biologically, in regards to a decreased level of spatial skills in women, these skills can be improved with practice. The issue of stereotype threat, which has been shown to affect even the highest-performing women academics, can be limited by simple, informative conversations, and by the inclusion of a role model. Lastly, reports highlight that female students lack an overall interest in STEM fields, especially in fields that do not appear to directly help people. Research suggests that, as early as middle school, a computer-generated agent can influence girls' self-efficacy and interest in engineering. These barriers provide an understanding of why young women may not choose to enroll in STEM fields. The next section of this literature review will explore the factors that do encourage women to pursue STEM.

Academic Factors That Steer Women Towards STEM Fields

Recent studies define high school as a critical time in which students' decide to pursue STEM fields (Maltese and Tai, 2011); this research suggests that to encourage more women towards STEM fields, high school factors, like courses, curriculum, extracurricular experiences and mentors, are critical. This section will discuss how high school experiences influence female students' decisions to pursue a STEM field in college, and also how these experiences affect their ability to remain in these majors. More specifically, this section will analyze factors such as academic preparation, like student GPA and AP course enrollment; high school environment; coursework in mathematics; preferences or affection for math and STEM fields; and lastly, pre-college major preference.

Pre-college academic success is a key factor that scholars believe affects whether or not young women decide to study STEM in college. In a comparative study, Espinosa (2011) utilized hierarchical generalized linear modeling (HGLM) to analyze how pre-college characteristics and college experiences of female STEM majors influenced them to pursue and study a STEM major. The data taken from a longitudinal survey from the Higher Education Research Institute (HERI) provided information from almost 2,000 women—1,000 white women and 1,000 women of color—who were enrolled in college as STEM majors. Espinosa (2011) created four major categories for over 40 variables including pre-college factors like academic preparation, school environment and students' beliefs in their ability to achieve grades of B or higher. The results of the study explain that for both groups of women, academic achievement in high school is directly correlated to college academic success. Academic achievement was also the only pre-college variable that remained statistically significant for both groups of women when all measures were included in the model. This result is significant because other pre-college factors, like school environment (e.g. public, private, charter or college prep), had no influence on minority and white women's persistence in STEM fields. This study also found that female students' beliefs in their academic abilities were not a predictive factor of whether they went on to study STEM in college either. The results of Espinosa's (2011) study strongly suggest that academic achievements are the critical factor in determining future success in STEM fields for female students, but it is important to delve deeper into this conclusion in order to clearly define exactly what these achievements are.

Additional research seeks to understand the specific academic factors in high school that are linked to female students' decisions to enroll and remain in STEM fields in college. For example, Griffith (2010) utilized longitudinal data from the National Longitudinal Survey of Freshmen (NLSF), NELS: 88, and Integrated Post Secondary Education Data

System (IPEDS) to investigate college students who were enrolled in STEM courses, in order to determine the factors that influenced them to study STEM. One part of Griffith's analysis reviewed the secondary school factors that were associated with successful completion of STEM majors. Key findings showed that students with exceptional high school GPAs, and those who had also taken a large percentage of AP courses in STEM fields, were more likely to major in a STEM field in college. Griffith's study narrows these results to suggest that high school females with a higher GPA and more AP courses are not only more likely to major in STEM, but are also more likely to persist in STEM majors. "Taking more AP classes in STEM fields, holding total number of APs taken constant, has a positive impact on persistence rates for women ... This indicates the importance of prior preparation in STEM fields for probability of persisting in the major" (p. 917). Griffiths' (2010) results highlight the critical role that secondary school academic achievement plays in influencing female students' decisions to study STEM. Other scholars look for even more refined evidence about academic achievement, such as You (2013), who focused on female students' mathematical coursework and achievements as a tool to predict future STEM enrollment.

You's (2013) study sought to understand how student enrollment in advanced math courses varied by race and gender, and how this possible difference could be related to the underrepresentation of minorities and women in STEM fields. You (2013) utilized two-level multinomial logistic models to compare independent variables, like student characteristics (e.g. SES, mathematical attitudes and performance, parent educational expectations), and school factors (e.g. percent minority, school socio-economic states (SES), student-teacher ratio, college preparation programs) with student course-taking patterns in mathematics and their enrollment in STEM fields in college. Data for this study was taken from student surveys in the Education Longitudinal Study (ELS) of 2002. You's (2013) results show that for all students, prior academic achievement in mathematics courses were a powerful predictor for taking advanced mathematics courses in high school. More specifically, You (2013) also found that Asian females, African American females and all white students (including white females) who participated in a college preparatory program were more likely to take advanced coursework in mathematics.

You (2013) also considered how the independent variables in this study predicted student enrollment in a STEM major in college, specifically for female students. The data for this study shows that 25.9% of females in the study enrolled in a STEM field in college. You (2013) found that mathematical competency was a major predictor of STEM enrollment. This study linked specific mathematics coursework to enrollment in STEM for female students in two key places. First, You (2013) established that female student enrollment in Algebra I in ninth grade (or prior) is associated with future enrollment in advanced mathematics coursework in high school. This study then showed that taking calculus in high school is strongly related to future enrollment in STEM fields.

You's (2013) research strongly suggests that there is a logical, cyclical pattern for female students taking mathematics courses in high school. Female students enroll in math courses, succeed in these, and move on to take more advanced mathematics coursework continuing on through Calculus. However, as the statistics presented in this literature review suggest, there may be a break in the cycle for many female students, which later causes low enrollment in STEM. More specifically, Maltese and Tai (2011) analyzed (NELS: 88) of

4,700 students from 8th grade through high school and into college in order to determine factors most influenced decision to pursue a STEM major in college. Maltese and Tai (2011) created a logical regression model with key predictor variables like, gender race attitude toward math and science at multiple ages grades in STEM courses and planned college major. This study found that once variables relating to 10th grade, including coursework and grades, were taken into account in the regression model, female students were significantly less likely to enroll in a STEM degree. This research suggests that for female students, 10th grade may be a significant academic year in continuing towards advanced mathematics courses or not. This is just one of many areas that affect the cyclical pattern of female progression in STEM courses.

Another critical piece to the cyclical pattern in mathematics courses for female students, is the feeling of affection towards the content. One result from You's (2013) study suggests that female students with a strong affection for mathematics were more likely to take advanced coursework in mathematics. Therefore, although academics are incredibly important to women's decisions to study STEM fields, scholars have started looking into other factors that may lead to interest in STEM. For example, Baker and Leary (2003) utilized a qualitative interview process of 40 female students at four grade levels (2, 5, 8 and 11), to determine the factors that influenced girls' decisions to study science. The authors analyzed data using a framework of women's affective and psychological needs. Key results from this study showed that female students, at all ages, felt confident about science. Further, for those who actively pursued science and math, a key person in their life seemed to engrain these sentiments in them. This suggests that a mentor may play a critical role in steering female students towards STEM fields.

In a similar study, Riegle-Crumb et al. (2011) consider how students' achievements and overall interests in STEM fields relate to future interest in STEM careers. They also analyze how race and gender affect this relationship. Data for this study, taken from 8th grade participants in the TIMSS 2003, used logical regression models and was analyzed using both race and gender groups (e.g. Hispanic females). When considering students' enjoyment and self-concepts in math and science, all females tended to have lower rates than their male peers. However, when the authors considered students' future interests in a STEM career, Hispanic and white females who reported the same level of science enjoyment as their white male peers also had similar career aspirations. This indicates, for at least two female sub-groups, that the enjoyment of science is critical to encouraging STEM field aspirations. Riegle-Crumb et al. (2011) generally conclude that "it appears that enjoyment of science is perhaps an important driver behind gender difference in career aspirations at younger ages, at least in the case of white and Hispanic girls" (p. 472). As the Sadler et al. (2012) study shows, the lack of female interest in STEM in comparison to their male counterparts only gets more prominent as they move on through high school.

Utilizing a randomly chosen, nationally representative sample of college students, Sadler et al. (2012)'s retrospective study examined how students' interests in pursuing a STEM related-career develops during high school years, with a focus on gender differences. Key findings from logistical regression models showed that males reported a greater interest in STEM careers than female students at the beginning of high school. Moreover, as students continued through high school, the difference between male and female students' interests in

STEM careers widened. The authors emphasized that the gender disparity is predominant when engineering careers are considered, not STEM fields linked to health or medical professions. Sadler et al. (2012) concluded,

> the amount of volatility in high school girls' career intentions suggests that there is certainly room for improving the female representation in STEM careers by measures and initiatives during the high school years that focus on reducing attrition from STEM career goals or on increasing recruitment from the ranks of the initially uninterested or on both. Engineering is an obvious candidate for these efforts (p. 424).

This research suggests that female students' career interests in STEM are evolving during high school and their decision to study, or not to study, STEM can be influenced during this time. Moreover, research also suggests that students' preferences, or intended major upon college entrance, is a salient factor in female students' abilities to persist in a STEM field. (Riegle-Crumb et al., 2011). Even for those female students who do have an interest in STEM in high school, there are large percentages that do not go on to major in STEM once in college. This brings up the last topic of this section: pre-college major preference.

In a study by Rask (2010), a series of linear regression models were utilized to understand how pre-collegiate factors, like student preference of a major upon entering college, influence enrollment and retention in STEM fields for female college students. The data for this study comes from administrative records—including enrollment numbers, grades, and student majors—for 5,000 students from 2001-2009 at a liberal arts college in the Northeast. Results from this study suggest that females are more influenced by pre-college preference of major than male students. Rask states, "women appear to follow their preferences more strongly than men. Aside from physics, in the rest of the STEM departments, the estimates for women are higher than men, in some cases much higher ... it could be that women hold stronger preferences entering college than men" (p. 897). Although Rask notes that these findings are preliminary, he does suggest that to increase enrollment in STEM at the college level, more research and funding should focus on high school preparation. Rask's (2010) results are important because it appears that all students, and women in particular, are more successful in STEM fields when they enter college with this major.

Entering college with a major in STEM is one of the strongest factors linked to the successful completion of that major. 93% of students who completed a major in engineering declared this major as incoming freshmen (Ohland et al., 2008). This finding seems particularly salient for female students. In a recent study, Maltese and Tai (2011) followed female students through high school and college. They found that female 12th graders who were planning to major in a STEM field "were more than three times as likely to earn a STEM degree as those who were planning for a different major at that time" (p. 899). In general, once students are enrolled in a non-STEM field, very few will change their major to a STEM field (Rask, 2010). As a result, few students graduate with a STEM degree that did not initially enter college with this major (Griffith, 2010). Female students tend to be even less likely to change their major from a non-STEM to a STEM field (Crisp, Nora & Taggart, 2009), which means that for female students to complete a STEM major, they should enter college with a STEM major. This makes the period of time prior to college—high school—critical for encouraging female students to study STEM. Research suggests that academics are just one piece of women's decision to major in STEM fields; fostering an interest in STEM fields, in high school, is also critical to steering women towards STEM majors.

All of this research suggests that secondary schools must focus, not just on academics, but also on engagement as a means to increase the number of female students in STEM. "An educational system that focuses on increasing achievement without some degree of attention to whether students are engaged and having positive experiences is unlikely to produce greater numbers of future scientists, especially female ones" (Riegle-Crumb et al., 2011, p. 472). It is crucial to provide a supportive learning environment in secondary schools for female students to engage and intrigue them about STEM. This research also indicates that for female students, two key factors play a role in inspiring interest in STEM: secondary school experiences (Riegle-Crumb et al., 2011; Sadler et al., 2012), and the influence of role models (Baker & Leary, 2003). The following section will explore both of these factors.

Curriculum, Pedagogy and Experiences as Influential Factors for Women

Many scholars agree that schools are the place to inspire and encourage student interest in STEM (Rockland et al., 2010; Sadler et al., 2012; Subotnik et al., 2010). As research in this area has grown, scholars are focusing on a host of issues linked with schools, such as coursework, curricula, student engagement, student experiences in STEM, and the influence of mentors. The mentor role will also be explored in future sections due to the significance of the student/mentor relationship.

Though scholars agree that student interest in STEM is fostered in middle and high school, there is a disagreement about whether or not particular curricula truly impact student interest in these fields. For example, in a quantitative analysis of 3,500 students transitioning from high school to college, LeBeau et al. (2012) found that specific math curricula were not correlated with students' decisions to enter a STEM field in college. However, research suggests that a tailored curriculum, utilizing real-world situations and challenges relevant to the lives of female students, increases female student engagement and interest in math and science (Baker & Leary, 2003; Shapiro & Sax, 2011; Subotnik et al., 2010). Therefore, although LeBeau et al.'s (2012) findings suggest that a specific curriculum may not steer women away from STEM fields, there may be aspects of *how* a curriculum is utilized that could steer female students towards a STEM major in college (Riegle-Crumb et al., 2011).

A quantitative study completed by Hazari et al. (2007), linked curriculum and pedagogical factors in high school with success in introductory physics courses with consideration of different genders' experiences. The author argues that stronger grades in introductory physics—a gateway course to most STEM fields—will build confidence and interest in females and will also encourage females to pursue more STEM courses. The data for this study was collected from 4,000 college students taking an introductory physics course. This data was analyzed using a hierarchical linear model, which included factors like content, pedagogy, and curriculum in high school physics, as well as male and female performance in their college physics course. The results clearly showed that female students reported more success in college physics when their high school physics course focused on real-world examples; fewer assessments rooted in lengthy essays; and a curriculum that introduced fewer topics and covered each topic more extensively (i.e. depth over breadth). Based on these findings, Hazari et al. (2007) argued that the curriculum and pedagogy in math and science courses should be designed with a focus on the gender of students.

Additional research also shows that female students have better success rates in single sex classrooms than in mixed gender environments (Parker and Rennie, 2002). "Perhaps, this is part of the reason that single-sex education using reformed curricula and teachers trained to develop students' self-concept has been so successful in improving female performance and persistence. These reforms concentrate on the pedagogy and affective support that work for females" (Hazari et al., 2007, p. 873). Overall, this research suggests that curriculum geared towards female students is a key tool in increasing success and interest in STEM fields for women.

A national movement that seeks to create a curriculum designed to engage all students, particularly girls in STEM fields, is the Next Generation Science Standards (NGSS). Scholars maintain that the NGSS offers a new opportunity for equal access for all students, specifically those who have been underserved (e.g. minority and female students) in science education (Miller, & Januszyk, 2014). These standards seek to integrate engineering design into science coursework at all levels of education along with crosscutting concepts (i.e. asking students to look for real-world patterns and cause-effects) (Pruitt, 2014; Miller, & Januszyk, 2014). In their review of NGSS, Miller and Januszyk (2014) describe the aspects of the NGSS that directly address diversity and equity issues. The authors, Miller and Januszyk, highlight a case study of underrepresented groups in STEM fields, specifically girls, and describe classroom strategies that ensure the NGSS are accessible to these students. The authors conclude that the NGSS "provide(s) an opportunity for teachers to reach girls more effectively because girls perceive a disconnect between school science learning and science career goals" (p. 11). Other recommendations from this study suggest that classrooms that focus on instructional strategies like inquiry, collaboration, and risk-taking will support female students' learning. Finally, the authors argue that by promoting female scientists in class, discussing science topics that girls can relate to, including design or aesthetic experiences in science learning, and developing girls' abilities and confidence in STEM fields, teachers can build girls' interests in pursuing STEM fields. These suggestions are taken from literature reviews like Baker (2013) and also, Scantlebury & Baker (2007), which analyzed the difference between male and females' science learning experiences.

Another positive experience that may lead to increased female interest and success in STEM fields are afterschool and also summer extracurricular STEM programs. In these extracurricular environments, teachers and students are not obligated to follow a structured classroom curriculum, and therefore have the freedom to explore real-world problems related to engineering. One example of an extracurricular program with technology and physical resources for female middle school students and other underrepresented students like Hispanics, is iQUEST summer student camp. The goal of the iQUEST program is to provide technology-enhanced learning opportunities to students while connecting students with individuals in STEM careers. In their article, Hayden et al. (2011) analyzed the effectiveness of the iQUEST program and found that female students made substantial gains equal to their male peers using a tool called the Information and Communication Technology Attitude, which analyzed students' self-perceptions of their information and communication technology skills. Another tool, The Test of Science Related Attitudes (TOSRA) showed that male students made more significant gains than female students. Although the results of this study are mixed, it is important to note that female students increased their self-perceptions and attitudes towards science overall after completing this program. Research shows that students in extracurricular programs have more of an opportunity to learn about career paths in STEM fields, and also to make stronger connections with mentors (Hayden et al., 2011; Kendricks, Nedunuri & Arment, 2013). The section focusing on mentoring programs, and the relationships that develop in these programs, will further explore the role of these extracurricular and mentoring opportunities for students of all ages and why they are so effective.

To further explain the importance of extracurricular programs, the 2010 Presidential Executive Report, a key recommendation for encouraging women to study STEM fields is to encourage active participation in extracurricular STEM experiences, like the one described above. This report explains that these programs expose female students to a host of STEM fields, and they provide students with opportunities to explore their own interests in these fields. Programs like these are running throughout the country during the academic school year and also during the summer, specifically for female students. One example of an after school extracurricular organization that exposes female students to STEM experiences, is Girls Inc. Operation SMART (Science, Math and Relevant Technology) is one of the after school programs offered at Girls Inc. for students ages 12-14. This program seeks to "develop girls' enthusiasm for and skills in STEM through hands-on activities." It also introduces students to women and men who have careers in the STEM field (Girls Inc., 2014). Students in this program meet throughout the school year and also have an opportunity to complete an internship in a field of interest.

Another example of an extracurricular STEM program offered to female students is Boston University's Summer Pathways program. This weeklong program provides female high school juniors and seniors with enrichment activities that stimulate their interests in STEM fields. It also exposes them to science labs and lectures from notable STEM scholars. While living on campus for a week, students experience college life and make connections with undergraduate and graduate students as well as STEM professors (LERNet Programs, 2014). These are only a few examples of the extracurricular programs many scholars believe can encourage and inspire female students to study STEM fields. Research proves that these programs can greatly improve the confidence of female students.

MacPhee, Farro and Canetto (2013) utilized a longitudinal study to analyze how the self-efficacy and academic skills of underrepresented STEM students change from college enrollment to graduation when involved in a mentoring program. In this study, participants were minority and female students (or both) who were in the McNair Program at Mountain West University. This program is one of six U.S. Department of Education TRIO Programs, which aims to support minority students in STEM majors. Collected data for this study include students' GPAs, GREs exam scores, self-reported academic and study skills, as well as graduate plans. The results of this study showed that female students entered college with lower confidence in their test taking and study skills than their male peers, even though their academic grades were similar. These findings were supported by other research on stereotype threat (Hill, Corbett & St Rose, 2010). However, by the end of their undergraduate experience, the women in this program reported the same level of confidence as their male peers. MacPhee, Farro and Canetto (2013) suggest that for female students' self-efficacy skills to improve, mentoring is one of the most promising means. "Mentoring efforts such as the McNair Program are one of many vehicles for exposing STEM women to accurate information about their capabilities and for boosting their self-efficacy and nurturing their commitment to STEM. Given the pervasive negative messages about women and STEM, interventions to support women's self-efficacy need to be multimodal and sustained" (MacPhee, Farro & Canetto, 2013, p. 365). The authors further push these findings to suggest that particularly for double minority students (i.e. women of color), mentoring programs may be an effective and necessary tool with which to encourage these students towards STEM fields.

As mentioned earlier, the presence of mentors, whether in a program setting or one-on-one, have been tremendously positive influences for women who have decided, not only to study STEM, but to go on to pursue STEM-related careers. The following section will further explore the various student-mentor relationships.

How Mentors Shape and Develop Female STEM Students

The presence of a supportive mentor in a young person's life has been linked to critical educational benchmarks. Higher graduation rates and increased college enrollment are two examples of the achievements related to students with positive mentor influences (Ferreira et al., 2007; Klem & Connell 2004; Samel et al., 2011). Along with educational achievements, these mentor relationships also impact students' interests and decisions. In relation to STEM interests, many scholars have specifically defined the secondary school years as a time when mentor relationships can significantly influence a student's decision to enter into a STEM field (Baker & Leary, 2003; Liang et al. 2002; Maltese & Tai, 2011;

Shapiro & Sax, 2011). The relationships between student and teacher; student and student; student and family member; and student and scientist have been proven to influence young women more significantly than they influence men (Sax & Shapiro, 2011). There are a number of reasons why young women are more susceptible to these mentor relationships than their male counterparts, one of which is the development of identity.

Based on research, scholars believe that female students develop their identity and self-efficacy through relational interactions (Baker & Leary, 2003; Sax & Shapiro, 2011). Therefore, the presence of supportive and positive mentors in a young woman's life is exceptionally important to her general development. When considering ways for young women to develop interests and skills in STEM, strong mentor relationships are even more necessary. "Relationships, which include caring, responsibility, and affective needs, provide the standard by which… girls make judgments concerning science" (Baker & Leary, 2003, p. 197). Baker and Leary conclude that female students with supportive mentors not only develop strong identity and self-efficacy, but they are more likely to have a stronger interest in science. The need for mentor relationships is important even after young women develop an interest in STEM due to the personal and emotional struggles females experience in this field.

In comparison to their male peers, women feel more isolated as students in STEM fields (Burke & Sunal, 2010). Women also have less confidence in their academic abilities. This trend in confidence begins in middle school and continues through high school, college, graduate school, and often follows women into the workplace (MacPhee, Farro & Canetto, 2013). Luckily, strong research shows that a student-mentor relationship can alleviate these feelings of isolation or reticence. Mentor relationships can also encourage students to pursue and persist in a STEM major (Holland, Major, & Orvis, 2012; Espinosa, 2011; Sjaastad, 2012; Wilson et al., 2012). Bloom (1985) argues that the development of brilliant, award-winning mathematicians is aided by a host of supportive mentors throughout an individual's life.

The types of mentors in a student's life can differ depending on the student's age and the personal and academic opportunities in which they have access. Mentors for female students can be their own age, male or female, family or teacher. Most student-mentor relationships that develop during the critical decision-making years (i.e. between middle school and into college), fall into these categories:

- Female Student and Teacher
- Female Student and Professor
- Female Student and Family Member
- Female Student and Mentoring Program

The last bullet—student in mentoring program—was described in the previous section. As discussed, these programs pair a student or groups of students with a host of mentors in a structured mentoring program. This remaining section will provide an overview about the other three student-mentor relationships listed above, and how they can influence a student's knowledge of and interest in STEM.

According to the President's Council of Advisors on Science and Technology (2010), "teachers are the single most important factor in the K-12 education system, and they are crucial to the strategy of preparing and inspiring students in STEM" (p. 57). Research also concludes that, specifically for female students, the relationships developed with teachers during middle and secondary schools are critical to encouraging interest in STEM fields

(Baker & Leary, 2003). According to Sjaastad, "this might be the reason why, so many teachers when given the opportunity to influence specific self-views concerning STEM-abilities, are mentioned by women compared with men" (p. 1623). Sjaastad's research (2012) surveyed over 5,000 college STEM students and found that at a rate of two-to-one, in comparison to their male peers, women reported teachers as significant influences in their decisions to study STEM. Even more so, *passionate* teachers who have a strong knowledge of their content, and who expose their students to a challenging curriculum, have a stronger impact on students' interests and overall abilities in math and science (President's Council of Advisors on Science and Technology, 2010; Sjaastad, 2012; Subotnik et al., 2010). While these findings are helpful and intriguing, it is also important to consider *how* specific teacher behavior can be used to inspire interest in STEM.

Students often see teachers as 'scientists' or 'mathematicians' because, for students, each teacher's behavior models the identity and characteristics of these professions (Sjaastad, 2012). Teachers who influence their students to study STEM are both passionate and knowledgeable about their content (President's Council of Advisors on Science and Technology, 2010), and they actively introduce their students to STEM fields and careers through the use of technology and career projects (Berkeihiser & Ray, 2013). However, policymakers and researchers are concerned because many teachers do not have training in specific STEM fields, like engineering (Baker, 2003). As a result, students are not regularly exposed to role models who are knowledgeable about STEM and capable of modeling STEM professions (Brown & Borrego, 2013; Dierking, 2010). "If teachers are given enhanced professional development through increased content knowledge, model teaching practices, and authentic experiences in one or more of the STEM disciplines, it would impact how they teach, which would then ultimately impact the learning of students" (Brown & Borrego, 2013, p. 42). Teachers, in high school, are just one example of individuals who model careers and behaviors for students in STEM fields. Once students enter college, college faculty can take on this role.

In addition to secondary teachers as mentors, female students majoring in STEM benefit greatly from a supportive relationship with a faculty member, particularly a professor (Herzig, 2004; Hong & Shull, 2011). Unfortunately, women who are interested in STEM are disadvantaged when it comes to finding a professor/role model in their field, as there are a smaller number of female professors in STEM departments. This lack of female representation creates multiple issues for female students (Blickenstaff, 2005; Shapiro & Sax, 2011). First, these women must often seek out cross-gender mentor relationships. This is a challenge most male students do not face. Further, as Blickenstaff (2005) explains, a small presence of female faculty can also create a negative message to female students, suggesting that the field, and balancing this type of work and a family, is unattractive for women. These issues can be overcome with the support of caring faculty and by connecting female students with individuals who have persevered despite such setbacks, but it is another example of a struggle young women must tackle.

When looking closer into the professor mentor role, the development of caring relationships between student and professor is a critical factor in steering women towards a STEM degree. For example, Hong and Shull (2010) completed a retrospective phenomenological study interviewing six women who successfully completed engineering degrees. One of the key findings of this study proposes that it is not each professor's pedagogical technique, but it is the interpersonal characteristics of faculty that played a more crucial role in the female engineer's success. "When students in this study spoke about relationships with their professors, they described a caring presence among faculty who were concerned about their well-being, their learning, and their future goals" (Hong & Shull, 2010, p. 276). In this study, successful female engineers articulated how faculty supported their learning through genuine care and compassion. Unfortunately, these types of relationships are difficult to find. Additional studies have suggested that women, particularly in graduate studies, often feel isolated by faculty.

In Herzig's (2004) phenomenological study, the experiences of six graduates in mathematics are recorded through a series of interviews. In the results, Herzig (2004) explains that female mathematics graduate students are lacking a culture of caring professors. As a solution, Herzig utilized Nodding's (1984) "Notion of Caring" to encourage professors to find a way to create such a culture between themselves and their students. She argues that,

> in effective mathematics teaching… teachers would do four things. They would model their care for mathematics and for their students. They would engage students in dialog—in meaningful, mutual, open-ended discussion. They would provide students with opportunities to practice caring about mathematics; this is not intended to merely be rote drill in mathematical computation, but engagement with the habits of mind often referred to as 'mathematical thinking.' And they would provide confirmation to their students—positive, affirming feedback that stems from a trusting, established relationship (p. 390 - 391).

Herzig's conclusion that nurturing and caring teachers are often lacking for female graduate students in mathematics is disconcerting, especially since these types of relationships are so critical to the success of females in STEM. Fortunately, there is another form of mentoring that women can also have access to: family members.

Data suggests that family members, particularly parents, have a strong role in steering their female children toward STEM fields. Baker and Leary's research (2003) suggests female students ranging from second grade to eleventh grade who reported a love of math and science, tended to learn this from their parents and grandparents. Besides instilling a love of science in students, there seems to be a relationship between parents' involvement in STEM fields and also student success. Hazari et al. (2007) suggest that parents can influence their children in multiple ways to study STEM. This study found that families who encouraged their female children to study science, and also those families that displayed interest and positive attitude towards science, were more likely to affect female students' decisions to study STEM. Further, female students with a parent who studied a STEM field also report higher enrollment in STEM fields. This data is supported by Sjaastad's study (2010), which found that half of the college students in STEM (both male and female) reported at least one STEM-educated parent. These findings suggest that parents have influence over their daughters' decisions to study STEM. However, the details about parental influence are still an issue to be studied further. For example, Bloom's study (1985), which will be detailed in the last section of this review, found that in an overwhelming majority of outstanding research about mathematicians, ten out of twelve had a father who knew calculus. However, only two of these fathers actively taught their child mathematics.

Moreover, a majority of the parents in Bloom's study specifically did not attempt to interfere or pre-teach topics to their children prior to school, and yet, Bloom reports all families were supportive of students' interests in mathematics. This in-depth view of early learning provides information about how families can encourage their children to study STEM fields.

The review of literature presented in this section defined ways in which women can be influenced to pursue STEM fields in college and as a career. It described the academic and school factors (e.g. curriculum), and experiential factors (e.g. after schools programs), which influence female students' decisions to enroll and persist in STEM fields.

Curriculum is one factor that can reach most, if not all, female students in middle and secondary school. However, as research suggests, curriculum itself does not appear to be a major factor in female students' decision-making processes to study STEM, but rather *how* curriculum is implemented can steer women towards STEM fields (LeBeau et al., 2012; Riegle-Crumb et al., 2011). Multiple studies have analyzed curriculum with specific consideration of female students' experiences, and there are well-established best practice strategies to engage female students in STEM fields (Baker, 2013; Hill, Corbett & St Rose, 2010). After school and summer programs, like the iQUEST program, have been shown to encourage and increase female students' confidence and attitudes towards science (Hayden et al., 2011). However, these programs are not readily available or accessible to all female students. Therefore, even if a female student does not have access to an extracurricular program, it is important for her to at least have access to a supportive mentor.

As research relating to women in STEM suggests, mentors play a significant role in students' experiences and decision-making processes (Baker & Leary, 2003; Herzig, 2004;

Hong & Shull, 2010). In fact, many of the factors that have previously been designated as barriers to women entering STEM fields, can be overcome by the role of mentors. For example, research has shown that stereotype threat can be avoided completely by informing women that they can do just as well as men in STEM exams. This is exactly where a strong mentor can play a critical role in a female student's life (Good et al., 2011).

In the next section, an analysis of Bloom's 3-Stage model, the theoretical framework for this study, will provide further support for the idea that mentors play a critical role in the development of talent, particularly for students in STEM fields.

Theoretical Framework for Study: Bloom's 3-Stage Model

Benjamin Bloom is best known for his theory, Bloom's Taxonomy, which focuses on the classification of content objectives for students. However, another area of education on which he focused his scholarly efforts, included the development of talent. Bloom (1985) defines the word talent as "an unusually high level of demonstrated ability, achievement or skill in some special field of study or interest" (p. 5). In his book, *Developing Talent in Young People* (1985), Bloom, and a team of researchers from University of Chicago, spent four years interviewing 120 exceptionally talented individuals and their families in six different fields. This research builds on prior knowledge from *Human Characteristics and School Learning* (Bloom, 1976), which found that most human beings have the same potential for learning in school as everyone else. Prior to completing research for his 1985 study on talent development, Bloom hypothesized that this finding may also be true for individuals learning a specific skill. He further suggested that if it is true that talent can be developed, and it is not naturally born, then there may be a large pool of potential individuals who are not being actively engaged in learning. Bloom's research about the development of talent and his resulting theory, Bloom's 3-Stage Model, are critical to the analysis of women's decisions to study STEM, and will be the theoretical framework for this study. Therefore, it is important to understand the key aspects of Bloom's (1985) research on talent development, as well as the limitations of the exclusion of gender specific data in Bloom's 3-Stage Model.

In this retrospective study, Bloom's (1985) research question asked: How are skill and ability developed in aesthetic, athletic and cognitive fields? Given the limitation of studying all aesthetic, athletic and cognitive fields, Bloom chose six specific fields to represent these areas. Bloom sought to interview and analyze the development and experiences of individuals who were at the top of their field in piano and sculpture (aesthetic), swimming and tennis (athletic), and lastly, research mathematics and research neurology (cognitive). Whenever possible, this overview of Bloom's Study (1985) will focus on the field of mathematics as an example of a STEM field, and wherever needed, it will provide details of neurologists' experiences as well. However, it is important to note that the experiences of both mathematicians and neurologists were extraordinarily similar to one another.

In order to recruit outstanding participants for this study, specific parameters were defined for each field with no consideration given to participant gender, race, ethnicity or socio-economic status. For example, participants in the mathematics field were selected based on two criteria: they were all winners of the prestigious Sloan prize in mathematics, and they were also the most frequently published authors in Science Citation Index. Bloom and his research team sought participants who were younger than 35 years of age with the hope that these individuals would have a stronger recollection of their early experiences.

To collect data, researchers sought 25 participants in each field, and had a strong rate of participation of close to 90%. Bloom and his research team completed semi-structured interviews with participants for 2-3 hours, and then contacted the participants' family members and major teachers and coaches for secondary interviews. The research team utilized an interview approach called retrospective-interview to understand the experiences of the participants. Bloom reported that as the interviews continued over the four-year period, "we acquired greater and greater confidence in the value of the retrospective-interview approach to the study of talent development" (p. 16). Through their work, Bloom and his team confirmed that this method is a strong technique for recording and analyzing individual experiences in talent development.

Each of the six fields had one specific researcher that compiled the data for their field and looked for common threads throughout all interviews in that field. There were four major time periods on which all researchers focused: experiences before attending school; early years with first teacher(s) in field; middle years with advanced teacher(s); and final years with master teacher(s). Researchers used evidence from all participant interviews to identify major themes and trends in talent development during each of these time periods. After this data was collected, each researcher completed a summary of the field with respect to their findings. They also, completed a case study on one participant who exemplified major themes within each field. Once these were completed, each of the six field reports were compared and contrasted to establish patterns between fields and to make generalized conclusions relating to talent development in all young people.

The results of this study show that clear themes emerged for the talent development of individuals in all six fields. Bloom confirmed that nurturing of talent was critical to each participant's success, no matter the field. He concluded that there was "strong evidence that no matter what the initial characteristics (or gifts) of the individuals, unless there is a long and intensive process of encouragement, nurturance, education and training, the individuals will not attain extreme levels of capability in these particular fields" (Bloom 1985, p. 3). Although each field varied slightly about how and when talent developed for participants, coinciding experiences emerged for all six fields, leading to Bloom's 3-Stage Theory.

Results from this study show that there are three major time periods in the talent development of individuals: early years, middle years and later years. Over this ten to fifteen year period, each stage is marked by the active involvement of a significant teacher or coach with varying levels of expertise in the field. A brief overview of each time period will be provided with an emphasis on the experiences of mathematicians and neurologists during these three stages.

The early years, typically during elementary school, is a time period when students develop a love and genuine interest in a field under the guidance of an actively engaging teacher. Most of the mathematicians in this study described how a teacher helped them to think differently about mathematics by helping them discover patterns, ideas, and processes. Mathematicians reported that during this time period their teacher made them feel special—a sentiment that Bloom believes is critical to increasing self-confidence in students' skills.

During this time, parents also fostered a stronger sense of self-confidence and interest in mathematics by encouraging and supporting their young child's learning. For many mathematicians, parent support came in the form of materials to build models, or in the form of time (i.e. as children, the mathematicians were given time to read and develop their own interests). This is one area where mathematicians' and neurologists' early experiences differ. Mathematicians reported preferring to build objects without instructions, whereas neurologists seemed to enjoy following directions and utilizing models whenever possible.

Through the encouraging relationships of both teachers and parents, the mathematicians' interests and self-assurance grew in mathematics, which inspired their curiosity in the field. Bloom noted, "in the first period of formal instruction, it is evident that motivation and effort count far more than do the particular gifts or special qualities in the field" (p. 518). The mathematicians described the importance of learning, discovering, and exploring their own interests. They reported that the teachers who allowed them to work on their own, were most effective (p. 295), which perhaps can be viewed as foreshadowing of their future work as mathematicians.

The middle years emerge during middle school and continue through high school graduation. According to Bloom (1985), these years are marked by the introduction of a teacher or coach who has a more specialized knowledge of a field, and who exposes students to the rules and content of that field. The mathematicians accessed these specialists in a variety of ways, both in the classroom and also through special experiences. Both the neurologist and mathematician participants reported that teachers who were interesting, knew their content, and were excited about the learning process, were most influential. However, most participants viewed their overall experience in secondary school as ordinary, and few even mentioned one extraordinary high school teacher. One exception is the mathematicians' description of special experiences outside of the traditional classroom setting.

Most of the mathematicians reported an extracurricular experience, like talent searches, summer programs, or high school math teams, which challenged and engaged them in mathematics differently than traditional math classes. "Math became special through these experiences, as did the mathematicians. That is, by excelling in contests and fairs, the mathematicians discovered the excitement of doing something well and being recognized for it" (Bloom 1985, p. 309). Parents of mathematicians also encouraged their children in these endeavors and also continued to influence them to study mathematics. It is unclear how teachers or coaches influenced students in electing to participate in these special experiences. At the end of this stage, mathematicians' identities became associated with their intellectual ability, particularly in mathematics. Further, the mathematicians reported that the field of math also matched their personality, their interests, and a desire to work independently. As young scholars, these mathematicians saw this field as "attractive" and one that could lead to exciting opportunities.

Although the experiences of the mathematicians were strikingly similar to neurologists, it seems that unlike mathematicians, neurologists did not recognize a future career during this middle stage. Bloom reported that their teachers and families did not recognize specific career opportunities for them either. Bloom (1985) stated, "it would have been extremely difficult to identify the research neurologists in our sample who have subsequently demonstrated extraordinary ability" (p. 383). Although neurologists developed a strong interest in science and math, and they were clearly very smart, they were not actively engaged in research or work in laboratories. These students seemed to be engaged in a host of activities, both academic and social, during their secondary school years, and while they were planning on attending college, they did not focus their lives solely on science and math.

The third and last stage of talent development focuses on the period when students master a field under the direct mentoring of an outstanding teacher or individual in the field. Bloom also characterized this stage as the complete dedication of the student to their field, which further connects students' identities with their talents. For the studied mathematicians and neurologists, this meant collaborating with well-established professors about complex academic work, research, and outstanding questions in the field. Bloom stated, "mainly they are learning research strategies and ways of finding and solving problems that are in some respects different from those that have ever been solved before" (p. 537). In many ways, in this stage, the mathematicians were not only extending their own knowledge, but they were also extending knowledge for the entire field of mathematics.

Herzig (2004) and Bloom (1985) agree that students during this time period engage in "insider practices" in the field and observe their mentors as role models for their future professions. Bloom (1985) specifically designates mathematics as a field where student peer contacts are almost as influential as the professors in students' lives. This also supports, as Herzig (2004) highlights, the importance of community within mathematics departments. In her study of female doctoral students in mathematics, she suggests that participants were often isolated from faculty and peers creating a feeling of invisibility and isolation. Herzig sites these experiences of exclusion as a major reason for two of the six participants to dropout of their doctoral program. Herzig concludes that a caring community of practice is critical to opening mathematics to all students. "In order to open the discipline of mathematics to a broader range of students, and to engage them in mathematics in meaningful ways, students need the means to participate in the practices of mathematicians in genuine ways, in the context of relations based on care among teachers, students and the discipline of mathematics" (p. 393). Both Herzig (2004) and Bloom (1985) believe that role models and environment play a critical role in the development of academic talent, particularly in STEM-related fields. However, as Herzig (2004) considered gender as a frame to view each participant’s experience, Bloom (1985) actively dismisses gender as a social structure.

Throughout Bloom's study (1985) the social structure of gender is actively ignored and hidden. In the section focusing on mathematician talent development, Bloom relayed the following, "there is one female in the group of accomplished mathematicians. In order to avoid making her conspicuous, all references to the mathematicians will be masculine" (p. 271). In order to protect the female participant's anonymity, her experiences and development of talent were morphed into that of a male. This makes it impossible for readers and researchers to understand how and if this female mathematician’s experiences were similar to or different than her male peers. Therefore, the results of this study are limited because it is impossible to analyze them with a focus on the female mathematician, or more generally, other outstanding female researchers in various fields.

As Bloom suggested, this study (1985) provided an opportunity for experts, teachers, families and policy-makers to understand how talent is developed in young people, and to ensure that all students are engaged in the learning process. However, Bloom failed to consider how gender plays a critical role in students' learning processes. This suggests that a gap in the literature exists about how and why talent is developed in female students, particularly in fields like mathematics. Recent research supports this concern and suggests that future research focus on in-depth analyses of female experiences, particularly in STEM fields (Riegle et. al 2012, You 2013). Moreover, recent research using Bloom's 3-Stage Model, has begun to analyze how students' experiences in talent development are shaped by experiences with mentors, and with no consideration of female students' experiences in the theoretical model, the results of these studies may be limited. These studies will be explained in the remaining parts of this chapter.

Bloom's 3-Stage Model is utilized in education research most frequently to analyze talent development in areas ranging from ballet to STEM. Subotnik et al.'s (2010) study utilized Bloom's 3-Stage Model as a theoretical framework to analyze if, and how, specialized STEM schools are increasing student participation in these fields. The authors of this study argued that the most important findings from Bloom's (1985) study relate to instruction, and more specifically, the role of teacher and mentors. The authors believe that by utilizing Bloom's 3-Stage Model, researchers can track how students' interests and talents are developing within specialized schools in relation to teachers and mentors. Subonik et al. (2010) also suggest that by unraveling student experiences, all researchers and educators will have a stronger understanding of the factors that influence development of talent in STEM fields.

Another research study utilizing Bloom's 3-Stage Model, focused on development of talented ballerinas (van Rossum, 2001). In this study, van Rossum applied Bloom's 3-Stage Model as a theoretical lens to analyze how teachers and peers played a role in the development of a dance career. Relevant findings from this study suggest that Bloom's 3-Stage Model is a useful tool to analyze student experiences relating to teachers. The study also found that peers played a critical role in influencing students' dance careers. Although both of these studies do not focus explicitly on female STEM students' decision-making processes, both studies show that the 3-Stage Model is a useful and effective tool to analyze qualitative data about student development and the role of mentors in this process. Hence, the methodology of Bloom's study (1985) does provide a strong foundation to replicate a study focusing on female students' developments.

The researchers in Bloom's study used a retrospective-interview approach, whereby early experiences of exemplary individuals in a specific field were compiled and analyzed. Researchers also interviewed family and teachers to corroborate results. Despite the strong methodological techniques of this study, female participants' experiences were hidden. Therefore, a future study could extend Bloom's (1985) results, and also Bloom's 3-Stage Model, to include female participants' perspectives and to analyze how these students' relationships with teachers and mentors influenced their decisions to study STEM (Subotnik et. al, 2010).

Bloom's 3-Stage Model relates directly to known research in the field of STEM education, which was explained earlier in this report. First, research concurs with Bloom's finding that maintaining interest in fields from early, to middle, to later years is critical in developing talent. Similarly, Bloom's results suggest that during the middle years, typically at the end of high school, students report that they can see themselves as mathematicians, while neurologists, although certainly college-bound, are still developing interest in their specific field. This finding parallels with students' decision-making processes to enter into college with a STEM field, as most students who graduate with a STEM degree, enter college with a desire to study math and science. Finally, during the later years, Bloom (1985) suggests that mathematicians and neurologists focus on developing relationships with outstanding professors and completing research to answer open questions in their field. Bloom fails to mention any issues or concerns that students may have in engaging with a community of learners in their field. However, research suggests that for many women, particularly in graduate school, a community of learners does not exist and can limit women's abilities to succeed in STEM fields (Herzig, 2004). This also suggests that strategies, like actively engaging women in positive relationships, may play a critical role in helping women persist in challenging STEM fields. This strategy, along with a host of others presented in this literature review, provide important information, which will help female students persist in the pipeline and ultimately, decide to major in and complete a STEM degree.

Summary of Related Research

Research presented in this literature review suggests that there are a host of barriers and factors that account for women's low enrollment in STEM fields. This research also examines specific strategies that can keep women in the STEM pipeline and steer women towards higher education degrees in these fields. Scholars believe that to increase the number of women in STEM fields, all women must be academically prepared for the rigor of challenging STEM courses in college (Espinosa, 2011; You, 2013); they must be interested in studying STEM fields (Hill, Corbett & St Rose, 2010; Riegle-Crumb et al., 2011); and finally, they must be confident enough to breakdown barriers to STEM fields like stereotype threat and hostile environments (Good et al., 2011; Herzig, 2004). These factors influence women's complex decision-making processes in a multitude of ways, and they can be utilized as tools to steer women towards STEM fields.

For instance, female students' enjoyment of science and math seems to play a critical role in determining if women will decide to pursue a STEM field (Hill, Corbett & St Rose, 2010; Riegle-Crumb et al., 2011). Research shows that the disparity between the sexes when it comes to interest in STEM, grows from the beginning to the end of high school (Sadler et al., 2012). Therefore, increasing female students' interests in STEM fields is an area where improvement during critical high school years can be made (Rask, 2010; Sadler et al., 2012). Researchers suggest that specific strategies, like curricular and pedagogical changes, academic coursework, extracurricular experiences, and connection to a mentor, can improve the enrollment of women in STEM fields (Hayden et al., 2011; Hazari et al., 2007; Riegle-Crumb et al., 2011; You, 2013).

Retrospective studies of individuals in STEM fields suggests that mentors played a strong role in guiding these students towards, or away from, STEM fields (Bloom, 1985; Herzig, 2004). For example, women who pursued STEM fields could identify a key person in their life who instilled in them an interest in math and science (Baker & Leary, 2003). The theoretical framework for this study, Bloom's 3-Stage Model, also highlights the dynamic and imperative nature of mentors in steering students towards excellence in STEM fields. Yet, this theory fails to consider gender as a key influence on the development of scholars. Whereas other research strongly suggests that gender is a critical factor in students' decisions to enter STEM fields (Riegle-Crumb et al., 2012). If the mentor relationship is a critical tool in steering students towards STEM fields, more research about women's experiences with mentors in the decision-making process would be beneficial.

Chapter 3: Methodology

The literature review presented in Chapter 2 of this study provides an overview of both the barriers which women face upon entering STEM fields in college, and also, the strategies which have been shown to be effective in encouraging enrollment and persistence in STEM fields. The research in this field suggests that mentors play a critical role in the development of talent in STEM fields for women, and further, in female students' decision to pursue a STEM major. However, studies have failed to address the decision-making process of female students who decide to pursue STEM fields, and how mentors influence this important process. This current study addresses the current gap in research in the field of women in STEM by analyzing the lived experiences of female high school students who have decided to enter college as STEM majors. Further, this study focuses on differentiating the experiences of females majoring in different STEM fields (e.g. chemistry versus engineering).

The present study will utilize a phenomenological approach with a focus on gender as a lens to analyze female students' decision-making process to study STEM (Creswell, 2003). This present studying adopts methodologies presented in Bloom's (1985) study on talent development as well as the theoretical frame created by this study, Bloom's 3-Stage Model.

The data collection process for this study includes semi-structured interviews, responses to writing prompts as well as creation of a graphical representation for six female high school students. Analysis of data utilizes Moustakas' (1994) structured method with modifications from Creswell (2003). The rationale for choosing this analysis technique is purposeful on my part as a researcher. As a female mathematician, I have experienced the process of deciding to major in a STEM field. Moustakas' (1994) methodology allows me, the researcher, to first identify my perspective, bracket it out and then utilize a transcendental state to separate myself from the experiences of the participants in this study (Creswell, 2003).

As a female who pursued a STEM field in college, I believe that a multitude of factors led to my decision to study mathematics and I believe that this is also true for most females who are pursuing a STEM major. I am still unsure of which factor had the greatest impact on my decision, but I do feel strongly that a combination of supportive family members, teachers, and experiences like science fairs, encouraged me to consider entering a STEM field. I often wonder if I would have considered computer science or engineering if I had had greater exposure to those fields during my educational career.

Based on my role as a math teacher, I believe that mentors and experiences can play a large part in steering female (and male) students towards STEM fields. I know firsthand that one conversation to encourage a student to pursue a STEM field can truly make a difference. I have had female students who, as freshmen, knew they wanted to be doctors, while other students have entered high school with little interest in engineering, but graduate with a plan to study it in college. These varied examples are the inspiration behind this study, in which I seek to uncover the personal experiences that truly influence each person's decision to enter into a STEM field. With this methodology and insight, the following research questions, and sub-questions have been developed and which guide the data collection and analysis processes of this study:

1) How do experiences and relationships influence female students' decision to major in a STEM field?

a. How do experiences in elementary, middle and high school play a role in female students' decision to study a STEM field?

b. How do relationships in elementary, middle and high school affect female students' interest in STEM fields?

c. Are there barriers during elementary, middle and high school which women overcome to decide to major in a STEM field? If so, what are these barriers and how do women overcome these?

2) How do the decision-making experiences of female students majoring in STEM

This present study is framed from a pilot study called, "Factors that Influence Students to Study STEM Fields" (2013). The research question for this study focused on determining which factors influenced male and female students' decision to study STEM fields. To collect data for this pilot study, I interviewed both male and female STEM majors at the University of Albany who were in their sophomore or junior year. The results of this study suggested that mentors played a critical role in steering women, and also men, towards STEM majors; however, differences existed between who male and female students identified as mentors. Many of the decisions made in this study, particularly the age of participants, were influenced by methodological issues which arose in this pilot study (2013).

Participants

The participants for this study were recruited from urban, suburban and rural high schools in the Capital District within 30 miles of Albany, New York. In order to identify participants the following criterion was established; the six chosen participants in this study have the following characteristics:

- Female
- Enrolled in high school within 30 miles of Albany, New York
- Aged 18 years old by February 15, 2015
- Planning on attending a 4-year college and majoring in a STEM field

In the pilot study (2013), participants reported a host of mentors, particularly college professors, who steered them towards particular STEM careers. These participants had a difficult time differentiating between their decision to major in STEM and their decision on which career to pursue. In order to study the decision-making process to major in a STEM field, this current study will utilize participants who have recently decided to major in a STEM field, meaning students who have recently applied to college. Research also suggests that high school experiences are critical to influencing participants' decision to studying STEM (Maltese & Tai, 2011). Even if participants decided to major in a STEM field long before their senior year, the act of applying to college with an intended major is a significant step in showing participants' interest and intent of studying STEM in the future. The next section will describe how and why each characteristic has been selected for all six participants as well as the recruitment process itself. The rationale for utilizing six participants stems from a similar study completed by Herzig (2004) of six female graduate students in STEM fields. Herzig (2004)'s semi-structured interviews of six women yielded an in-depth understanding of each woman's experiences which allowed for the researcher to identify and differentiate patterns among participants.

Recruitment of Participants

This section provides an overview of the recruitment process for participants as well as a statistical and research-based explanation for the choice of specific participants. Further, the recruitment of participants for this study is based on methodologies and protocols which worked well in the pilot study (2013). For example, a mathematics professor provided me with access to contact students in his high-level math class. Participants were recruited, in a similar manner, for this current study through their high school math, technology and science teachers. Teachers who were in the New York State Master Teacher Program (NYSMTP) for the Capital District area received an email asking for help identifying participants for this study as described above along with a recruitment hand-out for students. On this recruitment hand-out, students learned the requirements for participation in the study along with my email address. Teachers in the NYSMTP had contact with female students who are seniors in high school, and also, taught at a variety of schools that are urban, suburban and rural. Further, I was a member in this program, and believed that my rate of teacher participation response will be higher from teachers in this program. All teachers in this program received receive an email from myself that can be found in Appendix A.

Teachers in the Master Teacher program will were then asked to give recruitment hand-out(s) to interested students, who then emailed me directly expressing interest in participating in the study. Once I received emails from students, I then emailed back with an invitation to participate (Appendix B) and asked students to provide me with their age, intended college major and also availability to meet for an interview. Students were informed that they will need to commit to a total of 65 minutes to participate in this study. Participants were asked to participate in:

- Writing prompt (15 minutes to complete)
- 1 Timeline graph (5 minutes)
- 45 minute interview in person

In exchange for this time, all students received a $25 gift card to Amazon.com which was given to them upon signing their consent form. Students were reminded that all conversations and writing prompts would be kept completely confidential and anonymous. Further, students were informed that to participate in the study, they would need to sign a consent form and their parents also needed to sign one as well.

Six students were chosen based on criterion explained above. Students chosen for the study were 18 years of age, female and planning on majoring in a STEM field in college. Furthermore, in order to allow for variation sampling within this study, students were chosen who are planning on majoring in different, specific fields. According to Patton (2002), variation sampling allows for results which allows to compare patterns throughout all cases as well as consider each case uniquely. This study students in the following fields were recruited:

- 2 female students from engineering field
- 2 female students from computer science field
- 2 female students from physical, mathematics or biological science field

These specific subsets of majors were chosen based upon the statistics presented in Chapter 1 of this study which show that engineering and computer science have the lowest female enrollment rates of all STEM majors (NSF, 2013). Research also supports that these fields have low enrollment, possibly because of female's lack of interest in, and access to, engineering and computer science topics or perhaps, since these fields are often not perceived as helping people (Hill, Corbett & St Rose, 2011; National Academy of Engineering, 2008). However, current research fails to suggest which factors, like mentors, may steer women towards these specific fields through the lens of women's own lived experiences.

One potential area of bias in this study is my current position as a mathematics teacher at Saratoga High School. In the pilot study (2013), one of the participants attended Saratoga High School and I found that this student limited their discussion of experiences during high school. Hence, no participants for this study were chosen who are currently enrolled in school at Saratoga High School.

Once I received an email from a student, which stated their interest in participation, I then made certain that this individual fit the criteria of the study. Then, I categorized this student according to major, computer science, engineer or other STEM field. I selected the first two students, from each major, who emailed me back as participants in this study. Once students were selected for the study, I then sent them each an email (Appendix C) which asked participants to determine dates and times as well as locations which were convenient for them to meet for an in-person interview. Participants were then provided with the consent form for this study as well as information about confidentiality. Participants were also asked to participate in member-checking once the analysis chapters for this paper are written, which all did. The interviewer informed each participant of this member checking process and also informed participants that they have the right to amend or withdraw any part of their participation in this study, if so desired. At the end of the study, only one participant had a small change to be made to their story.

Data Collection

The collection of data for this study draws from Bloom's study (1985) as well as Herzig's (2004) qualitative study of female graduate students in STEM. Bloom's study (1985) yielded results which added to the research in the field of talent development of students in STEM fields but did not include female perspectives. Herzig's (2004) study utilized qualitative methodologies to understand and analyze the experiences of graduate women in STEM fields. There were three methods of data collection, from each of the six participants, for this study. Participants filled out *a timeline* (Appendix D), responded to a series of *writing prompts* (Appendix E) and lastly, participated in *an interview* (Appendix F). The use of these three methods allowed for triangulation in the data analysis process and ensured both the validity and trustworthiness of the study as a whole (Creswell, 2003). The data to address each question, and sub-question for this study, is aimed at ensuring consistency and providing rich data sources with which to analyze (See Table 3.2).

Furthermore, the protocols utilized to conduct phenomenological studies, as described by Moustakas (1994), included open-ended, broad questions which allowed participants to explain their experiences with the phenomena of choosing to major in a STEM field (Creswell, 2003). Whereas the graphical representation, or timeline, utilized in this study allowed for data about participants' interest in STEM fields to be organized and categorized more effectively and efficiently. According to Huberman and Miles (1998), in qualitative research, graphical representations allow for patterns and themes to be more easily identified, creating a stronger, more valid study. Further, these scholars also suggest that the use of a graphical representation represents a dynamic way to represent data which cannot always be captured through transcriptions or writing. The use of a timeline in this study is also influenced by previous studies that analyze female students' experiences throughout their educational careers.

A relevant study discussed in Chapter 1 from Baker and Leary (2003) is the source of inspiration for the creation and use of a time line in this study (Appendix D). In their study, Baker and Leary (2003) interviewed female students during specific age groups, beginning in elementary school and continuing till the end of high school, to understand their interest in math and science at each time period. In this present study, the time line served a similar purpose as to measure or chart participants' interest, retrospectively. The time line extended the methodologies used by Baker and Leary (2003) by allowing participants to explain and discuss moments or experiences, in their past, which influenced their decision to study a STEM field. Participants were provided with the timeline during the interview with specific directions on the top; the interviewer asked each participant to read the directions and then complete the timeline. Please note that the timeline directions, see Appendix E, asked for participants to use a star to denote any changes of interest in STEM overtime. In the analysis of this study, the time line allowed for triangulation of writing prompts and interview data, which also allowed for a thick description of how (and if) participants' interest in STEM fields has changed over time.

The writing prompts (Appendix E) offered participants an opportunity to first consider their experiences in STEM at multiple stages of their lives, while the timeline, drawn by participants, showed the development of their interest in STEM over their educational career (see Appendix D). By asking participants to first complete these writing prompts and timeline, more in-depth, rich responses to interview question were gleaned (Appendix F). Table 3.2 below shows how research questions for this study align with the data collection and analysis process.

Table 3.2

Overview of Research questions, Data Collection and Analysis Processes

Research Question	**Data Collection Process**	**Data Analysis**
1a) How do experiences in elementary, middle and high school play a role in female students' decision to study a STEM field?	-Writing Prompt -Time line of STEM interest -Interview questions	-Horizontalization, use of open and a priori coding term (like experiences), development of clusters of meaning by stages
1b) How do relationships in elementary, middle and high school affect female students' interest in STEM fields?	-Writing prompt -Time line of STEM interest -Interview questions	-Horizontalization, use of open and a priori coding (like relationships, mentor, role model, parent), as well as development of clusters of meaning by stages
1c) Are there barriers during elementary, middle and high school, which women overcome to decide to major in a STEM field? If so, what are these barriers and how do women overcome them?	-Writing prompt -Time line of STEM interest -Interview questions	-Horizontalization, use of open and a priori coding terms (like barriers, challenges) as well as development of clusters of meaning by stages
2) How do female students' experiences differ depending on planned major? (i.e. computer science versus mathematics or engineering versus chemistry)	-Writing prompt - Time line of STEM interest -Interview questions	-close reading, use of open coding, development of clusters for specific majors, development of table with similarities for each major

The first research question: *How do experiences and relationships influence female students' decisions to major in a STEM field?,* analyzes the role of elementary, middle, and high school experiences and how they may impact whether or not females will enroll in STEM fields in college. The data collection method for each sub-question for this first question is described below; Table 3.3 (below) was utilized to organize data for each participant. Please note all interviews were audio-recorded and later transcribed.

Table 3.3

Data Collection Tables for Participants

Participant A Participant's Major:	**Timeline Evidence**	**Writing Prompt Evidence**	**Interview Evidence**
Experiences **(***Question 1.a)*			
Relationships **(***Question 1.b)*			
Barriers **(***Question 1.c)*			

Question 1.a: How do experiences in elementary, middle and high school play a role in female students' decision to study a STEM field? In the first part of this study, participants responded to a writing prompt that asked them describe, in a paragraph, any experiences in elementary, middle, or high school that increased their interest in a STEM field. This

provided participants with the opportunity to describe and illustrate their experiences in STEM from elementary to high school. The timeline also provided a visual of each participant's interest level in STEM during elementary school.

During the semi-structured interview, which was audio-recorded, participants were asked to expand upon their answer to writing prompts and describe these experiences. If students do not have experiences to explain, then the interviewer asked students to consider how they felt about math and science during differing time periods in their life; this protocol was utilized for all of question 1, where participants do not have an experience to discuss. Further, based on each participant's time line, specific questions were developed to understand how or why students' represented their interest level; the stars, designated by participants on time lines, also served as indicators of experiences, which may be noteworthy. This open-ended interview style allowed the interviewer opportunities to follow pre-determined questions and omit these or add other questions depending on participants' responses and experiences (Robson, 2002).

Question 1.b: How do relationships in elementary, middle and high school affect female students' interest in STEM fields? In the writing prompt, participants were asked to describe, in a paragraph, the relationships (if any) that developed in elementary, middle, or high school, which positively influenced their decisions to major in a STEM field. They were also asked to describe how the relationship developed. A separate writing prompt asked participants to explain the role their family played in their decision to study a STEM field as well. This prompt sought to determine if and how family plays a role in each student's decision to study a STEM field.

In the interview, participants were asked to expand upon their experiences with mentors. As with the first sub-question (a), the timeline also provided the interviewer with specific opportunities to explore how or when interest in STEM fields increased, decreased based on stars. Again, during the interview, a semi-structured approach was utilized to allow for more in-depth exploration and understanding of each specific participants' experiences.

Question 1.c: Are there *<u>barriers</u>* *during elementary, middle and high school which women overcome to decide to major in a STEM field? If so, what are these barriers and how do women overcome these?* In the writing prompt, participants were asked to describe, in a paragraph, the challenges (if any) that they had to overcome in order to pursue a STEM major. This prompt allowed participants to discuss, in writing, any barriers which they experienced in their decision-making process. The timeline also allowed for the researcher to identify trends of interest throughout each participant's education or where difficulty arose in their educational experiences. Lastly, participants were asked to explain, throughout their educational career, what or who contributed most to their decision to major in STEM. Utilizing a semi-structured interview style, the timeline helped to interviewer questions, and questions about the participants' entire experience.

The data collection process differed, slightly, for the second research question, as the goal of this question is to understand variation between STEM majors. Data for the second question: *How do the decision-making experiences of female students majoring in STEM fields differ?*, was collected first using the written prompt and timeline. The timelines of each student provided information about how, and if, development of interest varied over time depending on major. Further, a writing prompt asked students to explain why they have chosen their intended college major. This information led the interviewer to ask more in-depth questions regarding each participants' specific experiences within that field, and similarly, how and if, mentors and experiences played a role in developing interest in this field.

Lastly, after completing each interview, the researcher completed interpretive memo-ing. This allowed the researcher to record and reflect upon their experience in data collection with each participant, and also note important observations about each interview. This process also served as a tool to help the researcher begin to analyze the data for this study.

Data Analysis

This section provides an explanation of the process used to analyze data for this present study. Phenomenological data analysis, according to Creswell (2007) and Moustakas (1994), focuses on analyzing the broad, open questions provided in writing prompts and interview. Through the horizontalization process, significant statements and quotes which exemplify the essence of each participants' experience, were highlighted (Creswell, 2003). As described in Table 3.2, when appropriate, close reading along with the use of open or a priori coding also helped to identify clusters and themes throughout writing prompts and transcribed interviews. Open coding for all sub-questions, and use of a priori coding (see Appendix J) for the first research question were included the following terms, experiences, mentor and role model, while a priori coding for the last research question, focused on each specific major, like computer science or engineering. As the researcher read each participants' data, coding was developed which captures the essence of each individuals' experience.   All writing prompts and transcribed interviews were in NVivo, a tool to expedite the coding process.

After themes are developed, a textual experience of each participant was compiled as evidenced by Table 3.3 shown above. This led to the structural description of participants' decision-making process to study a STEM field. As described by Creswell (2003), this present study diverged from Moustakas (1994) by describing the researcher's personal statements, which can be found at the beginning of chapter four; in phenomenological studies, this description sought to expose insight brought by the research to this study. The essence of each female students' decision-making process is described, in detail, with quotes from participants as critical data in both the interviews and writing prompts. The timelines are also provided as evidence of essence of experiences.

Table 3.4, shown below, allowed for a deeper analysis of the data, and each participants' story, utilizing Bloom's 3-Stage Model as a theoretical frame. Each participant's story is presented as described above and where appropriate, key aspects of each features of each stage is described. Further, participant's stories, as described in Chapter 4, on addressing as many of the key features of each stage described below as possible. Also, the analysis of participants' stories discusses how and if these key aspects of each stage are not reported by participants, as this may suggest that the model is lacking in some specific way. To address the questions for this paper, the analysis process addresses the first research question of the study and then the second as described more fully below.

Table 3.4

Data Analysis Table for Participants' Story

Bloom's Theoretical Frame	Key Features
Stage 1 (Early Years)	- Teacher made student feel special - Student learns to think differently about math/science - Strong role in parental support - Motivation and effort are important - Students work independently - Students have interest in math/science but little sense of future careers in these fields
Stage 2 (Middle Years)	- Student works directly with teacher or mentor with special skills in field. - Teachers who are enthusiastic and interesting are most influential. - Students complete experiences that make them feel special. - Students have limited knowledge of future careers in field.
Stage 3 (Later Years)	- Student works directly with a master in the field. - Students develop an understanding and mastery of insider practices. - Students learn to do real research or real tasks in their field of study. - Students develop ideas of future careers.

After this first phase of analysis was completed, analysis to answer the second research question was then done. First, the textual experiences of female students was grouped together according to their major (e.g. engineering, computer science or other STEM field). Then, for each major, a structural description of participants' decision-making process was created. This provided the description necessary to then compare and contrast each majors' experiences with the others. In Chapter 4, after the two major research questions for this study are addressed, a thorough discussion of the use of Bloom's 3-Stage theory will be presented. In this chapter, the researcher will present how, and if, this framework can be utilized to understand the development of female STEM students.

In this study, a combination of participant interviews along with a writing prompt and a time line offered participants multiple opportunities to provide insight into their experience as well as ensure the validity and trustworthiness of this study (Patton, 2002). The use of these three different protocols is a technique utilized in narrative methodology to ensure validity of participants' responses (Clandinin & Connelly, 2000). During the analysis portion of this study, the researcher was able to compare and contrast all three pieces of data to ensure that the phenomenon described by each participant is a true representation of their experience. Data collection was completed at two different time periods, and covered similar topics. By collecting data over a longer time period and triangulating data, the credibility of this study was improved (Creswell, 2003).

To ensure reliability in this study, there were two females from each field (e.g. engineering or computer science) in this study, and a total of six female participants. The analysis of this study sought to understand the patterns for all participants in the study, and then, provided an analysis by each major (see Table 3.3 above); this two step process helped to ensure that patterns within all STEM majors and within each major are accurately reported. Finally, all participants also completed member checking, meaning that the researcher emailed the final chapters of this dissertation to each participant (Creswell, 2003). Participants had an opportunity to read their own stories and give critical feedback about the resonance and accuracy of this study's description of their experience. The one change requested by one participant based on member checking has been amended in upcoming chapter.

Chapter 4: Their Path to STEM Majors

Introduction

The two major research questions for this study ask (1) how relationships and experiences influence female students' decisions to major in a STEM field and (2) how, and if, the decision-making process varies for female students who are pursuing different majors. In this study, experiences are defined as opportunities—both in and out of school—that expose female students to STEM fields, like science fairs and enrollment in advanced placement courses. To answer the first research question, this study will explore three distinct time periods in each participant's life utilizing Bloom's 3 Stage model as a lens. We will further use Table 3.4, located in the prior chapter, as an analysis tool for each of Bloom's Stages. For each time period, this study will examine how experiences, relationships, and barriers affected each participant's decision-making process, and then analyze how Bloom's Stages related to participants' overall path. This study will then discuss common themes and trends for all participants. Finally, to answer the second research question, this study will analyze how, and if, the decision-making process varies for women who are pursuing majors in different STEM fields. The data that will be used to understand each participant's experience will include responses to writing prompts, an interview, as well as each student's timeline of interest in STEM. To analyze this data, we will use Bloom's 3 Stage Model as a theoretical lens for each participant's decision-making process.

This chapter will present each participant's experience in deciding to major in a STEM field, one at a time, and organized by intended major. When appropriate, analysis using Bloom's Three Stage model framework will be discussed for each participant; a special focus of variations between the model and participants' stories will also be highlighted when possible. The next chapter in this study will also provide an overview of a possible alternative model to Bloom's approach. Prior to introducing the six participants in this study, I will provide a brief statement of my own personal interests and beliefs in the STEM field as suggested by protocols from Creswell (2003).

Sarah[1]: Biometry Major

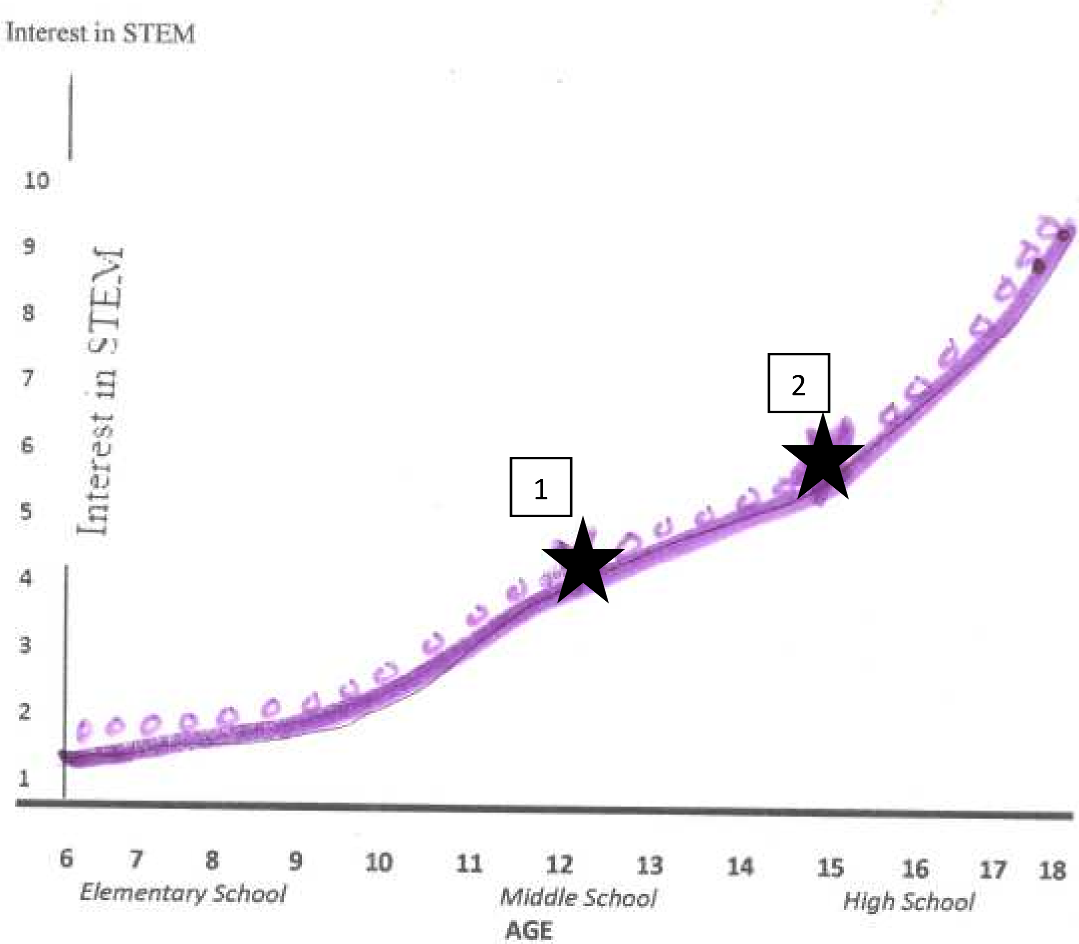
Sarah is an 18-year-old Indian student from a large suburban school who will be attending an Ivy League college in the fall of 2015. She will major in biometry, which, according to Sarah, focuses on the intersection of biology and statistics. Throughout her time in high school, Sarah maintained a 4.0 GPA. While looking at Sarah's timeline, shown in Chart 4.1 below, it is evident that her interest in STEM has increased gradually over time, even though Sarah feels strongly that in many ways her decision to study a STEM field was predetermined. For instance, in elementary school, Sarah recalls wearing a sticker with the words, "future scientist" on it; in many ways, this nametag symbolizes Sarah's path to studying STEM. She states that from an early age, "I felt like a science major was just what I was going to study." Despite her certainty about her decision, there are specific experiences and relationships that highlight Sarah's path to studying biometry. Please note that all stars

[1] Please note all names used in this study are pseudonyms.

have been re-formatted but represent real stars drawn by participants, and each star has been labeled by a number.

Chart 4.1

Sarah's Timeline



Experiences

Sarah's experiences during her early years suggests, as does Bloom's model, that experiences and family support were critical to encouraging her towards STEM fields during the first stage of development. Sarah’s early education (up through third grade) took place in private school. Upon entering public school in the fourth grade, Sarah felt that the school schedule was rigid and the classes focused heavily on testing, which was a much different experience than her time in private school. A highlight for Sarah during her first years in public school, however, was her frequent participation in science fairs; this is also a key feature of Bloom's model. As she transitioned into the middle school years, Sarah found that her interest in science and math courses increased.

During her sophomore year, Sarah gained entrance into the Science Research Program (SRP) at her high school. The second star on her timeline denotes her enrollment in this program and marks it as a significant factor that increased her interest in STEM; we will discuss the first star on Sarah's timeline in relationships section. In this credit-bearing program, students work at a local college or university with a professor or graduate student on a STEM-specific project. The program spans from a student's sophomore year through his or her senior year in high school. During the program, a science research teacher from the student's high school helps coordinate and advise him or her on the work he or she completes. This experience offered Sarah an opportunity to connect with experts in the field, a critical piece of Bloom's third stage and learn about insider practices. Sarah's project in this program focused on testing a blood thinning medicine. According to Sarah, "The Science Research Program I got into greatly influenced my decision to pursue a STEM field, especially when I consistently went to lab a few days a week over the summer. I felt like it was a nice place where everyone knew each other. I also thought the work and different machines used were very interesting." Two aspects of the SRP particularly captivated Sarah: the positive environment that was fostered by the graduate students and professors, and the lab setting, which varied each day. "I liked environment (at the lab) a lot. What you did every day changed from the day before. That was interesting that it kept changing." The enthusiasm Sarah had at the lab also seemed to flow naturally into her coursework in high school in which she excelled at and enjoyed AP Biology.

Relationships

As described by Bloom's 3-Stage model, parental support throughout all stages is critical to developing talent in any field; this was true of Sarah's path, particularly during Stage 1 and 2. Sarah describes the influence of her parents and grandparents as the most salient factor in her decision to study a STEM field. As seen on her timeline, the first star (from her middle school years) highlights the time when her grandparents suggested that she become a doctor. Sarah states, “I don’t think anyone necessarily pushed me to pursue STEM—my sister isn’t considering pursuing a STEM field—but I think it is what people have said over (the) years. I keep going back to a doctor comment, made by grandparents, which is in the back of my head to go somewhere near that.” Throughout my interview with Sarah, she repeated that she always felt that she would study a STEM field, and she believes her parents, both engineers, contributed to this feeling as well. This sentiment contrasts with Bloom's Model, in that, this model suggests that students grow in confidence and interest in their field.

During her high school years, Sarah formed positive relationships with a Stage 2 mentor, her high school science research teacher, and also, a Stage 3 mentor, her professor in the SRP. She describes her science research teacher as an individual with enthusiasm for both science and research. Sarah feels that he went above and beyond to learn about the medicine that she researched in the program; a critical characteristic of mentors during Bloom's Stage 2. Further, as explained in the experiences section, the SRP offered Sarah opportunities to experience life as a research and work with experts in the field. Sarah described her experience with her professor as "very helpful." She felt as though by working with her professor she gained insider knowledge about the field of research, and felt comfortable to ask questions or go to her professor with any questions. During our interview, Sarah paused and seemed taken-aback when I asked how she felt about not having worked with a female professor in a STEM field. It seemed as though this was the first time that Sarah had thought about the gender of her mentors.

Barriers

Sarah reports that the greatest barrier in her decision to study a STEM field was herself. She states, "The challenges were mostly me doubting myself and the impact I could make on something." Despite her positive experience in the SRP, Sarah's lack of confidence in both herself and her abilities to meaningfully impact a field of study limited her opportunities. For example, when Sarah originally applied for the SRP as a sophomore, she had a deep interest in pursuing cancer research, but she didn't feel that she "could really do anything to help." Now as a high school senior, Sarah expresses regret with her decision to avoid this area of research.

Although Sarah recognizes that her lack of confidence was one of her biggest obstacles, she also believes that the support of her parents helped to assuage these concerns. She states, "One of my biggest challenges is myself. Something might be too hard, or I think I wouldn't be able to do something, but my parents say 'You should at least try!' and they've definitely pushed me to do my best and try hard in whatever I want to do." Clearly, the support of Sarah's parents and grandparents has been a key factor in alleviating any self-inflicted barriers to her decision to pursue biometry.

Bloom's Stage Analysis

Overall, Sarah's path to majoring in biometry follows Bloom's 3-Stages to a varying degree. During Stage 1, the early years, Sarah was exposed to interesting opportunities in science and felt supported by her family. However, her belief that she would always major in a STEM field does contrast with Bloom's first stage. During her middle years, Sarah worked with a teacher in the SRP who was enthusiastic and engaged, and who also tailored instruction on her specialty, her research; this correlates directly with description of a Stage 2 teacher by Bloom.

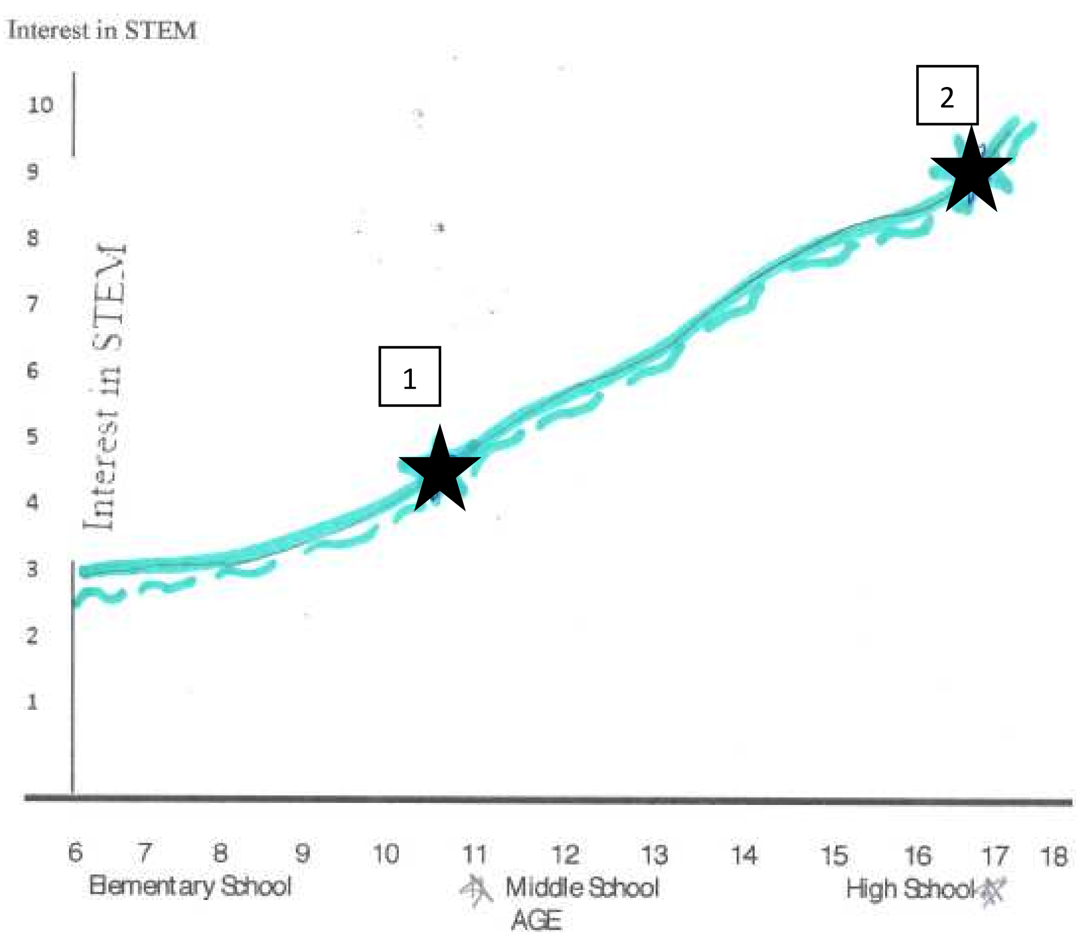
A key difference between Sarah's path and Bloom's model is the coinciding nature of Sarah's exposure to Stage 2 and 3 mentors and experiences. The analysis of Bloom's model suggests that Sarah's first exposure to research and experts in the field, a keystone of Stage 3, took place at the same time as Stage 2. While in the SRP, Sarah worked with experts in the field of biology, learned about insider practices and completed research in this field. However, this also took place during Stage 2, while Sarah was enrolled in high school and developing her interest in science. This is a common theme for many participants in this study, and will be discussed fully later in paper.

Rachel: Computer Science

Rachel is an African American student who attends a large, urban high school and plans to major in computer science in the fall of 2015. Throughout her time in high school, Rachel has maintained a 95% average while taking advanced placement and honor-level courses. Upon observing Rachel's timeline (Chart 4.2 below) it is evident that her interest in STEM fields has grown over time. There are two stars shown in her timeline, which Rachel marked to denote two of her most influential relationships. This study will first present evidence of Rachel's experiences throughout her educational career and then discuss the relationships and the barriers she has faced.

Chart 4.2

Rachel's Timeline



Experiences

Rachel describes herself, from her early years, as having both an affinity for mathematics and a strong confidence in her abilities. Conversely, since middle school, she has maintained a dislike for subjects like English and social studies. As highlighted in her timeline, Rachel's love for math truly increased in middle school, as denoted by first star, when she worked with a teacher who Rachel says, "really made math interesting." As suggested by Stage 1 of Bloom's Model, the support of this teacher, helped to increase her development of interest and abilities in math and lead to her thinking differently about math. The experience Rachel had with her math teacher further propelled her to compete in math competitions, like Math Counts, during her eighth grade year, a critical aspect of Stage 1 development.

Once in high school, Rachel took four years of computer science electives, starting with a basic computer course on Excel. Rachel explains that she first enrolled in this course because the course description piqued her interest; this stems back to her increasing interest fostered during her Stage 1 of development. She also completed higher-level computer coursework, including topics in networking and programming. She received college credit by taking Cisco Networking courses, which Rachel says dramatically increased her interest in computer science. The Cisco Networking Academy Program, as described by the Cisco website, seeks to provide students with networking skills, which will prepare students for 21st century technology fields. While courses vary based on the participating high school, students must pass an exam at the end of the course in order to receive credit and a certification. Rachel's experience is denoted on her timeline by the second star.

Rachel explains that as she completed higher-level coursework in computers, her interest changed from a basic curiosity about how computers work to a desire to develop tangible skills that will allow her to *manipulate* computers; typically, this perspective is highlighted in Stage 1 of development for math and science but may be different for Rachel as she was exposed to computers at a later age. Rachel states, “When I started taking computer classes in freshman and sophomore years, I was interested in how computers work ... and how to make them think. And then I found out it was all by programming and ... I can learn to program and ... change what a computer does.” Additionally, Rachel seems inspired by discoveries and changes in the field of technology, particularly from companies like Google and Apple. She states that someday, she hopes to work for one of these companies.

Relationships

Rachel's early and middle years are highlighted by support from her family and then teachers. Rachel explains that she always felt supported by her parents to study a STEM field, particularly because they both have jobs in math and technology fields. Additionally, Rachel feels that her parents suggested she pursue a STEM field because “STEM careers generally pay better.” However, Rachel attributes her relationships with two of her teachers as having the greatest impact on her decision to study STEM in college. Rachel's timeline displays two stars that represent her relationships with these teachers.

During her middle years, Rachel's enrollment in a sixth grade math class with an enthusiastic teacher spurred her intense interest in mathematics. Rachel explains, "I initially just liked math, but then I loved it after sixth grade because of the enthusiasm of my sixth grade math teacher." Rachel remembers a classroom project in which students were divided into small groups and created songs about different math topics. Rachel recalls creating songs to remember order and operations and listening to her peers' songs. She remembers this as an exciting time in her education.

As Rachel entered high school, her interest in STEM fields continued to grow and then flourish with the support of another "enthusiastic" teacher. Rachel explains that in her Cisco course, her teacher gave her individualized instruction and attention. This teacher represents a critical person in Stage 2 of Rachel's experience, a teacher with specific skills in computer science who made her feel special. Rachel explains, "he would focus on helping me learn and improve and he was so supportive in class so that every day I could learn something new." Rachel feels that her teacher taught her to look at how minor details affect the overall success of her projects. Rachel states, "He taught me to look at the big picture and see, go back and check each step, just to be more precise, and check my work and gain more accuracy." Through the direction of this teacher, Rachel feels that she received a strong preparation to continue her coursework in computer science. It was also during this course, as discussed earlier in her *Experiences* section, that Rachel decided to pursue a college degree in computer science.

Barriers

Rachel explains that she has not had any specific challenges in school or in deciding to major in computer science when she enters college. However, she recognizes that the coursework in computer science can present barriers for some students and she offers the following advice on how to encourage more female students to study STEM fields: "Although it may be challenging, if they see how it can be used in real life, STEM courses can open doors to a lot of opportunities. We know that jobs usually pay better than other majors, you can never get bored with it, and you're always discovering new things to discuss. The whole world will advance with STEM." Through this quote, Rachel expresses her belief that studying a STEM field will provide an individual with more financial security and opportunities to consistently engage one's mind in complex issues. Additionally, Rachel's quote portrays her belief that individuals and society will benefit tremendously from the knowledge gained through STEM.

Bloom's Stage Analysis

For Rachel, Bloom's Stage 1 is highlighted by supportive parents, and an enthusiastic sixth grade math teacher, who made her feel special. Rachel's experience varied from Bloom's model, in that, she began to think of computers in a different and unique way, a key feature of Stage 1, during her high school years. It is clear that Rachel thought of mathematics as an engaging topic and challenged herself in this course, but her interest in computers, her STEM field, did not peak until later in life. It is unclear the reason for this but it may be as simple as her exposure to in-depth aspects of computer science were limited prior to her computer coursework.

For Stage 2, the middle years, Rachel felt special in her computer science class because she was enrolled in the Cisco program and had a teacher who worked directly to modify and challenge her. Further, one could argue that Rachel's experience in her Cisco program with her teacher, may suggest that Stage 2 and Stage 3 are overlapping in her story.

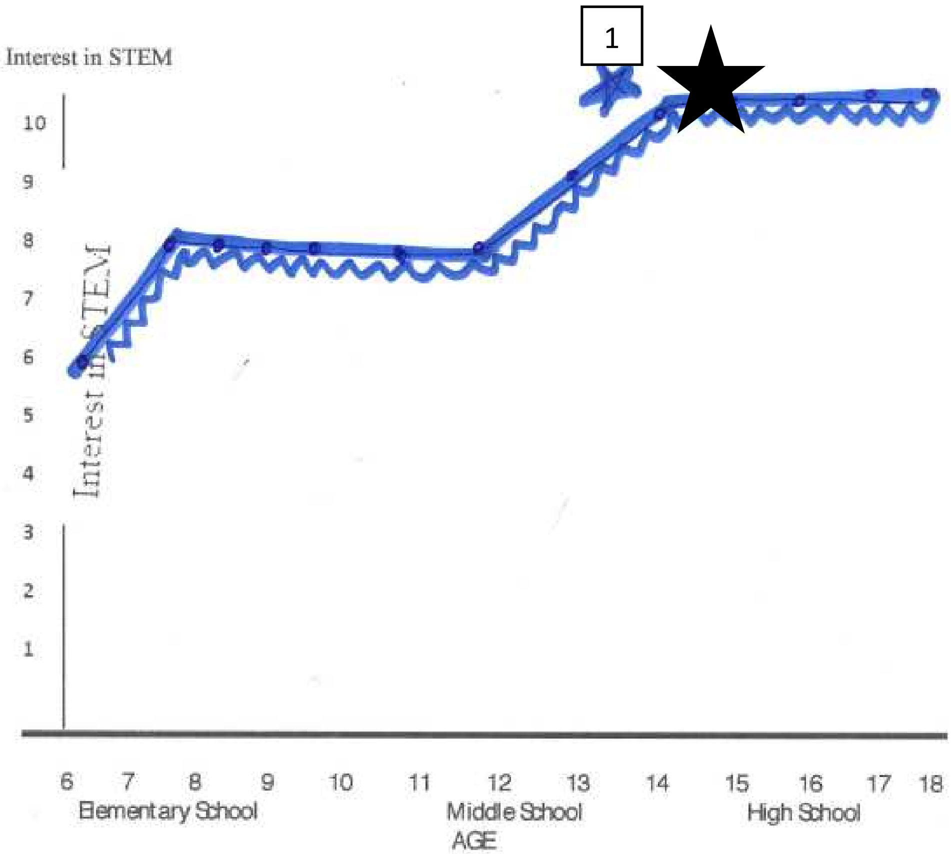
Although it is unclear if Rachel's Cisco teacher is a master in the field, Rachel did learn the "insider practices" of this field. Further evidence of Stage 3 experiences suggest that while earning college credit in the Cisco program, Rachel was exposed to real tasks in the field of computer science. Rachel also articulated clearly her desire to pursue a specific career in computer science, another key feature of Stage 3. The disconnect between Rachel's experience with a Stage 2 and Stage 3 teacher suggests a need for revision of Bloom's 3-Stage Model.

Natalie: Biochemistry

Natalie, a Caucasian student, attends a suburban, public high school, where she has maintained a 97 GPA during her time taking advanced science and math courses. Natalie plans to major in biochemistry, or a double major in biology and chemistry once enrolled in college next year. She additionally hopes to enter medical school after college graduation. For her elementary and middle school years, Natalie attended a small parochial school. She then transferred into a larger suburban high school. Throughout her K-12 education, as seen in Chart 4.3 below, Natalie's interest in STEM has increased overall and plateaued at times.

Chart 4.3

Natalie's Timeline



Experiences

Natalie feels that her opportunities to study science were limited during Bloom's Stage 1, elementary and middle school, because there was not much time dedicated in class to this subject. She says she has always had a passion for science, but when she began taking high school courses, her interest in STEM fields increased. During Stage 2 of her development, Natalie reflects on her high school chemistry course and remembers that her teacher provided in-depth knowledge of both math and science topics, which Natalie says influenced her to explore these fields more seriously. Natalie's special relationship with her chemistry teacher will be described in the *Relationships* section below; this relationship correlates directly with key characteristics of Stage 2. In Natalie's timeline, it is clear that as she transitioned into Stage 2, from middle school to high school, her interests in STEM grew. She states that the only star on her timeline represents this academic change in her coursework and her experiences in extracurricular programs.

Natalie notes that during the summer before she entered high school, she attended a one-week program at Rensselaer Polytechnic Institute on forensics. In this program, in which her mother enrolled her, Natalie saw connections to science and the real world. In the program, Natalie collected evidence and solved crimes utilizing forensics. As she thinks back on her experience at Rensselaer, Natalie recognizes that the forensics topics that she was engrossed in applied and connected directly to her high school science coursework, which further increased her interest in her science courses. Natalie's experience directly corresponds to Bloom's description of how experiences can build student confidence and interest, particularly during Stage 2, as this stage introduces students to intricate aspects of a field of study.

During the summer between her sophomore and junior years, Natalie also participated in a medical program called the Global Youth Summit in Future Medicine in Boston. This program influentially exposed Natalie to opportunities in the medical field. While in Boston, Natalie visited medical schools, shadowed doctors, met with students, and learned about a host of medical-related professions; this exposure to experts in the field is a key feature of

Bloom's Stage 2. She feels that this experience "cemented" her decision to pursue science, specifically, a pre-med track in college. Natalie explains:

> I really enjoyed high school biology, which I took in eighth grade; chemistry, which I took as a freshman; and the general science that I learned throughout elementary school. I found these courses interesting, so I looked for opportunities related to science. I attended a forensic science summer program at a local college before high school. This program partially inspired me to take many science and math courses in high school. I also attended the Global Youth Summit on the Future of Medicine in Boston in 2013. This summit fascinated me and cemented my desire to pursue science in college.

In this quote, the link between Natalie's science coursework in school, her experiences in the forensics and medical programs, and her decision to study a STEM field in college is clear. The next section of this study will focus on how the relationships Natalie developed within these programs and classes also impacted her interest in STEM fields.

Relationships

Natalie explains that her parents have always been supportive of her academics and they have encouraged her to take challenging courses while she was in elementary and middle school. However, she does not feel that they dramatically influenced her decision to pursue a STEM field. The support of Natalie's parents correlates with Bloom's description of Stage 1. Once in high school, Natalie's interest in math and science grew with the support of two teachers in algebra and chemistry. The development of relationships with two teachers, in her field of interest, links directly with Bloom's Stage 2. Natalie describes her algebra teacher as passionate about his teaching as well as the integration of science and math. She explains that in addition to being a math teacher, he also had a strong interest in science, as his background was in the science field. In his course, he focused on engaging students in the scientific application of math topics, which peaked Natalie's interest in working with multiple STEM disciplines simultaneously.

In addition to her algebra teacher, Natalie also describes her chemistry teacher, "Mrs. K", as passionate, fun, and able to relate chemistry to everyday life. While in chemistry, Natalie often felt unchallenged by the coursework. She notes that Mrs. K. made a particular effort to modify the curriculum and provide Natalie with more challenging work; as described by Bloom's Stage 2, Natalie's teacher made her feel special. Natalie states,

> I always looked forward to her class. Mrs. K. taught me so much, but she also encouraged me to pursue science further, at least in high school ... I found the class to be too easy, and I should have been placed in the honor level. Mrs. K. realized that I wanted to learn more, so she would teach me more than the curriculum called for.

Natalie also notes that Mrs. K. encouraged her to not only pursue general science courses in high school, but to also challenge herself through honors and advanced placement courses. Mrs. K. positively contributed to Natalie's academic success in many ways. She actively engaged and interested Natalie in the curriculum. She also modified and pushed Natalie to work on more challenging content, which helped Natalie feel confident about her abilities in science. In these ways, as described in Bloom's Stage 2, Natalie had access to two teachers in her field who were enthusiastic, encouraged her interests and also made Natalie feel special.

Finally, in addition to teachers, Natalie feels that the counselor in her medical summer program also inspired her to pursue studies in science. During her weeklong experience in the Global Youth Summit, Natalie worked with a counselor who was also a medical student; this suggests that Natalie moved into Stage 3 of Bloom's development since she was both exposed to an expert in the field as well as began to learn about intricacies of medical careers. The counselor oversaw Natalie's work in the program and provided Natalie with a firsthand experience of the medical field. Natalie feels that by working with this counselor and speaking with her about the realities of medical school and her struggles and challenges as a medical student, Natalie became more confident in her decision to attend medical school in the future.

Barriers

The greatest challenge in Natalie's experience with STEM relates to a lack of support from the guidance department. Upon entering her public high school, Natalie's guidance counselor was reluctant to give her credit for a high-school-level science class that she took at her private middle school. After much negotiation with the school, she did receive credit, but Natalie says the experience was discouraging. In addition to this frustration, Natalie also had difficulty enrolling in the courses she found most interesting. Natalie pushed to take courses that she was passionate about and not courses that had been prescribed for her based on her grade level. This meant that each year in high school, Natalie had to receive special permission from the guidance department to take science courses out of sequence. Natalie expresses frustration that her school did not support her decision to pursue sciences of her interest. Despite this challenge, Natalie was able to enroll in the science courses she wanted, and as her timeline shows, she maintained a strong interest in science and math throughout high school.

Bloom's Stage Analysis

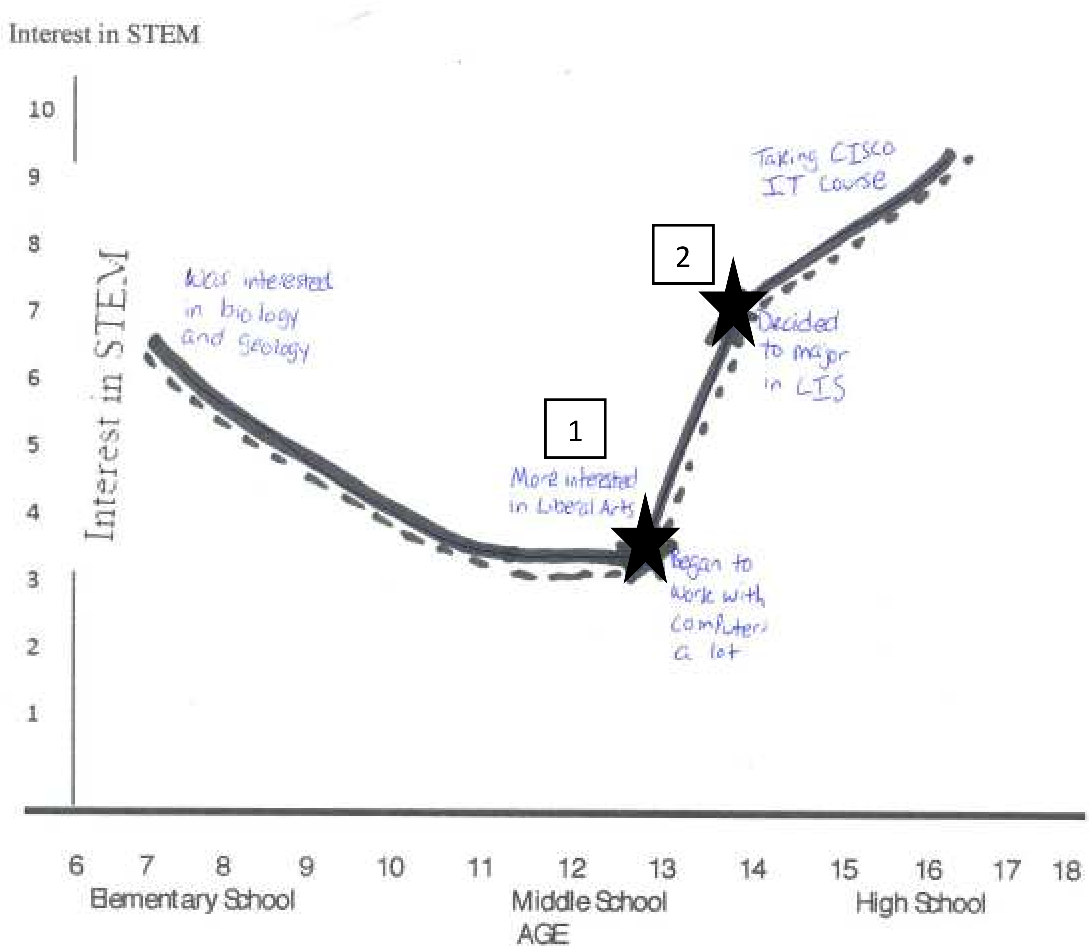
Overall, Natalie's decision-making process coincides with the key characteristics of Bloom's 3 Stage model, in particular, the development of relationships with teachers during Stage 2. One key difference is the lack of prominent experiences during her Stage 1 time period, elementary and middle school. Since science coursework is salient to Natalie's decision to major in biology, it makes sense that the lack of coursework during elementary and middle schools may account for this difference in Stage 1. Also, it is important to note that Natalie had exposure to fields in medical careers during her experience at the Global Youth Summit; this experience seems to have transitioned her to Stage 3 of development particularly because she had an opportunity to work directly with a medical student and learned about specific aspects of medical career. Although as mentioned in other participants' stories, this experience took place also when Natalie was working with her Stage 2 teachers, thus, suggesting that there is a continuum of time where multiple stages may be taking place.

Kacie: Computer and Information Science

Kacie, a senior in high school, attends a small, suburban high school and plans to attend college with both a major in Computer and Information Sciences and a minor in business. During her time in high school, Kacie enrolled in, and received college credit through, the Cisco program, which is the same program as discussed in Rachel's section. After college, Kacie hopes to either build her own technology business in which she will make personalized devices, or work as a computer information specialist while running her own tea shop. According to Kacie, her decision to pursue a career in computer science was influenced by her family, the courses she took in school, and a close friend. The diagram, Chart 4.4 below, shows how Kacie's interests have changed throughout her K-12 education.

Chart 4.4

Kacie's Timeline



Experiences

As shown in Kacie's timeline, she had a strong interest in geology, specifically playing with rocks, during her elementary school years. A budding interest in science and playing independently is common in Stage 1 of development. Once in middle school, Kacie faced some personal challenges, including bullying and an anxiety disorder. At that time, she focused more on liberal arts like literature and writing, which can be seen by the decline in her timeline during her middle school years. Kacie describes writing as an outlet that helped her deal with personal difficulties. However, as a result of a friend's encouragement, Kacie began to play video games online. She explains that her experience with these games, and her digital interactions with peers from around the country, sparked her interest in computers; this represents the first star on her timeline. According to Bloom's stages, this development of interest as a result of a relationship with a peer is unique, however, we could also consider Kacie's friend a mentor as well. Kacie adds that computers provided her with a safe space and encouraged her to positively interact with her peers on a social and emotional level during a time in which she was not comfortable doing so with her peers in school. Kacie states, "When I met a couple friends online who were very good (at games) and interested in computers and talked about computers ... they would talk with all the jargon I didn't understand ... I realized how much I liked it. I didn't want to be left out and that is when my (STEM) interest incline started again." Through the video game, *League of Legends,* Kacie found her place in a community of people with insider knowledge about computers. As expressed in Kacie's quote, the *League of Legends* community introduced her to a new world and, as she later explains in our interview, one that helped her overcome her mental health struggles; in other words, during this stage, Kacie felt special in this community. Kacie's involvement with the *League of Legends* community gave her the confidence to decide to major in computer science, which then put her on the path to enroll in the Cisco program.

Bloom's Stage 1 suggests that students may develop an interest in studying their field at a deeper or more abstract level; Kacie feels that her interest in video games propelled her to explore computers in this way. She states,

> I picked up video games as a hobby, which is really what first got me more in-depth interested in computers, because at first I just used computers, but once I really began to think about how they worked, how to improve performance, and how I could manipulate them to whatever I wanted to do, my interest in that really grew.

Kacie's use of video games pushed her to consider, not just basic-level use of computers, but also how she could use computers to create and manipulate video games. In our interview, Kacie connects her experience with video games and the online community to her academic and career interests by recognizing her unique role as a woman in the computer space. She states, "I realized there was demand for women in this field ... and it would be a wise decision to incorporate that more into my future plans. That's when I enrolled into Cisco IT, which I am nearing completion of for college credit." As seen on her timeline, Kacie first decided to major in computer science and then, as shown by the second star, enrolled in the Cisco program.

According to Kacie, the Cisco program exposed her to both basic and abstract computer concepts in a formalized classroom setting. Kacie describes the program, which is broken into two separate classes, as first an introduction to hardware and building computers, followed by networking and systems analyses. Through this program, Kacie received college credit, which she hopes will allow her to take extra classes or even to graduate early. Kacie found the Cisco activities rewarding. She worked to refurbish donated computers for the Computers for Kids program, and she then trained families on how to use the refurbished computers.

Relationships

In Kacie's family, there are two major individuals who influenced her decision to major in computer science: her father and grandfather. Kacie's father works in the technology field as a systems analyst and has encouraged her to consider a career in computer science with a specialty in an area like security. Kacie feels that her father provided her with access and exposure to unique computer topics as well as a preview of future careers, a key part of Stage 3 development. In many ways, Kacie had exposure, through her father, to an expert in the field during her Stage 1 development. Kacie explains, "My father teaches me things about computers that I mightn't learn in a classroom and gives me insight into what CIS (computer information system) jobs are like." These supportive family relationships are a cornerstone of Stage 1 talent development.

Kacie also explains her relationship with her grandfather, which she says encouraged her curious nature and unveiled her passion for teaching others about computers. Kacie explains that her grandfather did not know a lot about computers and she would often show him how to use a computer and answer his questions. She expresses particular excitement that her grandfather was so interested and curious about computers, even though "most old people don't like computers." While working with her grandfather, Kacie saw how hard he worked to learn new things and this propelled her to have a similar perspective on her academics.

Along with Kacie's father and grandfather, she also attributes her interest in computers to her friend who introduced her to *League of Legends* during her difficult middle school years; this transition from supportive family to a mentor with insider knowledge of computers shows Kacie's movement from Stage 1 to Stage 2. According to Kacie, this friend graduated high school early and has developed a very successful app. She notes that the strong uptick in her timeline during middle school, and first star, represents her friend's influence. Kacie says he encouraged her to actively learn and create technology. He also supported her as one of the few female participants in the *League of Legends* community. During my interview with Kacie, she became quiet and tearful when reflecting on her friend's encouragement and acceptance. She feels that their relationship not only sparked her curiosity in computers, but also introduced her to one of the first communities in which she felt accepted and special, a key aspect of Stage 2.

Barriers

Kacie doesn't believe that she has faced any real challenges in her decision to study a STEM field. Despite being the only girl in her Cisco program, she explains that she always felt accepted by her peers. One potential barrier, however, could be Kacie's decision to pursue computer science in college rather than a liberal arts field. Although Kacie does not identify this as a barrier, she did struggle with her decision to pursue computer science over something like literature. Throughout her education, along with computer science, Kacie also had a strong interest in liberal arts and even in fields like Psychology. Kacie explains that her interest in liberal arts is still strong, but when factoring in finances, the draw to be a computer scientist is stronger:

> I was really passionate about literature and potentially therapy and liberal arts, that would be my emotion brain thinking but I also have this logic brain thinking I need to enter a field to make money and to support yourself and to establish yourself in career and I was faced with balancing those ... everybody says do what you love, but then don't give up your day job kind of thing. Computer science is to me combining my interest and economic decision.

This quote shows that Kacie's desire to pursue liberal arts has been outweighed by her desire to enter a field with stronger job prospects and higher pay. In my interview with Kacie, she further expresses her concern about majoring in a field like psychology because her starting career may be part-time or even clerical in nature. However, in computer science, she feels that she would find a job of her choice and be in a position to actively make an impact on the world.

Bloom's Stage Analysis

Kacie's development of talent in computer science in unique. First, during her Stage 1 development, which seems to span from elementary to almost high school years, Kacie felt supported by her family but also learned insider knowledge about computers from her father, usually a Stage 3 characteristic. This suggests that Kacie had a distinctive exposure to computer topics and careers from an early age while her initial interest was developing. Also, Kacie's interest in abstract thinking about computers, a feature of Stage 1, seems to have taken place during her late middle school years. This is later then typically described by

Bloom but may be because of her exposure to computers at a later age. Kacie's experience suggests that a revised model, one which is not linear in nature, may be necessary to analyze Kacie's path to majoring in computer science.

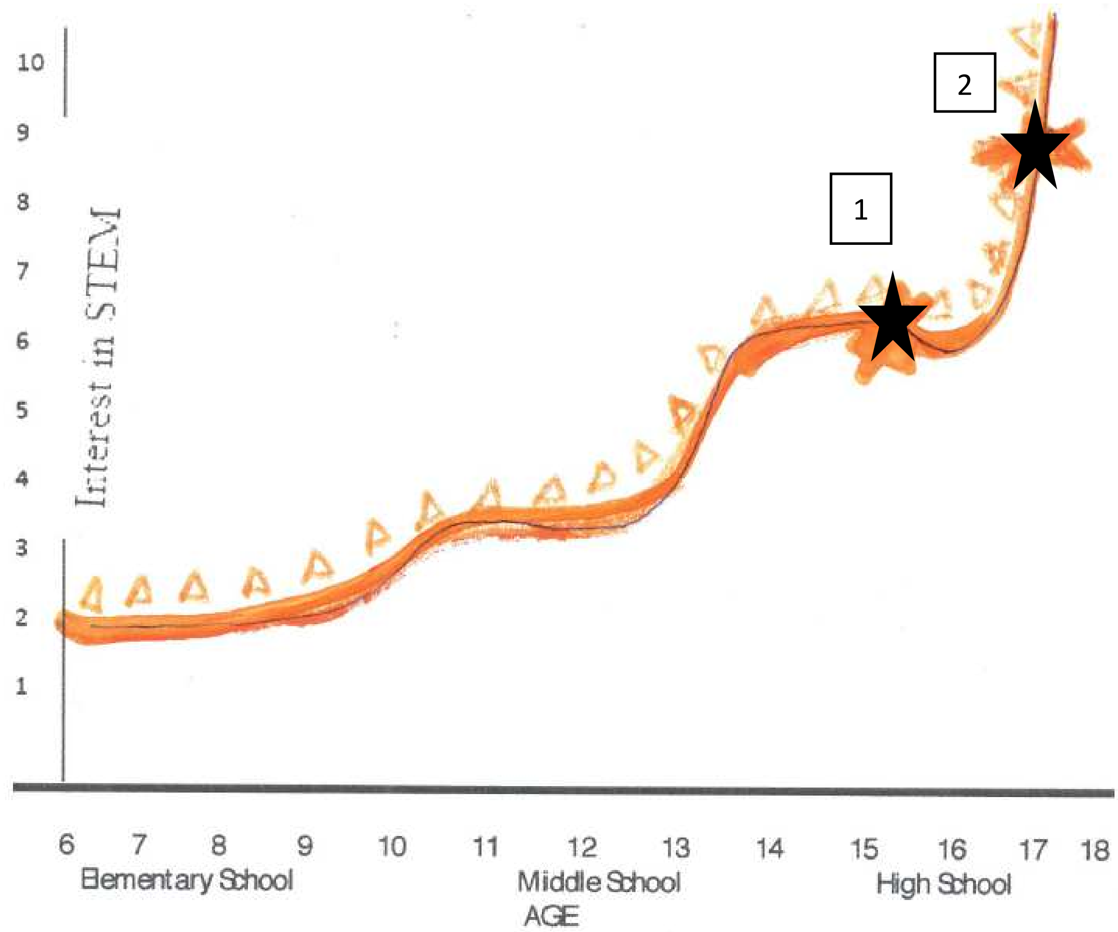
Kacie's transition to Stage 2 is highlighted by the development of a relationship with a peer. However, according to Bloom's stages, Kacie's friend really acted as a mentor; he exposed her to a community of gamers, and helped her to engage, deeply, in the field of gaming, and hence, computer science, which made her feel special. Through this experience, Kacie felt propelled to pursue the Cisco program, and earned college credit; this exposure to higher-level coursework signals her movement into Stage 3. Also, unique to Kacie's decision-making process is that she had no teachers who influenced her at any stage, and seemed, rather, to rely on her father's access to insider knowledge throughout her education.

Lucy: Engineering

Lucy, a Caucasian student, attended a large, public high school where she has earned a GPA of 98 while enrolled in a New Visions STEM program during her senior year. Lucy plans to attend college in the fall of 2015 with a major in engineering. While she is not yet certain which engineering field appeals to her the most, she does have a preliminary interest in chemical and mechanical engineering. After college, Lucy hopes to continue her studies in engineering and pursue an advanced degree. Chart 4.5 below shows how Lucy's interests in STEM fields, and engineering in particular, have grown throughout her education.

Chart 4.5

Lucy's Timeline



Experiences

Throughout her elementary years, Lucy enjoyed reading and English classes, but as she approached middle and high school, she began to find these classes less fascinating and challenging. Conversely, during this time, Lucy's interests in science and math grew. However, when Lucy was not accepted into an advanced mathematics class in middle school, her increasing interest in science and math leveled off, which can be seen on the diagram during her middle school years. As Lucy continued into high school and her coursework began to focus more heavily on math and science classes, her love of these subjects began to redevelop; the first star in her timeline shows this change. In particular, earth science, chemistry and pre-calculus were courses during her sophomore and junior years that helped solidify her interest in STEM. Along with these courses and the encouragement of her friends, family, and teachers, Lucy was encouraged to apply for the New Visions STEM program during her senior year of high school.

Lucy explains that the STEM program, a special experience as described by Bloom's Stage 2, provided her with unique opportunities and exposure to STEM fields, like engineering. Instead of attending her high school for a full day, Lucy went to the STEM program for half of each day throughout her senior year. In this program, Lucy worked with a teacher and a small group of students on real-world engineering design projects like protecting homes from forest fires. This group traveled to a host of locations throughout the area to learn about STEM fields and jobs and to meet individuals who worked in these fields, a key feature of Stage 3. In addition to learning firsthand from these one-of-a-kind experiences, Lucy also competed in a Lego robotics competition and won. Finally, as part of the STEM program, Lucy also enrolled in Physics I and II at Renssalaer Polytechnic Institute (RPI). She attended class on-campus with the general population of college students and received college credit for completing these courses.

Lucy describes her experience in the program and her desire to be an engineer:

> This experience has been absolutely amazing and it completely solidified my love for math, engineering, and science. We were able to tour different engineering firms and companies throughout the year and take RPI Physics classes with actual (college)

> students. Around Christmas time, we were asked to make and program LEGO robots. I actually won the competition and after this project, I knew that I would become successful as an engineer. It was also a lot of fun.

Although the program, as a whole, represents the second star on Lucy's timeline, she seems particularly influenced by her experience at RPI. While taking classes at RPI, Lucy collaborated with college students, interacted with college professors, and also had the authentic opportunity to experience the life of a college engineering student. She says, "It was nice to get hold of what I would have to do in college and know about the struggle." Lucy recognizes that taking college-level physics courses was a challenge, but she acknowledges that was a struggle she could handle. Overall, when asked to explain the changes in her timeline and her desire to pursue engineering in college, Lucy states that she feels engineering was intrinsically interesting to her and it provided her with an opportunity to contribute positively to the world:

> At first, I was opposed to it (engineering), but as I looked into it more I found it to be such a versatile field with so many opportunities. I enjoyed learning about how things worked and the mechanics behind objects, automobiles, and planes fascinate me and I really want to make a difference. Engineering seemed like the perfect way to make all of this possible.

For Lucy, the engineering field provides unique opportunities, which coincide with her values. In particular, Lucy values that engineering provides her the chance to pursue her interests, while also helping greater society.

Relationships

Lucy recognizes the critical role that her parents have played in encouraging her to focus on STEM fields. Her father is an engineer, and when she expressed interest in this field, he would actively discuss all the opportunities an engineering career could provide. However, Lucy emphasizes that her parents supported her in *any* endeavor, and she notes that, at one time, she wanted to be a pilot and her parents supported that dream as well. Lucy's sentiments echo the description provided by Bloom of Stage 1 development and support of parents.

In addition to her parents, Lucy also felt encouraged to study STEM fields by her ninth grade earth science teacher, who coincides with Bloom's description of a Stage 2 teacher. Lucy's teacher influenced not only her interest in science, but also her plan for pursuing science throughout high school. Lucy states, "I had an earth science teacher in ninth grade who made science extremely easy to understand and was always willing to talk about the course work and help in any way. She told me about all the classes I could take the next three years and really pushed for me to do the best I could." Lucy also explains that her earth science teacher made the effort to contact Lucy's mom about her potential in science; in this way, Lucy's teacher made her feel special. This then led Lucy's mom to encourage Lucy to take advanced coursework in science. Lucy went on take two advanced placement courses in science during her high school education as well as two physics courses at RPI.

Lastly, Lucy also describes positive relationships with her pre-calculus and STEM program teachers as influential to her overall decision to pursue STEM in college. She explains that, "teachers who were excited about subject matter I liked better than the (other) teachers. The ones who were excited about classes made me excited too." For Lucy, her teachers' enthusiasm and interest in their content was incredibly inspirational and sparked her interest in these subjects as a result. These two teachers again highlight Stage 2 enthusiastic teachers who worked directly with Lucy and made her feel special.

Barriers

Lucy states that she faced two differing challenges in her decision to study engineering in college. First, the small, private school she attended in middle and high school did not offer high school courses in advanced science and math. With the support of her parents, Lucy decided to transfer to a different school, which offered advanced and honor level courses. This experience shows how supportive parents, during Stage 1 development, helped further Lucy's pursuit of studying a STEM field. Lucy explains that socially, it was difficult to make this change, but she feels in the long term, she had made the right decision.

Secondly, Lucy also explains that one of her female friends was not supportive of her decision to pursue engineering. Lucy states that, "my one friend didn't (support me) and said something to effect of … 'Oh, you are going for engineering? That's what lesbians study.'" Although, in our interview, Lucy quickly changed the subject and did not want to discuss it further, it was clear that her feelings were hurt by this comment. This topic did not come up in our in-person interview or writing prompt again.

Bloom's Stage Analysis

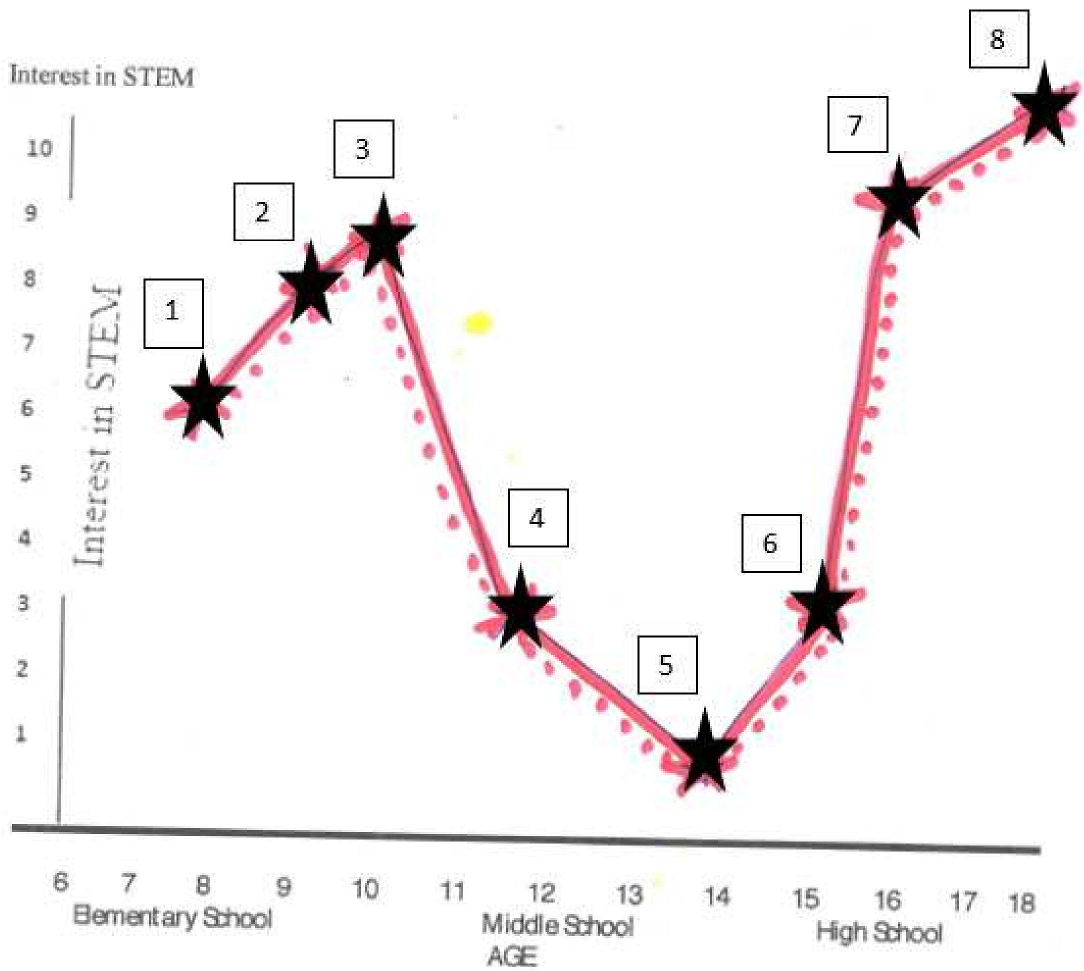
Overall, Lucy's path follows Bloom's 3-Stage development with a few exceptions. Lucy's description of her Stage 1 experiences highlight, as Bloom describes, how general interest in math and science was enough to spur a deeper interest in science, later in Lucy's life. Further, the support of Lucy's parents also was clearly present throughout her education. For Stage 2, Lucy had exposure to enthusiastic teachers who spurred her interests in STEM fields and encouraged her to apply to a STEM program. Perhaps, the most unique aspect of Lucy's educational path is her participation in the STEM program. This program exposed her to careers, college courses and experts in the engineering fields, which according to Bloom, would make this a Stage 3 experience. It seemed as though Lucy had an opportunity to truly enter into the field of engineering prior to enrolling in college, and thus, could experience life as an engineer and engineering student before she actually became one.

Leah: Chemical Engineering

Leah, a Caucasian student, attends a medium-sized, suburban high school and plans to pursue a double major in chemical engineering and French during college. Throughout her time in high school, Leah has maintained a GPA of 94. During college, Leah hopes to travel abroad, specifically to locations in need of engineering tasks, to better the quality of life for others. Once she has completed college, Leah sees herself using her language skills—she currently has a working knowledge of three languages—as a tool to support her engineering work. At the end of her senior year of high school, Leah felt strongly about her interest in engineering, which is depicted in Chart 4.6 below. Her interest in STEM fields, however, has drastically changed throughout her educational career.

Chart 4.6

Leah's Timeline



Experiences

Leah is able to clearly link experiences and relationships from elementary school that impacted her decision to study chemical engineering in college. For instance, the curriculum utilized by Leah's second and fifth grade teachers greatly impacted her interest in STEM fields. In second grade, Leah can remember that her teacher specifically provided her with more challenging, timed math tests than her peers received; this is a feature of both Stage 1 development. Leah explains that as she was successful on these more challenging tests, it "gave me a lot of confidence and started my love of math." As a result of these experiences, Leah's timeline shows that her love of STEM fields was high and growing throughout elementary school as seen by stars one and two in her timeline.

The third star, on Leah's timeline, during elementary school, represent her experience with a culturally based math curriculum during fifth grade. In this class, Leah learned to use mathematics as a tool to understand the lives of Mayans and how engineers created the Roman aqueducts. Throughout the course, Leah saw how math was used to impact lives and improve the lives of a community of people. In addition to this experience, Leah also notes that she fondly remembers going to Ellen's Universe of Energy in EPCOT Center in Disney World and finding it extremely fascinating. After elementary school, however, as shown in Leah's timeline by stars four and five, there is steep decline in her interest in STEM. She attributes this change to her parents' divorce and revealed that, in general, she could not focus in school and felt disengaged from learning; according the Bloom, during Stage 1 development, the support of family is critical and this feeling of support may have been disrupted.

During freshmen year of high school, Leah attended a Digigirlz event through her school; this event along with the development of a relationship with a teacher highlights Leah's transition to Stage 2. According to Microsoft's website (the host of this event), a Digigirlz Day provides students with opportunities to learn about careers in technology fields. Leah explains that this event "really opened my world to the possibilities science and engineering can make real." Through this opportunity, as well as through courses like chemistry, Leah began to visualize herself as an engineer. In class, she learned the difference between a chemist and a chemical engineer. She explains that chemists experiment with chemical substances, while chemical engineers work to make people's lives better by directly creating solutions to their problems. Throughout our interview, Leah frequently mentioned the term, "problem solver" in reference to the jobs and tasks of engineers that interest her most.

Relationships

As discussed previously, two teachers in Leah's elementary school inspired her love of math through their classroom pedagogical style. Leah's second grade teacher challenged her to complete more challenging math tests, and Leah's fifth grade teacher helped her realize how math has been used to solve problems throughout time; these teachers are unique, in that they both acted as Stage 2 teachers but were engaging with Leah during her first stage of development. Leah also had access to an expert in the field, a Stage 3 feature, during her earliest developmental stage. Leah's decision to study engineering seems to follow a non-linear and non-sequential path which Bloom's 3-Stage model does not provide for; this suggests that a model without a focus on a set time frame or set criteria for mentors may be more able to capture Leah's experience.

Leah also recalls how her uncle, a NASA employee, would encourage her to create theories about asteroids.   At an early age, he suggested that engineers were the people who solved the world's problems, and that she should consider studying a STEM field in college so she could do the same. At first, Leah seemed reluctant to consider her uncle's suggestions about her future. Leah explains that, "he always saw that I should be someone who should be going into STEM. ‘Oh,’ I just said ‘it’s my uncle, that’s just what he says. He’s being nice!’ But then it really did start to click with me." Leah began to take her uncle's encouragements with more brevity as she started to consider the opportunities and experiences that are available to her within the STEM fields.

In addition to these individuals early in her life, Leah also mentions her chemistry teacher, a quintessential Stage 2 mentor, as a major influence in her decision to pursue chemical engineering in college. Leah explains that:

> His willingness to help me ... he told me books and articles to look into. I got to see how everything that I thought, when I was younger, could be applied again ... that was when I saw all the power of chemistry and I was good at chemistry and that would be my calling and I could use that to find new ways to help people.

Based on the one-on-one attention that her chemistry teacher offered her, and her exposure to articles about chemical engineers helping people around the world, Leah feels that these were the salient factors in her decision to pursue engineering in college. She has a deep desire to help Africans who are living in villages without access to clean water, and she believes that with training in chemical engineering, she can help solve crises like these.

Barriers

Leah struggled in her decision to study chemical engineering for many reasons. To start with, Leah often felt pressure from adults to pursue her academic interests in fields like French and history. Leah states that she felt her history teacher wanted her to pursue a softer science. She explains, “My one teacher ... told me that the brain loves the poverty of the mind ... he thought I should pursue something like a language or history, or that I should be more of a softer science—like psychology—person." Leah also felt pressure from her guidance counselor to focus on French in college. For instance, during a meeting in her senior year, Leah's counselor suggested that she major in French since her grades in that subject were higher than her grades in math and science. Despite these individuals' opinions, Leah recognizes that, she does "love humans and humanity, and I want to help progress society, but if I went into any another field, I feel I wouldn't be able to make as much of an impact."

Although Leah feels that as an engineer, she will be able to most effectively and widely help people, she still expresses concern about her own abilities. She states, "If any, the challenge would be overcoming the doubt in myself that I'm good enough to be an engineer." In many ways, Leah sees engineers as the problem solvers of the world and she questions whether she can earn a place in this revered position. She expresses concerns that she may not be smart enough to become an engineer.

Bloom's Stage Analysis

Leah's path to engineering is distinct from Bloom's stages in that all the influential aspects of her development link with relationships from multiple stages. From Stage 1, in elementary school, Leah had access to teachers who acted as Stage 2 and 3 mentors. Leah described these teachers as influential because they focused on her learning needs, made her feel special and also exposed her to curriculum which used math and science to solve problems. Furthermore, during Stage 1, Leah described her family's support throughout her life but Leah also had access to a Stage 3 expert, her uncle, who encouraged her to pursue engineering at a young age. He exposed her to insider knowledge of this field as well as possible careers. As she continued to high school, and into Stage 2 of development, Leah also had an enthusiastic Stage 2 teacher, who helped to foster her interest in chemical engineering.

Despite these positive relationships Leah mentioned few experiences as influential, mainly a DigiGirlz event and an experience at Walt Disney World. Leah has not had an opportunity to research or complete tasks in the field of engineering which would highlight her entrance into Stage 3 of development. Further, although she had access to her uncle from a young age, Leah does not mention any other relationships with experts in the field. In many ways, this suggests that Leah will just be entering Stage 3 of development once she arrives at college and is exposed to professors and higher-level coursework.

Main Trends

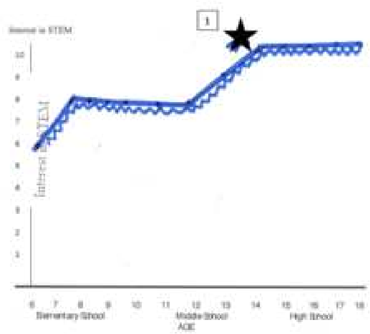
After presenting the narratives for the six participants in this study, common trends and outliers will be discussed in order to answer the research questions presented in this study using Bloom's 3-Stage model as a framework. We will consider each sub-section (experiences, relationships and barriers) for the entire group to address the first research question: *How do relationships influence female students' decisions to major in a STEM field?* Then, we will analyze the narrative of participants according to college major to answer the second research question: *How does the decision-making process, in which female students choose to major in a STEM field, differ based on the subject of interest (e.g., computer science versus mathematics or engineering versus chemistry)?* The fifth chapter in this paper will then discuss how and why these findings are important in the larger context of these specific fields, while also addressing further questions that result from these findings.

Table 4.7, shown below, provides a reference for all participant timelines identified by participant name and major.

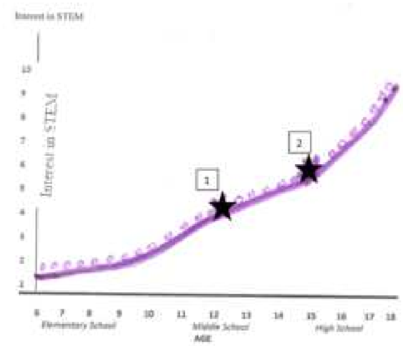
Table 4.7

All Participants' Timelines

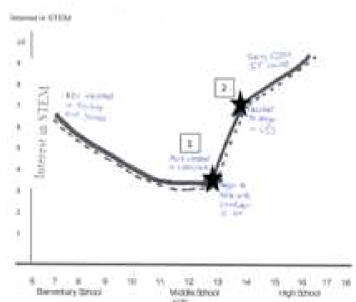
Natalie's Timeline (Biochemistry)



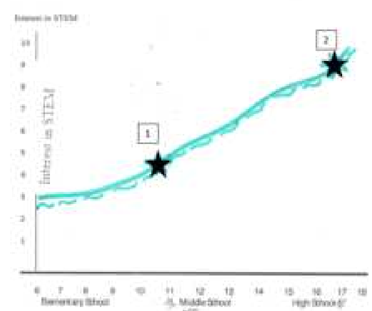
Sarah's Timeline (Biometry)



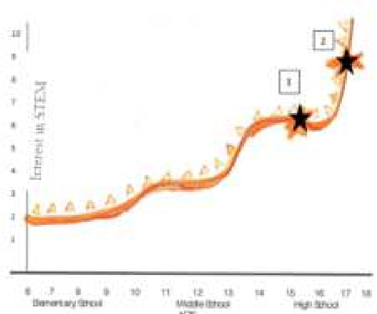
Kacie's Timeline (Computer Science)



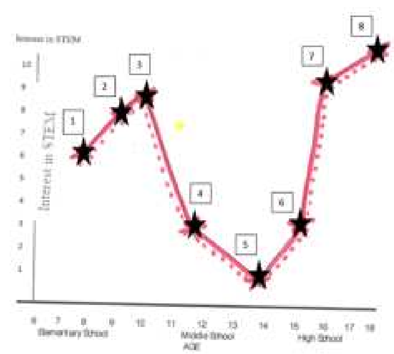
Rachel's Timeline (Computer Science)



Lucy's Timeline (Engineering)



Leah's Timeline (Engineering)



Discussion of Experiences

Overall, the participants in this study most frequently mention their experiences in Bloom's Stage 2 as critical to influencing their decisions to study a STEM field (Plant et. al, 2009; Hayden et al., 2011). A majority of the women (four of the six) entered elementary school with a low interest in STEM. Although Natalie notes that there were limited opportunities to study science before high school, these four women also fondly discuss STEM experiences in elementary school like playing with rocks (Kacie) or enjoying math, three of the four participants who entered elementary school with low interest in STEM (Natalie, Rachel, and Lucy), explain that they felt more interested in STEM fields as they entered middle school. These findings correspond with Bloom's first stage which suggests that interest in STEM fields is budding and can be developed with the support of family as well as influential teachers.

The two participants who had a high interest in STEM, not a typical feature of Bloom's Stage 1, at the start of elementary school were Sarah and Leah. Sarah recalls wearing a nametag with the words "future scientist" to a science fair. This nametag symbolized her initial interest in STEM, which steadily increased over time. Leah's experience in elementary school highlights a unique case in this study, and one that may shed light on ways in which elementary years can be used to promote female students' interests in STEM. While in second grade, Leah recalls that her teacher provided her with more challenging math tests on a regular basis; this bolstered her confidence and ability in math. Further, in fifth grade, Leah's teacher utilized a cross-curricular approach to instruction, which allowed Leah to see mathematics and science as tools to solve the world's problems.

Leah formed relationships with two teachers who acted as Stage 2 mentors during her first stage of development. While explaining her decision to major in engineering, Leah reiterates that engineers are the people who solve the world's biggest problems. This outlook is linked directly to her experience in fifth grade, and ultimately, her decision to major in engineering in college. Moreover, Leah is the only participant in this study who did not participate in a program that would introduce her to a community of STEM professionals. This makes her experience in elementary school one of the most significant factors in her decision to study a STEM field in college.

During the late Stage 1 and early Stage 2, around middle school years, participants describe few experiences as having influenced their interest in a STEM field. However, for four of the six participants (Sarah, Rachel, Natalie, and Lucy), their interest in STEM continued to increase steadily throughout this time. Rachel recalls how her sixth grade math class, in which students created math songs, helped to encourage her interest and confidence in math. She also remembers participating in a Math Counts math competition as another highlight in her middle school years. Additionally, Natalie feels that her experience at the RPI Forensics program, during the summer between middle and high school, steered her towards science courses in high school. Aside from these few instances, participants do not pinpoint middle school experiences that helped increase their interest in STEM.

Two participants, however, note a drop in interest in STEM fields during middle school for personal reasons (MacPhee, Farro & Canetto, 2013). For Leah, the divorce of her parents made her disinterested in school, in general, while Kacie faced bullying in school and disengaged from the school setting as much as possible. It is important to note how these personal factors seemed to negatively affect both students' interests in school overall, and not in STEM specifically. Bloom's model suggests that without the support of family, and also perhaps friends, it may be challenging for students to pursue their academic interests. For Kacie, the introduction into *League of Legends*, during this time period, helped her to overcome her anxiety about school and allowed her to find a role in a community. The theme of acceptance into a community, particularly during the high school years, is common among all of the participants, which we will now explore in more depth.

STEM Programs and Their Influence

Five of the six participants in this study joined a group or program during high school, which directly relates to their planned major. These STEM programs provided students with Stage 3 mentors and experiences, often while students were still developing in Stage 2. Hence, these STEM program may have acted as a developmental bridge for participants, ushering them from one stage to another. Table 4.8 below identifies the name of the program that each participant was a part of and provides a brief overview of the program.

Table 4.8

Participants' STEM Programs

Participant	**Program**	**Overview**
Sarah	Science Research program	Research done at local college with professor
Natalie	Global Youth Summit in Future Medicine[2]	Summer program shadowing doctors
Rachel	CISCO program	Computer programming courses
Kacie	CISCO program/*League of Legends*	Computer programming courses; Online gaming group

[2] Did not receive college credit for this summer program.

Lucy	New Visions STEM program	Engineering half-day program; Courses at RPI

For the women in this study, the hands-on opportunity to engage in their future major solidified their desire to pursue a STEM field. For instance, in reference to her experience in the New Visions STEM program, Lucy states, "This experience has been absolutely amazing and it completely solidified my love for math, engineering and science." Additionally, Natalie explains, "I also attended the Global Youth Summit on the Future of Medicine in Boston in 2013. This summit fascinated me and cemented my desire to pursue science in college." While it is certainly clear that these experiences were significant factors in each participant's decision to major in STEM, this study seeks to gain a deeper understanding of *why* and *how* they did so.

Exposure to Professionals in Their Field

Through STEM programs, participants had opportunities to learn about careers and opportunities in STEM fields by professionals in their field of interest; this is a unique feature of development in Bloom's Stage 3. In her program, Sarah was paired with a medical student and also shadowed doctors; Natalie researched in a lab with graduate students and a professor; and both Kacie and Rachel worked with a Cisco-trained computer analyst. Lucy, whose program specifically focused on highlighting multiple careers in STEM fields, explains that, "We were able to tour different engineering firms and companies throughout the year and take RPI Physics classes with actual students." These young women were exposed to professionals in their STEM fields, and in many cases, were given opportunities to work and establish strong relationships with these professionals over a long time period.

An excellent example of this is Sarah's experience in which she contributed to and worked alongside graduate students and professors to research blood thinners. As described by Bloom's third stage, STEM programs allowed participants, in high school, to preview life as a college student or professional in their STEM field.

Hands-on Projects

As described by Bloom's third stage, through STEM programs, participants completed a host of hands-on projects in their field, many of which represented actual careers in STEM. Lucy, for example, was engaged in the New Visions STEM Program by studying real-world problems like how to save homes from forest fires. As a result, Lucy plans to pursue environmental engineering once in college. Additionally, Kacie, who participated in the Cisco program, now plans to pursue a career in security as a computer specialist. Natalie, however, who had the shortest time in her program at the Global Health Summit (only one week), has not yet specified which field of medicine she plans to pursue. Through long-term programs, participants in this study developed intense interest, not only in the STEM field, but also in a targeted area within STEM. As Bloom describes, these experiences allow students an opportunity to develop ideas of their own future careers.

Insider Knowledge

Another critical aspect of Bloom's third stage focuses on opportunities for students to gain insider knowledge of their fields; through these STEM programs, participants had this opportunity. Kacie and Rachel both feel confident in their decision to study computer science because through their Cisco program they developed a strong knowledge of networking and programming. In fields like engineering and computer science, which are not traditional high school classes, STEM programs allowed participants in this study to learn about the intricacies of their field. This helped to build confidence in their abilities, which, as we will discuss in more detail in the *Barriers* section, is a major obstacle for participants.

These STEM programs also provided participants with insider knowledge of life as a college student in their field of study. For instance, when asked about taking Physics I and II at RPI, Lucy references her newfound understanding of college life when she says, "I know how to study. It was nice to get a hold of what college was like and how much effort I will need to put in." Since all except one of these women received college credit for their participation in their STEM program, participants were able to learn content that is critical to their planned major and get a jump-start on coursework. This experience also enabled participants to think more widely about their major, and to perhaps consider multiple fields of engineering, like Lucy, or a minor in business, like Kacie.

Acceptance into a Community

For the participants in this study, the acceptance into a community that mirrors a college and/or workplace setting has also been critical in their decision to study a STEM field. Acceptance into a community is described to some extent by Bloom's Stage 3 but not as extensively as participant's experiences may suggest. Sarah, for example, worked directly with a professor and graduate students in research labs in a science research program. She identifies the environment and small community within the lab as essential to her positive experience. She states, "There were two grad students I worked with a lot and everyone would go out to lunch together, I liked the environment a lot." By being included in lunch and working collaboratively with grad students, Sarah felt accepted as a positive, contributing member of their working community, which, as a result, increased her interest in the program and the STEM field in general.

Along with Sarah's positive experience of acceptance within her science research program, it is also important to note that none of the participants who participated in STEM programs express concerns about being welcomed into male-dominated fields. For instance, Kacie states ,

> When I became interested in computer science, I at first thought it would make me feel dorkier, but within those circles of computer science I've been really accepted and wanted and welcomed into computer science. My friend in Alabama, my peers in Cisco course, I am the only girl in course, but I usually don't feel like I am only the girl. That's kind of unexpected. A lot of times, when you think about women in these fields, you think they will be ostracized, left out, judged, or treated differently, but I haven't really experienced too much of that except for random people on the internet, but they don't matter. I haven't experienced that too much, which it has been heartening.

The positive relationships formed within these programs significantly contributed to participants' desires to continue pursing STEM fields.

This aspect of STEM programs may be under-utilized in Bloom's model. Bloom's model mentions the importance of developing a relationship with an expert in the field in order to gain content knowledge and learn practices to become a strong researcher; however, his model fails to consider how acceptance into a community, like Sarah's community in her SRP, may bolster student confidence and interest in a field as described by participants. In the next section, we will take a deeper look at relationships formed in these STEM program as well as others influential to participants' path to studying a STEM field.

Overall, the results of this study suggest that there may be compelling evidence to suggest that exposure to Stage 3 experiences, such as the STEM programs, may be critical and necessary to encourage women into STEM fields. Moreover, these programs, which are often completed during high school may be critical in allowing women an opportunity to "try out" life as an engineer, computer scientist or biologist. Once women in this study participated in these STEM program, their confidence increased as did their interest level; they knew that they wanted to pursue their STEM field because they had already had an opportunity to try it out.

Discussion of Relationships

As discussed in the previous section, experiences (like the STEM programs) provided participants with opportunities to meet professionals in their field of interest, work with peers, and establish themselves in a community; all key characteristics of Bloom's Stage 3. For some participants, the relationships formed within these STEM programs greatly influenced their decision to study their STEM field. For other participants, relationships established *before* entering a STEM program, usually in Stage 2, steered them towards a STEM field. All of the women in this study recognized that the support and encouragement of family members influenced their decision to study a STEM field. However, the degree to which family involvement aided their decision varies greatly. Five of the six women in this study were able to identify a high school teacher who provided them with individualized attention, modified curriculum, and also a "push" to study their STEM field of interest. We will explore these relationships in depth by first analyzing family relationships, followed by teachers. This section will explicitly seek to answer the first research question: *How do relationships influence students' decisions to study a STEM field?*

Relationships with Family Members

Although this study seeks to understand how interest in STEM develops over time, which ultimately leads participants to decide to study a STEM field, it is challenging, if not impossible, to separate the influencing role of parents and family members into separate time periods like elementary, middle and high school. Therefore, we will consider how family members played a role in participant's decision to study a STEM field as a whole and discuss time periods, whenever possible when referencing these relationships.

Parents' Role

For most participants in this study, parents played critical, yet varying, roles towards increasing interest in STEM fields. As suggested by Bloom's model, the overall support of family is critical to developing students' talent throughout their educational years but is a key feature of Stage 1. Sarah, Kacie, Lucy, and Rachel all explicitly link their relationships with their parents as crucial to their decision to study STEM fields. It is important to note that all four of these participants had a parent, or both parents, with current jobs in a STEM field. This suggests that even during Stage 1 of development, participants with parents in STEM fields were exposed to Stage 3 mentors. These participants explain that with a parent in a STEM field, they had insider knowledge and exposure to STEM careers outside of the classroom. An example of insider knowledge given by a parent is Kacie's father, a computer technologist, who provided her with a host of information about careers in technology.

Lucy's father, an engineer, exposed her to mechanics early on and this, she feels, helped encourage her to consider engineering as a profession. Rachel's parents, both in STEM careers, did not explicitly expose her to computer science, but did support her decision to study STEM fields because of the financial security associated with STEM careers. Lastly, Sarah's parents, both engineers, pushed her to consider a STEM field from a young age. Access to a Stage 3 mentor, at a young age, seems to have a salient impact on women's decision to enter into STEM fields.

Meanwhile, Natalie and Leah, whose parents do not have careers in the STEM field, feel that their families were generally supportive of their interest in STEM; this description of familial support mirrors Bloom's model. Natalie expresses similar sentiments as Leah, who explains, "My mom always supports me and tells me how proud she is of my decision (to study a STEM field in college)." While both participants feel supported by their parents, they were not specifically encouraged to study STEM fields, as was the case for the other four participants in this study.

Other Family Members

Aside from parental influence, Sarah and Leah can directly link their interest in STEM fields to an outside family member. Sarah states that her grandparents' suggestion that she consider a career as a doctor has resonated overtime with her. When asked whom she feels encouraged her most to pursue a STEM field, she says, "I keep going back to the doctor comment, which is in (the) back of my head." Additionally, Leah's path to engineering may have begun as a result of her uncle, a NASA employee and Stage 3 mentor, who encouraged her from a young age to think about engineering as a career; Leah's situation parallels with other participants who had parents in STEM fields. Her decision to study engineering is linked directly to her desire to problem solve, an interest she developed as a result of her Uncle's influence. Leah states, "What could have made me think that an engineer is (sic) a problem solver? It is probably from my uncle." Leah and Sarah's experiences have instilled strong sentiments towards specific STEM fields.

Overall, analysis using Bloom's model suggests that the role of Stage 3 role model, particularly when they are family members, may be a salient commonality among women who enter into STEM fields. Five of the six women in this study had a Stage 3 mentor as a family member, and most of the women cited this individual(s) as important in their decision to major in STEM fields. Bloom's model describes familial support generally but participants in this study suggest that specific, career-focused support of family may be more influential in steering women towards STEM fields.

Relationships with Teachers

While family relationships played varying rules of importance in participants' decisions to study STEM, for a majority of the women in this study, there was one high school teacher who significantly steered them towards a STEM major. Bloom's model describes this Stage 2 influential teacher as skilled in their field, enthusiastic, interesting and having the ability to make students feel special. Five of the six women in this study identified a Stage 2 teacher. Participants described a teacher (or two) who focused on their individual learning needs and interests, modified the curriculum in their course to challenge each participant, and guided them in conversations about their "next steps" towards pursuing a STEM field. These interactions built each participant's interest and confidence in STEM fields while also steering them towards a future in science. Further, as in Bloom's model, the theme of teacher enthusiasm is also a critical part of the connection between teacher and student. It is interesting to note that all of the teachers w were mentioned in this study taught a subject that relates directly to the college major in which each participant plans to enroll. We will refer to these "influential teachers" in Table 4.9 below.

Table 4.9

Influential Teachers

Participant/Major	**Teacher**
Sarah (Biometry)	Science Research teacher
Natalie (Biochemistry)	Chemistry teacher
Rachel (Computer Science)	Cisco program teacher
Leah (Chemical Engineering)	Chemistry teacher
Lucy (Engineering)	Earth Science teacher

To truly understand how these teachers influenced participants and bolstered their interest and confidence in STEM, we will analyze three key aspects of each student-teacher interaction: enthusiasm, individualized attention with modified work, and a push towards STEM fields.

Enthusiasm for Teaching, Content and Students

Participants regularly use the terms "enthusiastic" and "passionate" when describing their influential teacher(s); according to Bloom's model, these descriptions are characteristic of the most influential educators and mentors. According to participants, these teachers were passionate about both the content they were teaching and their interactions with students. Lucy explains that her earth science teacher, "really loved what she did, cared about what she did, and about science." These influential teachers also seemed to have a propensity to engage students in content by focusing on real-world examples. Natalie states that her influential teacher "was very passionate about chemistry and science, in general. She made the class intriguing and related everything we were learning to how it applied to our everyday lives. I always looked forward to her class." For many of the participants, teachers who were able to enthusiastically engage them in the content were the most influential in increasing their interest in STEM.

As also suggested by Bloom's model, there seems to be a deeper level to students' perceived notion of enthusiasm. For instance, through his enthusiasm, Sarah's science research teacher made Sarah feel as though her research and interests were unique and important. She explains, “My science research teacher has played a really big role… He knows what every single student is researching and he knows much more than I do and he didn’t even know (about the topic) until I picked it. He’s super enthusiastic about what everyone is doing, which really helps students want to do it." Throughout this section, we will see that teacher enthusiasm has also been a critical aspect for Lucy, Leah, Natalie, and Rachel towards encouraging them to pursue STEM fields in college.

Individualized Attention with Modified Work

As referenced above through Sarah's experience, the most influential teachers focused specifically on engaging each participant in content that they found interesting and challenging, which created a dynamic, engaging learning environment. Bloom's model also suggests that making a student feel special is critical to influencing students' development. According to participants, influential teachers identified that they were curious, special, and needed extra attention. The results of these interactions sparked a desire to attend class, a love of science, an interest in solving the world's problems, and an overall increase in interest as well as a knowledge of STEM fields. These Stage 2 teachers, as described by Bloom's model, typically are high school teachers with a strong content knowledge who directly engage students in learning.

When asked about her Cisco program teacher, Rachel says, "he could tell I was interested and he would focus on helping me learn and improve and he was so supportive in class so that every day I could learn something new." Individualized attention allowed Rachel's teacher to stimulate and encourage her specific interests in computer science on a daily basis. For Rachel, this made the class more dynamic. Additionally, Natalie attributes her love of science to the modified curriculum her chemistry teacher, Mrs. K., used to challenge her. Natalie explains that her influential teacher “realized that I wanted to learn more, so she would teach me more than the curriculum called for. Overall, Mrs. K. was a fantastic teacher and certainly contributed to my love for science."

In Leah’s experience, her chemistry teacher sought out a host of resources to inspire and engage her in real-world chemistry. Leah states, "He told me books and articles to look into ... when I saw all the power of chemistry and that I was good at chemistry I knew that would be my calling and I could use that to find new ways to help people." It’s interesting to note that the interaction between Leah and her chemistry teacher may also be cyclical in nature, i.e. the more individualized attention Leah was given, the more her teacher tailored content to her interests, which continually increased Leah's interest and her confidence in her abilities in chemistry. This cyclical pattern may also be relevant for all of the participants who describe a positive relationship with an influential teacher.

Push Towards STEM Fields

Once these influential teachers individualized instruction and modified curriculum to fit each participant's interests, they went one step further; they suggested how and what next steps participants should take to excel in STEM fields beyond their course. This action step is not described in Bloom's model of Stage 2 teachers and mentors; this suggests that revisions to this model may be necessary to capture the experience of female students pursuing STEM fields. This interaction is particularly salient to this study because it concretely shows how relationships between teachers and students can facilitate an action plan to pursue STEM fields. For example, Natalie explains that her chemistry teacher "taught me so much, but she also encouraged me to pursue science further, at least in high school." Natalie's teacher encouraged her to pursue honors and advanced placement courses as early as sophomore year and created a science plan for her for the remainder of high school. These actions taken by her teacher propelled Natalie on a track towards studying STEM in college.

In addition to working with their students to tailor course content and create a future STEM-path, these influential teachers also reached out to parents and guidance counselors to ensure participants were on-track to study science in the future. Lucy states that her ninth grade earth science teacher "told my mom I could do things, take courses ahead, and she pushed my mom who then pushed me. My mom pushed me because the teacher loved what she did. I loved the teacher because she loved what she did." Lucy's quote shows how a teacher's enthusiasm translates into concrete actionable steps for a student's future.

There are many possible reasons for the difference between this specific description of influential teachers and Bloom's model. Bloom's study, completed in the 1980s with participants who grew up in the 1960s and 1970s, may reflect a simpler time when coursework and choices were limited for students; hence, few students needed guidance on coursework beyond the traditional path. In 2015, there is no direct path through high school, and as described by participants' experiences in STEM programs, there are a host of opportunities available for secondary students now. However, Bloom's model does express the importance of teachers role in making students feel special; by helping guide students in course decisions and future plans, influential teachers most likely are creating this special feeling for their students.

Outlier Case with no Teacher: Kacie

One of the participants in this study, Kacie, does not mention or reference any teacher as being influential to her decision to study STEM. Although Kacie does not discuss this in her interview, it is important to consider her personal and social circumstances surrounding school. Kacie describes school as a place she avoided for long stretches of time due to her mental health issues, and she further explains that her online community of *League of Legends* is where she felt most accepted. It is possible to hypothesize that Kacie did not feel that school was a safe place to make strong relationships. It's also possible that no teacher presented him or herself as willing to actively collaborate with Kacie. Whatever the case, Kacie's path to STEM fields is unique, in that it shows that there are multiple entry points to pursue a STEM field.

Discussion of Barriers

Finally, to answer the first major research question of this study: *How do relationships influence students' decisions to major in a STEM field?,* we will analyze challenges that participants faced in their path towards STEM. Overall, most of the women in this study (except for Leah) feel that they only faced minor challenges in their decision to study a STEM field. Contrarily, Rachel does not feel that she has had *any* challenges in her path to computer science. For the other participants, however, three major themes presented themselves as challenges they needed to overcome: lack of confidence in oneself, issues relating to course selection, and a desire to study softer science or liberal arts fields. The influence of personal issues, like mental health and family situations, also played a hidden role in negatively impacting participants' interests in STEM.

Lack of Confidence

Two students in this study explained that the largest barrier they've had to overcome to pursue a STEM field is their lack of self-confidence. Sarah explains, "One of my biggest challenges is myself. Something might be too hard, or I think that I wouldn't be able to do something." While Leah states, "If any, the challenge would be overcoming the doubt in myself that I'm good enough to be an engineer." Both quotes suggest that these participants not only worry about their academic abilities, but also their belief that they are "good enough" to enter into STEM fields. Leah's quote, in particular, shows that her strong notion of engineers as the problem solvers of the world makes engineering a position of revered status and one that she may not feel confident maintaining. Similarly, as discussed in Sarah's story, Sarah feels that she may not be smart enough to study cancer research.

When both of these students were asked how they overcame their lack of confidence, Sarah suggests relationships as a critical force to build self-assurance. Bloom's model also suggests that relationships, particularly with family over the long term, help bolster confidence. She references the importance of her family's support and how they were always "pushing" her to continue. Sarah also mentions her experience working in the research lab as a salient factor in increasing her confidence. For Leah, she feels that personal reflection helped her to overcome her insecure feelings. However, she also specifically notes that her guidance counselor was of no help in overcoming this challenge, which suggests that Leah may have sought out support from her counselor and did not receive it.

Humanities, Social Science and Liberal Arts

Although Kacie expresses that she has not faced any barriers in her decision to study computer science, she does mention that she often feels pulled towards studying social sciences. Additionally, Leah explains that her history teacher and guidance counselor actively pushed her towards liberal arts. She describes her struggle as a question: "Do I want to go into humanities, does my brain only love the poverty of the mind, or is it that I actually love science and I can do this?" Leah and Kacie both regularly felt divided between two academic loves: humanities and science. In their interviews, they explain that they felt they had to choose one or the other and that there isn't a link between liberal arts and sciences. While Leah hopes to use French as "a tool" when working with people throughout the world as an engineer, perhaps a guidance counselor or teacher may have been able to help alleviate this "all or nothing" attitude of studying humanities or science.

Course Selection and Guidance

Along with the struggle to choose between the STEM and humanities fields, participants also faced challenges in selecting science and math courses that they felt would best prepare them for a STEM field in college. First, Natalie explains that each year, her guidance counselor urged her to take traditional coursework in science instead of more challenging, upper-grade science courses. For Natalie this situation was not only frustrating, but it also required the active involvement of her parents to negotiate with her guidance counselor. Secondly, for Lucy, her private high school did not offer advanced coursework, and as a result, she had to move to a different public school to gain access to these courses. In both of these participants' stories, in order to study STEM, concrete actions with the support of their families needed to be taken; this mirrors Bloom's models belief that generally family support is critical to developing talent.

When looking at the need for Natalie and Lucy to overcome their specific challenges, it highlights how important relationships with family are for students pursuing STEM fields. Both Natalie and Lucy needed the active support of their families to pursue science courses that would prepare them for STEM fields. Specifically, when considering how Natalie's guidance counselor played an active, negative role towards determining her science and math coursework—similar to Leah's experience, described earlier, who was urged by her guidance counselor to study history or French in college instead of engineering—it is interesting to hypothesize how and if Natalie would have even decided to major in STEM without her parents' intervention and support.

Personal and Family Issues

The final barriers, although not mentioned by Kacie and Leah as specific barriers, were their challenges with personal difficulties, i.e., parents' divorce and mental health issues. As highlighted by steep drops in both of their timelines, these personal difficulties impacted their interest and engagement in school and in STEM fields, overall. Personal difficulties may be a hidden barrier for students in poverty, those with mental health issues, or those struggling with conflict at home. Kacie and Leah's experiences show how all the aspects of a student's life, in and outside of school, can affect their academics.

No Challenges at All: Rachel's Story

An interesting outlier in this study is Rachel, who does not express any qualms about entering into the male-dominated field of computer science. When asked about the challenges she has faced, she explains that there were no barriers to her path to computer science. On the contrary, she feels, that her teachers, parents, and the offerings at her school were critical and beneficial to her ability to enter a STEM field. Rachel's path mirrors closely the three stages of Bloom's model, as she has support from family, influential teachers at all stages and also a keen interest in discovering abstract concepts about computers. She states that she "always had support from teachers and my parents. Luckily our school has lots of classes here ... Our school is very good at providing classes that help us do whatever we want." Rachel started high school with a basic computer class, Excel, and after years of computer science courses eventually took courses on programming. Through a structured, supportive course sequence, Rachel's confidence and interest in computer science was bolstered. Further, as discussed in the previous section, she received individualized attention from an influential teacher in the Cisco course.

Differences Between STEM Majors

The second research question for this study compares and contrasts the experiences and relationships for participants who plan to focus on different STEM majors: computer science, engineering, and biology/biochemistry. First, it is critical to note that within this study, only two individuals in each major participated, thus, making these findings merely preliminary. However, there seem to be strong signs of key differences between each major. We will consider each participant-pair's experiences and discuss how these are unique to their major using Bloom's 3-Stage Model as a framework.

Computer Science: Strong Confidence, Few Barriers, and Financial Motivation

Both of the female students that are pursuing computer science, Kacie and Rachel, express the fewest educational barriers out of all participants in this study towards their decision to major in computer science: Rachel, none at all and Kacie, a minor hurdle to decide between majoring in social sciences or computer science. Rachel's confidence in her decision stems from her four years of experience in computer classes, as well as the support from her Cisco teacher and parents; this experience closely mirrors Bloom's Stage 1 and 2 development. Kacie's confidence comes from her family's influence—particularly her father's insider knowledge of computer analyst jobs—as well as her active role in *League of Legends*; Kacie's path deviates slightly from Bloom's model in that she has a Stage 3 mentor, her father at an early age as well as a peer who acted as her Stage 2 teacher. As discussed in the experience section, their enrollment in the Cisco program also provided Kacie and Rachel with an opportunity to experience life as a computer scientist, a key feature of Bloom's Stage 3. Since both women thrived in this program, despite being one of only two females, they further developed confidence in their decision to study computer science. This suggests that a Stage 3 experience, like the Cisco program, may be a critical piece of steering women towards computer science.

Both of these participants also recognize that, financially, their role as a woman in the computer science field is unique and valuable. Kacie and Rachel are the only participants in this study who connected their major with finances. Both participants also suggest that their parents had a significant role in helping them understand how their future will be financially secure in computer science fields. For Kacie, finances truly pushed her towards computer science, while Rachel was interested in all STEM fields, but has a strong affinity for computers themselves.

Lastly, both computer science participants, as described in Bloom's model, expressed a keen interest in understanding, discovering, and manipulating computers at a more abstract level. Both students had access and opportunities to learn, not just basic computer skills, but also higher-level skills, like programming, which will allow them both to start college with a strong, working knowledge of computers and to possibly take higher-level courses as freshmen. However, in Bloom's model, this level of abstract thinking and engagement in one's field of interest is typical of Stage 1 development; yet, both participants in computer science developed this higher-level thinking while in high school. Perhaps, for computer science, a course not taught in the elementary setting, this level of abstract thinking may be more appropriate to consider at an older level when students have more exposure to coursework.

Engineering: Real-World Applications and Hands-On Learning with Male Relatives

The female engineers in this study, Leah and Lucy, both have a strong desire to help others using their engineering skills while challenging themselves to create and problem solve. Both women have developed a strong understanding of careers in engineering, a key feature of Bloom's Stage 3 model. Leah hopes to use engineering to provide clean water for Africans, while Lucy describes her desire to build homes that could resist forest fires. Both participants believe that engineers are the "problem solvers" of the world and want to actively pursue these fields in order to solve major world crises. Leah's quote summarizes both participants' feelings about engineering as a profession: "You get to problem solve and invent new ideas and your mind is constantly thinking and working." Both participants feel that a career in engineering would also consistently challenge their minds. This belief seems to stem from their early life experiences with male role models who introduced them to hands-on engineering and problem solving.

Both Leah and Lucy have male relatives, who, early in their lives, encouraged them to explore science-related topics in a hands-on way. For Leah, the opportunity to complete hands-on science resulted from interactions with her uncle, a NASA scientist, who encouraged Leah to hypothesize about asteroid development. Lucy worked with her father, an engineer, on machinery and cars. Both Leah and Lucy were able to explore topics in science under the guidance of Stage 3 experts at an early age. Both participants explain that these relationships peaked their early interest in STEM and engineering. Later in life, both Leah and Lucy actively sought out opportunities to pursue science and engineering in their education.

Biology Fields: Similar, Yet Differing Experiences

The two participants in this study, Sarah and Natalie, who are planning to study biology-related fields, describe similarities and differences in their paths to study a STEM field. Both students worked with Stage 2 teachers, and had experiences in STEM programs which exposed them to future careers and research in STEM fields. Although both participants feel they faced barriers, Natalie seems more confident in herself than Sarah, but faced frustrating challenges with her science course sequence, in which her guidance counselor made it difficult for her to take the upper-grade-level courses. Natalie acknowledges the support of her family, but feels they did not greatly impact her decision to study a STEM field. Sarah, on the other hand, feels she was pushed into sciences by her parents and grandparents at an early age.

When comparing the experiences of Sarah and Natalie towards deciding to major in biology-related fields, the differences outweigh the commonalities. Sarah and Natalie also have the most varied path towards pursuing STEM in comparison to the participants who are interested in engineering and computer science majors.

Comparing Biology with Engineering and Computer Science

To answer the second research question for this study, we will also compare the paths of participants with traditionally low-female enrollment (computer science and engineering) with high-female enrollment fields (like biology). Sarah and Natalie's paths to study biology were wholly different from each other and featured few similarities. This could be interpreted to mean that students who decide to major in a biology-related field may have multiple entry points to this major, like teachers, STEM programs, family influence, and course work in high school. A combination of any, if not all, of these factors can help to steer students towards biology fields.

The other participants in this study had specific aspects of their paths in common, which suggests that limited options exist to expose young women to engineering and computer science. For example, participants who plan to pursue computer science in college were all enrolled in the Cisco program and expressed few, if any, barriers to studying computer science as a major. For participants who plan to pursue engineering, they have the same perception of engineers as the world's problem solvers and were also exposed to hands-on engineering with a Stage 3 expert early in life. Additionally, these participants also had positive interactions with a STEM teacher during Stage 2 of development or a positive experience within a STEM program. These factors could be interpreted to mean that computer science and engineering have limited entry paths. For example, the Cisco program is a significant factor linking female students to future majors in computer science. However, if a school does not have this program, what other paths are available to steer women towards computer science? Further, for women in engineering, the belief that engineers are problem solvers seems to stem from relationships with family member experts and teachers. However, if female students do not have access to relationships like these, how else can these women be encouraged to enter engineering? Perhaps since the decision-making process for computer science and engineering participants seems strikingly similar, it is possible that these women may only have had access to this one path. This is problematic because the more limited the options are for entry into a STEM study, the more likely fewer people will enroll in these fields of study.

Another key difference between low (computer science and engineering) and high (biology) enrollment majors is the certainty of career plans. Both biology participants, Natalie and Sarah, were less certain of their future career paths than the other participants. Natalie wants to be a doctor, but doesn't specify in which area, while Sarah continues to waver between two fields of study: actuarial science and genetics. Meanwhile, all other participants who are interested in computer science and engineering have explicitly stated a desired career: aeronautical engineer, computer programmer working for Apple, and computer security analyst or a chemical engineer. This suggests that in order to enter fields like engineering or computer science, it is important that women be exposed to careers options, a feature of Bloom's Stage 3, before they leave the secondary setting.

Lastly, all of the participants in low-enrollment fields sought opportunities to create and invent (i.e., manipulate computers or create solutions to problems to help others), while only one of the biology majors, Sarah, expressed a similar interest. This may be another area to explore in future studies to determine if the desire to create and invent is truly a theme among all women in STEM, or only those pursuing computer science and engineering.

In conclusion, this fourth chapter of this study has sought to describe the paths of six female students majoring in STEM fields utilizing Bloom's 3-Stage Model as a framework. This chapter discussed and analyzed major patterns between all six women as well as trends amongst majors. The next chapter in this paper will provide an overview of further future studies relating to this topic as well as answer critical questions such as how this study can be used to inform policy at many levels. A revised framework will also be presented in the next chapter which may capture female students' path to STEM fields in a more comprehensive way.

Chapter 5

The goal of this study was to answer two key questions relating to women's decisions to study STEM fields. First, how do relationships and experiences influence the decision-making process of women in STEM fields? Second, how does this decision-making process vary for women pursuing different STEM majors? This final concluding chapter seeks to answer both of these questions, provide an analysis of Bloom's 3-Stage Model, and present a revised framework, which can better represent female students' paths to majoring in STEM fields.

This final chapter explains the findings discussed in Chapter 4 while also reflecting on the literature review presented in Chapter 2. Whenever possible, similarities, differences, and gaps in findings are presented in relation to current literature on the subject of women in STEM fields. The goal of the first section is to answer the first research question: *How do relationships and experiences influence the decision-making process of women in STEM fields?* After addressing all three sub-questions regarding experiences, relationships, and barriers, a following section will address the study's second major research question.

Discussion of Experiences

The major findings of this study suggest that for women who plan to major in STEM fields, exposure to a STEM program, or an experience in which they have an opportunity to try out a STEM field, is critical. In this study, five of the six participants were involved in a STEM program that directly related to their STEM major and which took place during high school, a crucial time in the decision-making process (Maltese & Tai, 2011). Within these STEM programs, participants learned about careers, completed hands-on projects, gained insider knowledge, and felt accepted in their STEM-field community. Prior research supports these findings and suggests that students in extracurricular programs have opportunities to learn about career paths in STEM fields and to make stronger connections with mentors (Hayden et al., 2011; Kendricks, Nedunuri & Arment, 2013).

Further, of the five participants who were enrolled in a STEM program in high school, four received college credit for completing the program, which suggests a possible link that connects STEM programs to high enrollment in STEM majors. This finding relates to Griffiths' study (2009), which explains that female students who take a variety of AP courses are more likely to major in STEM. However, the connection between college credit and a decision to major in STEM requires deeper analysis than prior research has discussed. For instance, based on the narratives from the participants in this study, STEM programs specifically—not advanced placement courses—provided them with a unique opportunity to engage in and develop an interest in STEM.

Unlike most AP courses, STEM programs provide students with the authentic, hands-on opportunity to be actively immersed in a real-world STEM field for extended periods of time. A STEM program goes beyond a course in school. In fact, the participants in this study described how their acceptance into a STEM community built their confidence, increased their interest in their field, and as Herzig (2004) and Bloom (1984) describe, provided them with insider knowledge about a STEM career. For instance, as a result of her experience in a STEM program, Lucy explained, "I knew that I would be successful as an engineer. It was also a lot of fun." As Lucy's quote demonstrates, STEM programs give female students a chance "to be" an engineer, biologist, or computer scientist in an active, engaging manner.

As a result of the clear link between completion of a STEM program and pursuing a STEM major, we can propose a key question for this study: *How can we get more female students involved in STEM programs during high school?* As discussed in previous literature, 10th grade may be a critical year in female students' paths towards pursuing STEM fields (Maltese & Tai, 2011). In fact, four out of the five participants in this study who completed a STEM program entered into their program during 10th grade; the fifth participant applied during 11th grade and entered during 12th grade. Moreover, research shows that typically, female students' interests in STEM wanes as they move on through high school (Sadler et al., 2012). Therefore, it is imperative to build female interest in STEM as early in their educational career in order for them to be interested and passionate enough to enroll in STEM programs in high school.

Data from this study and prior research suggest that the most critical time periods to build interest in STEM fields for female students are the middle school and early high school years (MacPhee, Farro & Canetto, 2013). By building interest during this time, students can prepare academically and continue to build confidence up through their 10th or 11th grade year when a decision about a STEM program can be made. However, even if student interest is present, it is critical that these STEM programs are also available to them and welcoming of female students. School districts and states need to fund and encourage enrollment of students (particularly females) in these STEM programs. On a personal level, one conversation or word of encouragement from a teacher or family member may help a female student decide to consider an influential STEM program. The next section will analyze how family members, teachers, and others steer women towards (and sometimes away) from STEM majors.

Discussion of Relationships

Research suggests that mentor relationships can significantly influence a female student's decision to enter into a STEM field while also encouraging her to pursue and persist in these majors (Baker & Leary, 2003; Espinosa, 2011; Holland, Major, & Orvis, 2012; Liang et al. 2002; Maltese & Tai, 2011; Shapiro & Sax, 2011; Sjaastad, 2012; Wilson et al., 2012). As defined in Chapter 1 of this paper, Cohoon and Aspray (2008) describe a mentor as an advocate who helps a student operate in an environment of interest and offers social and emotional support. The data from this study agrees with prior research which suggests that a mentor may play a critical role in steering female students towards STEM fields (Baker and Leary, 2003). However, this section will also expand upon prior research by providing an in-depth, qualitative analysis *about* the relationships between female students and mentors, which is an area of investigation that is lacking in current research (Riegle-Crumb et al., 2012).

In this study, mentoring included relationships between participants and their family members, relatives, peers, and professors. There were some relationships described by participants—particularly with guidance counselors—who were not supportive of participants' decisions to study STEM fields. However, this section will expand upon and focus on positive influential relationships; barriers towards STEM instruction will be discussed in a later section.

Bloom’s Model, as well as prior research, suggests that families that encourage their female children to study science and math are effective in steering them towards STEM fields (Hazari et al., 2007). Prior research also shows that half of all STEM majors have at least one parent educated in a STEM field (Sjaastad, 2010). In this study, for instance, four of the six participants had at least one STEM-educated parent.

In this study, all family members were supportive of participants’ interests in STEM fields, but some families provided participants with additional exposure to STEM. For example, Kacie's father, a computer scientist, acted not only as a supportive parent, but also as a Stage 3 mentor by exposing her to careers and insider practices within this field. This unique dual-role of a family member-expert (much like Leah’s relationship with her uncle, a NASA employee) seemed to have great influence over female students' decisions to pursue STEM fields. These relationships suggest that Stage 3 mentors (i.e., experts in fields) that develop sustained relationships with young female students may have a particularly salient role in steering them towards STEM fields. However, it is unknown if this strong relationship can develop outside of the bounds of a familial-based role.

In addition to family relationships, literature on this subject shows that female students are particularly influenced by teachers, specifically when these teachers are passionate, have a strong knowledge of their content, and expose their students to a challenging curriculum (President's Council of Advisors on Science and Technology, 2010; Sjaastad, 2012; Subotnik et al., 2010). The student-teacher relationships developed between five of the six participants in this study reflect that prior research is true. However, a deeper analysis of these relationships also shows that influential teachers in this study were not only knowledgeable and enthusiastic about their subject-area, but they also provided female participants with individualized attention, modified work, and also a plan (or push) to motivate participants' towards STEM fields. This new information provides a blueprint for influential teachers, and one that can also give teachers a concrete strategy of personalizing and differentiating instruction in order to steer women towards STEM fields.

Discussion of Barriers

To understand how relationships and experiences can limit female students' decisions to pursue STEM fields, this study also completed a barrier analysis. Research suggests that stereotype threat and lack of confidence are major barriers for female students (Good et al., 2010) and that the role of mentors can mitigate these feelings while also building female students' self-efficacy skills (MacPhee, Farro & Canetto, 2013; Steele, Spencer & Aronson, 2002). In this study specifically, female participants mentioned similar barriers. For example, Sarah stated that her biggest challenge was overcoming her confidence issues. When asked what helped her to feel more confident, Sarah credited the support of her family. However, in addition to these barriers, this study uncovered other factors that have not yet been deeply analyzed by current research.

The influence of guidance counselors as an anti-mentor (i.e., an individual who pushes female students *away* from STEM fields) emerged in two participants' experiences. Both Natalie and Leah felt unsupported by their guidance counselors in their desire to pursue STEM fields. Natalie's counselor did not support her decision to enroll in a non-traditional science course pathway, while Leah's counselor stated that she should major in French instead of engineering because she had a higher French average. Although Natalie and Leah were able to overcome these barriers—perhaps as a result of positive relationships with teachers and their families—their experiences suggest that guidance counselors play an important role in women's decisions to study STEM fields, and that counselors may need training on how, and what, they should do to encourage female students towards pursuing STEM fields.

Another emergent barrier that was uncovered through this study was the influence of personal and family struggles on female students' interests in STEM fields. In this study, Kacie and Leah both faced personal challenges (i.e., health disease and parental divorce, respectively), which tremendously decreased their interest in STEM fields. Both participants described an overall apathy for school during these time periods and explained that their interests in school and learning dropped dramatically while dealing with these personal challenges. This is a barrier that requires more exploration. For instance, how can these personal challenges be managed to help students continue to develop interests in STEM fields?

While this section has answered the first research question for this study (*how do relationships and experiences influence the decision-making processes of women in STEM fields?),* in order to provide more tangible solutions and strategies, numerous follow-up questions clearly remain.

Differences Between STEM Majors

The second research question for this study asked if the decision-making process varied for women pursuing different STEM majors. The answer clearly seemed to be yes, but to specify *how* the process varied between majors, this section will discuss the differences between high female enrollment majors (biology) and low female enrollment majors (engineering and computer science).

For participants in computer science, clear themes emerged: students completed a STEM program (namely the Cisco program), faced few (if any) barriers, and had high confidence levels and strong interests in innovation and manipulating computers. For engineering participants, their experiences were marked by the presence of Stage 3 mentors early in life, a belief that engineers were problem-solvers, and a desire to use engineering skills to help solve world problems. Lastly, biology-related majors in this study had STEM program experiences and supportive parents, but otherwise, the paths of the biology participants in this study varied greatly. To answer this research question, this section will separately consider how the paths of computer science and engineering majors compared with other STEM fields that have higher female enrollment (i.e., biology).

Comparing Computer Science with Other STEM Fields

The similar experiences of the two computer science participants in this study were striking and they suggest that the paths for women to enter into computer science fields are limited. Unlike the biology majors, whose experiences varied, the computer science participants both enrolled in the same STEM program and expressed few, if any, barriers. This suggests that more pathways need to be opened for female students in the future in order to increase their enrollment in computer science majors in college. However, how and what are the most effective ways to do this? One possible solution is to create more computer science programs that attract female students.

In addition to added computer science programs, it is also important to further analyze the barriers that young women who are interested in computer science may face. Specifically, participants in this study faced few, if any barriers; therefore, is it reasonable to hypothesize that women who *do* face barriers will be steered away from computer science? To determine how (and if) women in computer science overcome barriers, more research needs to be completed to analyze a larger sample of female computer scientists. One barrier that could be evaluated more deeply is the lack self-confidence. For instance, unlike the biology and engineering majors in this study—who express lower confidence levels—the computer science participants exuded confidence in both their abilities and their roles as a minority in their field. This fact leads to follow up questions: How do women in computer science build confidence in themselves and their abilities? One answer is the enrollment and completion of a STEM program. However, were the participants from this study a rare case? Is it possible for women with lower confidence in their computer science abilities to major in computer science? Perhaps, a different study focusing on confidence, rather than interest, may be crucial in addressing this issue.

Comparing Engineering with Other STEM Fields

Future female engineers in this study consistently emphasized that engineers are the world's problem solvers; this notion is critical to unraveling their path to this major. Both participants in this study identified not just their future career plans, but also the specific type of work they planned to do (i.e., helping people and communities). This direct career path to help others was unique to engineering majors in this study. Even Natalie, the biochemical major with aspirations of becoming a doctor, did not articulate her desire to help others.

Additionally, while computer science majors were more focused on innovation and invention, engineering majors in this study were interested in utilizing their skills to improve the lives of people around the world. This yields the question, how does a desire to problem solve develop? In this study, both engineering participants had opportunities to work directly with curriculum and individuals who exposed them to problem solving at young ages. However, more research is required to pinpoint these experiences as the leading factors that pushed them towards majoring in engineering.

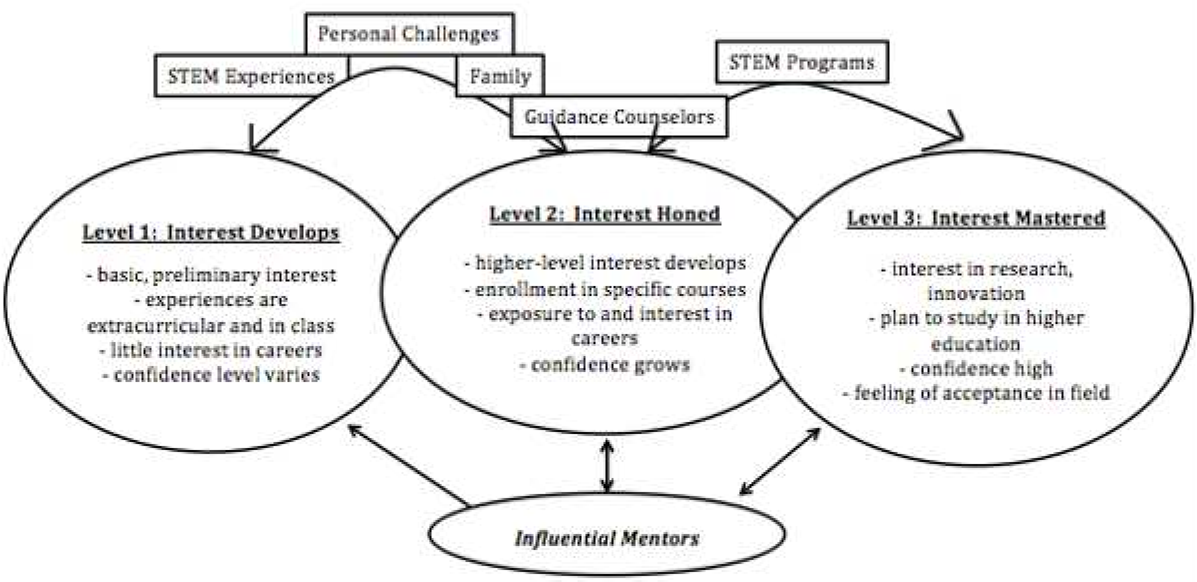
Another theme for this study, which also emerged from the engineering participants' experiences, was the development of interest in a STEM field at a young age as a result of a relationship with an expert in the field. When utilizing Bloom's 3-Stage Model as a lens, it is clear that both participants were exposed to Stage 3 mentors during Stage 1 of their development. This situation is not unique to engineering majors (i.e., Kacie also had a similar experience in her path to computer science), however, biology majors failed to identify any Stage 3 mentors who had an impact in their decision-making process at a young age. This suggests that for majors like computer science and engineering, early exposure to these fields by experts may play a critical role in steering women towards these low-enrollment majors. Further, as Bloom's Model does not provide for nuanced changes like Stage 3 mentors in Stage 1 of development, analysis of this phenomenon is challenging. Therefore, a revised model to analyze the development of female students' interests in STEM fields will be presented in the next section of this chapter.

Revised Model

As discussed in Chapter 4, Bloom's 3-Stage Model does not capture the essence of most of the female participants' experiences in this study. For example, there were multiple examples of Stage 3 experiences taking place during Stage 2 mentoring, and also, Stage 3 mentors having influence during Stage 1 of participants' educational careers. Additionally, Bloom's Model, developed in 1984, focuses mostly on white males from middle-class backgrounds, and as a result, does not coincide with the experiences of female participants. Therefore, a new model with which to analyze female students' decision-making processes has been developed from this study and is shown below.

Table 5.1

Revised Model for Women's Development in STEM Fields



There are three levels for this model described with the following titles, Level 1: Interest Develops; Level 2: Interest Honed; and Level 3: Interest Mastered. These paths do not follow a set timeframe and although they are presented as sequential, female students may move back and forth between the levels. The following summaries will explain how emergent contextual factors—STEM experiences, STEM programs, family, and influential mentors—impact each of the three levels of the Revised Model for Women's Development in STEM Fields. Definitions of the emergent factors are as follows:

- STEM experiences: opportunities, usually presented through course curriculum, for students to develop an understanding of STEM fields
- STEM programs: long-term, intensive experiences in which students choose to learn about STEM fields
- Family: any member of an individual's immediate family who influence a student's interest in STEM
- Influential mentors: individuals who provide students with one-on-one attention and a push to study STEM fields

Additionally, barriers (i.e., personal challenges and guidance counselors) will also be identified throughout these summaries. Definitions of these barriers are as follows:

- Personal Challenges: non-curricula-related experiences that take place in a student's personal life, which negatively impact her interest, confidence, and/or desire to succeed in STEM-related subjects
- Guidance Counselors: any individual within a school setting (excluding teachers) who provide academic guidance to a student

Level 1: Interest Develops

In this first level, female students develop a basic interest in STEM fields through extracurricular experiences or specific curricula in school. Most of these opportunities to explore STEM fields are short in nature (e.g., a one-day science fair or classroom-run exploration) and female students do not encounter a sustained experience in which they take active, long-term roles. Most students during this level have a budding confidence in their abilities and are greatly susceptible to factors such as the advice of family and influential mentors or the introduction of new STEM experiences. In the diagram, these emergent factors are paired with an arrow that relays between Levels 1 and Level 2. An example of this from the study is Sarah's experience, as she felt pushed towards STEM fields from an early age because of her grandparents' (i.e., family's) active role in suggesting she become a doctor.

Conversely, during Level 1, students are also susceptible to barriers in which their interests in STEM can be negatively impacted and their ability to progress through the levels is stunted. For instance, during Level 1, Kacie struggled with a mental health illness, which caused her to withdraw from school and lowered her overall interest in STEM fields; and in Leah's experience, the divorce of her parents made her apathetic towards learning in general, including STEM-related subjects.

Level 2: Interest Honed

Level 2 is signaled by female students' enthusiasm for higher-level concepts relating to their field of interest, enrollment in specific courses (typically in secondary school), exposure to careers in their field, and a growth in confidence. The emergent factors discussed in Level 1 (i.e., family, influential mentors, and STEM experiences) are still capable of greatly influencing student interest, but in this second level, students begin to make their own choices that steer them towards STEM fields. For example, in Rachel's experience, during Level 2 she *decided* to enroll in computer science in 9th grade and as a result, began to build an interest in not only what computers could do, but also why they worked. Rachel then began to consider careers in computer science and also sought advanced coursework in this subject.

While development is more solidified during Level 2, it can still change based on the introduction of barriers. In this study specifically, guidance counselors act as barriers rather than supporters in Level 2 participants' paths to STEM fields. For example, Natalie explained her yearly struggle to take a non-traditional path in science, and that only with the support of her family and teachers she was able to successfully overcome pushes by her guidance counselor to give up on STEM. Similarly, Leah's guidance counselor suggested she pursue French instead of engineering, and ultimately caused Leah to reconsider her interest in engineering altogether.

Despite the potential for barriers to negatively impact female students’ STEM interests during this level, Level 2 also signals a time period in which females may actively choose and participate in a STEM program. This is a critical decision, as the enrollment and completion of a STEM program is one of the strongest factors linking students to the third and final level of development.

Level 3: Interest Mastered

This final level in the development of female students' interests in STEM fields is highlighted by a student's decision to pursue a STEM major. In order to get to this level, students are greatly influenced by the experience and knowledge gained from STEM programs. During these programs, female students develop an interest in research and innovation in their field of interest and learn about potential future careers and insider practices. At this stage, women also *visualize* themselves as an engineers or computer scientists in which they are able to help others with their STEM knowledge. For instance, Lucy described her dream of protecting homes from forest fires, while Rachel explained an interest in creating a better iPhone to improve peoples' lives. This is the last and final stage of interest development because it signals that female students have decided to enter into a STEM field once in college. While this decision may also take place *during* college, research suggests that female students are most likely to be successful when they have already declared a STEM major upon college entrance (Ohland, 2008). A fourth level could also be developed for this model to explain how interest flourishes once in college, however, that is not within the scope of this study.

Influential Mentors

As shown in the bottom part of the model, influential mentors (i.e., individuals who steer women towards STEM majors) are critical to developing female student interest throughout all three levels. As interest develops in Level 1, the arrow points from "mentor" to "interest," which shows that at this early stage, interest is usually drawn *from* the mentor and provided *to* the female student. An example of Level 1 mentoring was Lucy's experience with her uncle who worked at NASA. Lucy's uncle provided her with engineering knowledge, and although she did not realize it at the time, greatly influenced and developed her ongoing interest in engineering. Although the Level 1 influential involvement of mentors is generalized, within the other two levels, mentors must modify their mentoring in order to meet the needs of individual students and greater influence their interest in STEM.

For a student whose interest in a STEM field is honed (i.e., Level 2), the role of a mentor introduces the student to future careers at a basic level. This mentoring relationship is similar to Leah's experience with her chemistry teacher who provided her with articles and information about chemical engineering and modified curriculum to fit her academic interests and needs. For five of the six participants in this study, the influential mentor at Level 2 was a teacher who was passionate and knowledgeable about STEM content, and who worked closely with students, modified their work, and also helped to steer them towards coursework and experiences in STEM fields. For Kacie, however, her influential mentor was her friend, who introduced her to the world of computers and gaming. He provided her with individual attention, exposure to new and innovative practices in computers, and helped her to feel accepted into the community of gamers.

Lastly, during Level 3, mentors are individuals who continue to support students in STEM fields even after they have decided to major in STEM. In some instances, the same influential teacher as described in Level 2 may continue to modify curriculum to inspire and challenge a student. In other cases, a new mentor may enter into a student's life, such as Sarah's professor in her STEM program. Level 3 mentors continue to support female students in their academic interests relating to STEM fields, but at a higher level, which is typically based on research and/or innovation. By working with influential mentors in this level, the confidence of female students is further buoyed and their feeling of acceptance into STEM is solidified.

Overall, this model describes the impact of emergent factors in relation to each participant's level of interest, unlike Bloom's Model, which only analyzes the experiences *within* the individual levels. For example, when Natalie participated in a weeklong summer medical program, her development spanned from Level 2 to Level 3 based on her interactions with a medical student. By considering the impact of emergent factors and barriers on each level of interest, this model allows for a deeper understanding of how female students decide to major in STEM.

Recommendations

By identifying the major patterns in female students' decision-making processes to major in STEM fields, and focusing on the differing experiences between women who pursue low and high female enrollment majors, this study has provided new information for scholars and policymakers who aim to increase the representation of women in STEM. The key findings for this study suggest that school districts should be encouraged to collaborate and expand STEM programs that are specifically geared towards female students. These programs will represent, not only venues with which to expose female students to STEM fields, but also opportunities for women to experience real-world careers as computer scientists or engineers. For instance, college-credit programs that focus on computer science (e.g., the Cisco program) played an important role in steering women in this study towards the computer science field. However, is there more that can be done to make these programs more engaging and attractive to female students? One recommendation from this study is to complete an overview of these computer science programs—using gender as a lens—to gain insights and strategies about how to increase female students' interests and enrollment numbers.

In regards to the experiences of female engineers, the data from this study highlights the importance of exposing female students to experts in the field at young ages. Although current research suggests that middle school is a particularly critical time to engage girls in STEM fields, the data from this study suggests that sustained relationships with experts at a young age, perhaps even as early as elementary school, may be even more influential. Therefore, another recommendation from this study is for schools and families to expose elementary-aged females to STEM experts from a host of fields for an extended period of time.

Another area of interest for this *Recommendations* section, are teacher-training programs. There is a critical need to educate teachers and guidance counselors about the role they can play in steering women towards STEM fields. As described by participants in this study, the most influential teachers were enthusiastic and knowledgeable about their subject-area, and provided participants with individualized attention, modified work, and advice about their future related to STEM fields. Many of these influential teachers also provided participants with concrete steps to help ensure that they were on the right path towards majoring in their STEM field of interest. A recommendation from this study is that professional development activities and resources should be expanded to help teachers develop skills to support female interests in STEM. Additionally, as evidenced by the

Barriers section of this study, guidance counselors may also play a role in steering women *away* from STEM fields. Along with teachers, it is important for guidance counselors to learn how to encourage female students to pursue STEM fields. As a result of the findings from this study, it is clear how influential positive relationships can be towards a female's decision to study STEM. Therefore, these teacher and guidance counselor trainings would be valuable and most likely impactful towards the increase of female STEM enrollment in college.

One last recommendation from this study is for a thorough analysis of a new, revised model, which more accurately represents female students' paths to majoring in STEM. Although a model has been presented based on this study (Figure 5.1.), the size of this study was limited to six participants, and only two per major. Therefore, it is important to complete more studies with larger participant populations for a longer time period. For example, to truly understand decision-making processes and experiences of computer science majors, future studies will need to focus on a larger group of women in these majors; similar studies can be completed for engineering female students as well.

Researcher's Reflection and Limitations of Study

One major limitation of this study was the small sample provided for each sub-group of participants in computer science, engineering, and biology. To truly understand and capture the experiences of women in each of these fields, a larger study is warranted. Despite this limitation, efforts were made to identify a group of participants that were diverse in nature, not just by major. The students in this study hailed from five different high schools—both suburban and urban—within the Capital District. This helped to provide a different perspective on opportunities and experiences for each participant within a variety of school settings. Further, by chance, participants in this study included one African American student and one Indian student, while all other participants were White; participants were not asked to identify their socioeconomic status.

Another limitation of this study was the use of retrospective reflection to describe participants' experiences, relationships, and barriers. In particular, it is likely that mentors who were more recently instrumental in participants' lives may have been described more frequently or in more depth than mentors from participants' pasts. Also, although female students in this study identified that they were planning to major in a STEM field, it is unknown how, and if, these students will maintain their major once in college. Future research should partake in longitudinal studies, which analyze not just the decision-making process of female students in STEM fields, but also the effectiveness of the emergent factors like mentors and STEM programs once students are in college.

Throughout this study, all attempts to maintain an empathetically neutral position, as defined by Creswell (2003), were made by the researcher. However, it is important to note the role of the researcher as both a teacher and a female who pursued a STEM field in college. Before beginning this study, the researcher already felt that relationships would be an important part of female students' decisions to enter into STEM fields. However, the researcher found the critical role of influential teachers, and the specific ways in which they helped the participants in this study, even more impactful than she had anticipated.

After completing this project, the researcher recognized her deep respect for the female participants in this study who overcame academic, personal, and social obstacles to pursue a STEM field. While completing the member checking for this study, the researcher was excited to hear back from participants and was intrigued about how they were adjusting to the start of college.

Summary and Conclusion

This qualitative, phenomenological study sought to understand the decision-making processes for women in STEM fields and if these experiences varied for women pursuing different STEM majors. The theoretical framework for this study, Bloom's 3-Stage Model, suggested that relationships and experiences at differing stages would influence female students. However after completing this study, it is clear that a new framework for analyzing female experiences in STEM fields is needed; hence, in this section a new model has been proposed and discussed.

This final chapter concludes this research study. The results of this study show that the decision-making experiences of women in STEM fields are influenced by experiences in STEM programs, relationships with family as well as influential mentors, particularly high school teachers, and that female students do face barriers, like low self-confidence and negative influence of guidance counselors in their decision to study STEM fields. Secondly, this study found that women pursuing different STEM majors, like biology, computer science and engineering, have unique experiences. For women in computer science, the presence of a STEM program as well as few barriers highlighted their path. Meanwhile, for engineering students, the notion of engineers as the world's problem solvers as well as presence of influential mentors at a young age, were key features of their decision-making process. Further both engineering and computer science students had definite career goals, while biology students did not. The data presented in this study suggests that biology students had multiple entry ways to their STEM fields.

To further understand students' paths to their STEM fields, more longitudinal research focusing on computer science and engineering students is needed. After completing this study, the main researcher for this project plans continue to follow each female participant in this study; after re-submitting an amendment to IRB, an interview, or two, with each participant in this study will be scheduled. Interviews with each participant directly after their freshmen year of college may provide critical insight into the transition and progress into college for female students pursuing STEM majors. Further, by following these students from high school to college, more data from each individual will be gleaned and allow for consideration of more factors which may (or may not) influence how and if each student continues to pursue their STEM field in college.

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Appendix A
Email to Master Teacher Program or NGCP Members

Dear Master Teachers (or Members of NGCP),

Besides being a member of the Master Teacher Program (or member of NGCP), I am also currently a doctoral student in the School of Education at the University of Albany. I am working on a study that focuses on factors influencing female students' decisions to major in a STEM field.

I am hoping to recruit female high school students who are planning to major in STEM fields to interview and participate in this study. Students must meet the following criteria:

1. A female student
2. Plan on majoring in a STEM field at a 4-year school in Fall 2015 (students do not need to be accepted into a program.)
3. Be age 18 by March 1, 2015

Students will receive a $25 gift card, for about 65 minutes of time spent for participating in this study.

Can you please provide your students with the attached flyer seeking participation in this study? Students can email me directly to express their interest in participating in this study. My email is stephanie.conklin@gmail.com

Thank you for your help!

Best, Stephanie Conklin

Appendix B

Invitation to Participate

To Whom It May Concern:

My name is Stephanie Conklin, and I am currently a doctoral student in the School of Education at the University of Albany. I am working on a study that focuses on factors influencing female students' decisions to major in a STEM field, and more specifically, how students' previous experiences have influenced their decision.

I am seeking female volunteers to participate in this study. To volunteer for this study, students must meet the following criteria:

- Currently be a female senior in high school
- Plan on majoring in math, science, technology, computer science or engineering at a 4 year school in Fall 2015
- Be age 18 on or by February 15, 2015

If you agree to this study, you will be asked to complete the following:

- 5 question writing prompt (15-20 minutes to complete)
- 45 minute interview in person

In exchange for your time, you will receive a **$25 gift card** to Amazon.

If you are interested in participating in this study, email me at saconklin@albany.edu.

Please email me back and confirm that you are:

- at least 18 years of age

- plan on majoring in a STEM field in college

- are willing to sign a consent form and also have your parents sign a consent form

Names and identities will be kept confidential throughout the research and transcriptions. This research is conducted under the guidance of Dr. Alan Oliveira, and has been reviewed by the University at Albany Committee on Human Subjects.

Thank you for your consideration,

Stephanie Conklin

Appendix C

Assent Form for Women in STEM Majors Study

Please consider this information carefully before deciding whether to participate in this research. If you agree to voluntarily participate in this study, you will be asked to sign this form.

Names of the researcher: Stephanie A. Conklin, Doctoral Candidate in Education and Theory Department, University of Albany

Description of the research:
For this study, I will seek to understand the factors that influence female students' decisions to enter into STEM fields. This study will be used to complete my dissertation research. This study will include one interview with you, about 45 minutes long as well as a completing a writing prompt and graphical representation (about 20 minutes of your time).

Description of human subject involvement:
If you volunteer for this study, you will be first complete a writing prompt and graphical representation which will take about 20 minutes, and then be interviewed for approximately 45 minutes. I will assign you a pseudonym to protect your anonymity. Our interview will be audio recorded. You have the right to not answer any questions during the interview. You will receive a $25 gift card after signing this consent form.

Risks & discomforts of participation:
I do not anticipate any risk in your participation other than you may become uncomfortable answering some of the questions.

Measures to be taken to minimize risks and discomforts:
We will complete our interview in a private location, and you will receive a pseudonym to protect your anonymity. You have the right to refuse to answer any question during the interview.

Expected benefits to subjects or to others:
Participants will have an opportunity to share and reflect their experiences about deciding to major in a STEM field.

Confidentiality of records/data:
You will be assigned a pseudonym prior to beginning the interview. After our interview, I will transcribe our interview and will only use your pseudonym. Your name will not appear in the transcription of the interview or in my final paper for this study. Further, I will keep the transcription of your interview on a password-protected computer at my home, and will delete this interview three years after our interview.

This research is anonymous. This means that there is no personal identifying information recorded on any research documentation, including consent forms and questionnaires that will link you to your interview. Please note that **a**ll information obtained in this study is strictly confidential unless disclosure is required by law. In addition, the Institutional Review Board, the sponsor of the study (e.g. NIH, FDA, etc.) and University or government officials responsible for monitoring this study may inspect these records."

Audio/Video Recording of subjects:
This interview will be audio recorded. After I have transcribed our interview, I will destroy the audio recording and will keep the transcription on a password-protected computer for three years, and then will destroy this transcription.

Before we begin the interview, please make sure to avoid mentioning names of or identifying information about yourself or third parties. If identifying information is mentioned inadvertently, the recording will be stopped immediately, the identifying information erased.

Please sign below if you are willing to have this interview audio recorded. You may still participate in this study if you are not willing to have the interview recorded.

Signature: ________________________ Date: ___________________________

Payments to subject for participation in the study:
You will receive a $25 gift card for your participation in this study. You will receive a $25 gift card from Amazon. I will give you the gift card after you sign this consent form.

Contact Information

If you have any questions about this study, please contact my faculty adviser or me.
Stephanie Conklin, Student, saconklin@albany.edu, (518) 495-5396
Alan Oliveira, Associate Professor, Faculty Adviser, aoliveira@albany.edu, (518) 442-5021

Your Rights as a Research Participant
Research at the University Albany involving human participants is carried out under the oversight of the Institutional Review Board (IRB). This research has been reviewed and approved by the IRB. If you have any questions concerning your rights as a research subject or if you wish to report any concerns about the study, you may contact University at Albany Office of Regulatory & Research Compliance at 1-866-857-5459 or hsconcerns@albany.edu.

Voluntary nature of participation:
You may choose not to answer any questions and may refuse to complete any portions of the research you do not wish to for any reason.

Withdrawal of subjects and data retention:
Your participation in this project is voluntary. Even after you agree to participate in the research or sign the informed consent document, you may decide to leave the study at any time without penalty or loss of benefits to which you may otherwise have been entitled. I will retain and analyze the information you have provided up until the point you have left the study unless you request that your data be excluded from any analysis and/or destroyed.

Future Participation.
The researcher for this study has your permission to contact you in the future for follow-up questions regarding this study. You may choose not to participate in future studies.

Consent of the subject:
I have read, or been informed of, the information about this study. I hereby consent to participate in the study.

Signature: ________________________ Date: ____________________________

Appendix D
Follow up Email for Interested Participants

Dear ____________:

Thank you for your interest in completing an interview for my study!

To participate in this study, you will need 65 minutes of time. The first stage of participation includes 20 minutes to complete a graph and also answer 6 writing prompts. The second stage will be to complete an interview which will last approximately 45 minutes. Could you please email me your response to the following questions about your availability for an interview of about 45 minutes, in person?

I am available to meet at the following times:

1. ______________________
2. ______________________
3. ______________________

A convenient location for me to meet would be:

____

If selected for this study, I will email you to schedule a time to complete the interview. During our interview, I will review the consent form for this study, and will also ask you to sign this form. Please note that the consent form is also attached for you to review prior to our meeting.

You will also receive a $25 gift card to Amazon.com once you have signed the consent form. and provided the signed parental consent form. During our interview you have the right to refuse to answer any questions, and I will give you a pseudonym to protect your privacy before beginning to audiotape our interview. Also, please note that your name and identity will be kept confidential throughout the research and transcriptions. This research is conducted under the guidance of Dr. Alan Oliveira, Department of Educational Theory and Practice, School of Education, and has been reviewed by the Institutional Review Board.

Thank you again for your participation,

Stephanie Conklin

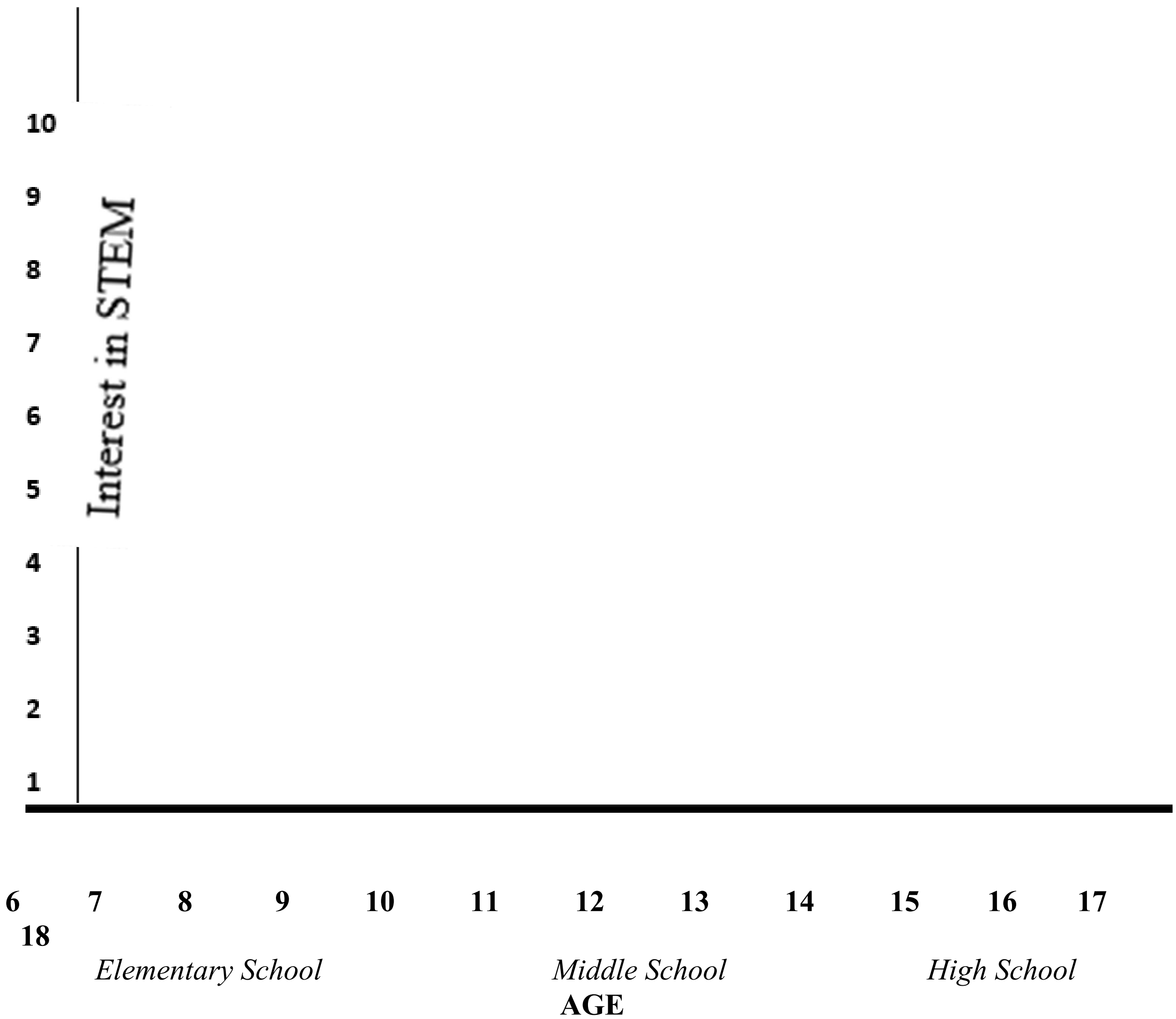
Appendix E

Timeline for Participant Interest in STEM Fields

Education scholars define STEM as any field in math, science, engineering or technology. On the time line below, please graph your interest in STEM fields time on a scale of 1 to 10, where 1 is lowest level of interest and 10 is highest.

Please <u>star</u> any important times in your life where your interest changed.

Interest in STEM



Appendix F

Writing Prompt for Women in STEM Fields Study

Please answer each question below about yourself.

First Name: ____________________ Initial of Last Name: ________

Planned Major in College: _________________

Please answer each question below about your experience.

1) How did you develop an interest in the STEM field that you are studying in college?

2) Are there any experiences in elementary, middle or high school that increased your interest in a STEM field? If so, can you explain this experience?

3) Are there any relationships that you developed in elementary, middle or high school that stand out to you as positively influencing your decision to major in a STEM field? If so, can you explain this relationship and how it developed?

4) Are there any challenges that you've had to overcome to pursue a STEM major? If so, can you explain these challenges?

5) Has your family played a role in your decision to study a STEM field? If so, how?

6) What do you see yourself doing once your finish college?

Appendix G
Interview Questions for Women in STEM Fields Study

1) Tell me about your plans for next school year.

2) By looking at your time line (Appendix D), I notice _____________. Can you tell me more about this?

3) In your writing prompt you mentioned *this experience* during elementary/middle/high school, can you tell me more about this experience?

    a. Can you tell me the effect that any individual(s) had on you during this experience?

    b. How did this individual(s) influence (positively or negatively) your decision to study a STEM field?

4) Tell me more about a person who has steered you towards your field of study.

5) Have there been any individuals who you felt didn't support your decision to study a STEM field? If so, can you explain this person or persons?

6) In your writing prompt you mentioned this challenge to majoring in a STEM field, how did you overcome this challenge?

Appendix H
Parental Consent Form

Institutional Review Board (IRB)
Parental Permission
For Child's Participation in Research

Protocol (Study) Number	
Study Title	**Women in STEM Majors**
Study Principal Investigator Name	**Stephanie A. Conklin**
Study Principal Investigator Phone #	**518-495-5396**
Study Principal Investigator Email address	**saconklin@albany.edu**

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child's participation is voluntary.
Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:

The goal of this study is to determine which factors influence female high schools to pursue STEM field majors in college. This study is being conducted for my dissertation research.

Procedures/Tasks:

Participants in this study will complete a writing prompt and also an in-person interview.

Duration:

65 minutes

Your child may leave the study at any time. If you or your child decides to stop participation in the study, there will be no penalty and neither you nor your child will lose any benefits to which you are otherwise entitled.

Risks and Benefits:

There are no foreseen risks to participating in this study.

Confidentiality:

Efforts will be made to keep your child's study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your child's participation in this study may be disclosed if required by state law. Also, your child's records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The University at Albany Institutional Review Board or Office of Regulatory Research Compliance;
- The sponsor, if any, or agency supporting the study.

Incentives:

Participants will receive a $25 gift card for their time.

Participant Rights:

You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.

If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at t University at Albany reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:

For questions, concerns, or complaints about the study you may contact **Stephanie Conklin at saconklin@albany.edu or 518-495-5396.**

Research at the University Albany involving human participants is carried out under the oversight of the Institutional Review Board (IRB). This research has been reviewed and approved by the IRB. If you have any questions concerning your (child's, parent's, etc.) rights as a research subject or if you wish to report any concerns about the study, you may contact University at Albany Office of Regulatory & Research Compliance at 1-866-857-5459 or hsconcerns@albany.edu

Signing the parental permission form

I have read (or someone has read to me) this form and I am aware that I am being asked to provide permission for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.

I will be given a copy of this form**.**

____

Printed name participant (child)

Printed name of person authorized to provide permission for participant	**Signature of person authorized to provide permission for participant**
Relationship to the participant	**Date**

Appendix I
Hand-out for Recruitment of Participants to Study

University at Albany Study Seeking Participants

- ✓ Are you a female high school student interested in studying math, science, computer science or engineering in college?

- ✓ Are you 18 years old?

- ✓ Would you like to add your voice to a research study focusing on female students' experiences in STEM fields?
- ✓ Would you like to earn a $25 for an hour of your time?

IF YES, please email Stephanie Conklin at saconklin@albany.edu to participate in a brief survey and interview through the University of Albany, Education and Theory Department.

All information provided for this study will be kept confidential!

Appendix J

A Priori Coding for Data Analysis

Experiences

- Any description of an opportunity or learning experience that was described by a participant either within context of school setting or outside.

Relationships/Mentor/Role Model

- Any interaction between a participant and individual who influenced (positively or negatively) their decision to pursue a STEM field.
- As defined by Aspray and Cohoon, a mentor engages in "an active process of sponsorship by experienced members towards less experienced entrants or trainees" (p. 160).
- The term teacher was also utilized as a code for this category as well as guidance counselor or counselor.

Parent/Family

- Any individual who was related to a participant.

Barrier/Challenges

- A description of a person who inhibited the participant from actively taking steps towards a STEM field; referred to as an anti-mentor or non-mentor.
- A situation, bias or experience which inhibited the participant from actively taking steps towards a a STEM field.

Interest

- Terminology which describes feelings of importance in relation to learning, content, experiences or relationships.