UNCOVERING THE LIVED EXPERIENCES OF JUNIOR AND SENIOR UNDERGRADUATE FEMALE SCIENCE MAJORS

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

Columbia University

2017

ABSTRACT

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The following dissertation focuses on a case study that uses critical theory, social learning theory, identity theory, liberal feminine theory, and motivation theory to conduct a narrative describing the lived experience of females and their performance in two highly selective private university, where students can cross-register between school, while majoring in science, technology, engineering and mathematics (STEM). Through the use of narratives, the research attempts to shed additional light on the informal and formal science learning experiences that motivates young females to major in STEM in order to help increase the number of women entering STEM careers and retaining women in STEM majors.

In the addition to the narratives, surveys were performed to encompass a larger audience while looking for themes and phenomena which explore what captivates and motivates young females' interests in science and continues to nurture and facilitate their growth throughout high school and college, and propel them into a major in STEM in college. The purpose of this study was to uncover the lived experiences of junior and senior undergraduate female science majors during their formal and informal education, their science motivation to learn science, their science identities, and any experiences in gender inequity they may have encountered. The findings have implications for young women deciding on future careers and majors through early exposure and guidance, understanding and recognizing what gender discrimination, and the positive effects of mentorships.

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CHAPTER I

INTRODUCTION

My lived experiences, my affinity for science, and my pursuit of equity have all molded me into who I am today. As a teenager, I was heavily involved in the punk and hardcore music scene of the early to late 1990s. A plethora of bands and artists in this scene spoke out against racism, sexism, political oppression and social class structures. Some of the bands that influenced my outlook on life were Minor Threat, Fugazi, Sleater-Kinney, Propagandhi, I-Spy, Born, Ministry, and Iconoclast. These artists exposed me to ideas that were not presented in the mainstream media. They showed me a different America, the one outside of the suburban New Jersey where I was raised. Singing along to these bands made me feel part of a movement for change, which lead me to a passion for equity. The punk and hardcore scene was a community of friends trying to make changes in the world for the better or all humanity.

When I first graduated college with a degree in biological science, I entered the workforce in drug discovery at a large pharmaceutical company in New Jersey. My dreams of discovering the cure for cancer were quickly crushed when I realized how different the corporate world was compared to the academic one. Armed with only a bachelor degree, my tasks were pedestrian and monotonous, with little excitement or room for creativity. Many of my coworkers were complacent, happy to receive a decent wage and not overly concerned with changing the world. While working, I noticed a dearth of women in the lab and even fewer as head scientists. I often thought the atmosphere would have been better if there had been a more equitable ratio of women to men in the lab. Men in the lab would talk with little regard to the women in the room, saying offensive and degrading things. Being the newest and youngest person in the lab, I remained quiet more often then I would have liked. Within two years, I left the research lab and moved into education. In the classroom, I could be an agent of change, while helping all students achieve equity in science education.

When I first started teaching high school science in 2000, I had ambitious ideas about equity and making a difference. However, within the first few years, I often thought about quitting; teaching was nothing like I thought it would be. I went home upset and angry with the students and with myself for not inspiring them. I often felt like a failure. I wanted to show the students that education was the great equalizer; if you worked hard enough you could make it. It was not until I attended Teachers College that I realized how many other, besides those in the classroom, are involved in a student's education.

Being a White male has its privileges, but it also carries a greater responsibility for the onset of change. I must be aware of my actions while not suppressing or undermining the voices of women. My race and gender affords me certain advantages when talking to universities, corporations, and public schools. I am looking forward to championing the movement of greater equity in science, technology, engineering, and mathematics (STEM) throughout the country. The concepts that facilitate my research include:

- Social learning theories.
- Student support systems.
- Student engagement as it influences student performance.
- Mentorship.
- Gender disparity in STEM profession.

Rationale

As technology and science research spread globally, there is an increased competition among nations to become the world leader in scientific research and development. The United States was once a world leader in this area, but in recent years other nations have caught up and may soon surpass the United States. The amount of men majoring in science, technology, engineering, and mathematics (STEM) is almost double that of women majoring in STEM (National Science Foundation, 2009). Women make up approximately half of the population of the United States, and a proportional amount should be encouraged to enter a STEM career. Women provide new insights differing perspectives from men; their inclusion in STEM fields may help accelerate innovations; "When women are not well represented in these [STEM] fields, everyone misses out on the novel solutions that diverse participation brings" (Corbett & Hill, 2015, p. 10).

Science and technology are at the forefront of globalization. Peggy McIntosh (1992) discusses the capacity for achieving global citizenship; many of the characteristics of global citizenship wish she identifies are more closely aligned with women. To achieve global citizenship, it is necessary to have equal partnership between and representation of men and women. Science and technology are the forefront of globalization. Understanding why women enter STEM fields can help educators encourage and inspire more young women to consider science as a major, a profession, and a career.

There are areas of concern once women start entering STEM careers, which have been historically dominated by men. When women start encroaching on male-dominated fields like game development, the reactions can become aggressive and violent in the form of cyber bullying. In 2014, an incident known as "gamergate" involved an ex-boyfriend posting negative comments about his former girlfriend, a prominent game developer. This sparked a campaign of cyber bullying that escalated quickly and included death threats, sexist attacks about rape, and negative remarks about women in the gaming industry (Corbett & Hill, 2015). Once women enter STEM fields, gender equity policies need to be implemented and enforced in order to promote equity in the workforce.

Currently, both male and female students leave high school with nearly identical educational backgrounds in math and science, but few women are entering college with majors in STEM. Even fewer are earning bachelor degrees in physics, computer science, and engineering: 20.7%, 20.5%, and 19.5% respectively (Hill, Corbett & St. Rose, 2010). STEM careers in computers and engineering make up 80% of the STEM work force and offer higher starting salaries (Corbett & Hill, 2015). According to The U.S. Department of Labor, Bureau of Labor and Statistics, there will be an additional 1.2 million computer jobs by 2022 (Corbett & Hill, 2015). Forbes (2016) published the college degrees with the highest earning starting salaries and 13 out of the top 20 careers were in STEM, with the top three careers in engineering.

Previous held beliefs that suggest males are more intelligent than females have been proven false (Burgaleta et al., 2012); though unfortunately, these beliefs persist. Learning styles and strengths and weaknesses do still vary between both the sexes. Men tend to perform better at spatial orientation, visualization and some quantitative tasks, while women excel at verbal skills, writing, memory and perceptual speed (Hill et al., 2010; Burgaleta et al., 2012; Halpern et al., 2007).

Negative stereotypes have been shown to decrease the scores of females on math and science tests by propagating the idea that men are better at math and science than women. When teachers used positive reinforcement, explaining that both males and females are equally talented in math and science, the differences in test scores between the sexes decreased (Ambady, Shih, Kim, & Pittinsky, 2001). Evidence suggests females struggle with 3-D spatial thinking and reasoning (Halpern et al., 2007). This technique is rarely taught in high school and middle school and is essential for engineering and computer science fields. Recent studies have shown that once women are taught how to develop and use spatial skills, they are equally adept as their male counterparts (Baenninger & Newcombe, 1989; Sorby, 2009). Another reason fewer females enter the science field is due to the fact that they hold themselves to a higher standard than males (Correll, 2001). Studies have shown that females will more harshly judge their test performance than their male counterparts who score similar results. Only about one-third of the STEM work force had SAT math scores above 650 (Weinberger, 2005). Incorrect ideas about the minimum intelligence or test results needed to enter STEM fields may serve as a deterrent to women considering those professions. According the National Science Board in 2010, females are finishing high school with the skills needed for STEM majors, but they are not entering those fields in the same number as men.

Research done by in late 1990s in the computer science department at Carnegie Mellon University tried to explain disparity in numbers between men and women in computer science majors. After an extensive four-year study, where over 100 men and women were interviewed within the computer science department, researchers came up with a number of reasons that may account for the low turnout of women within the program (Margolis & Fisher, 2002). Some of these reasons are cultural, where society sees computers as “guy things”, an attitude that women are reluctant to challenge. Men are more likely to show a great interest and passion for computers at a young age, while many women enter computer science programs with less experience in programming. They may struggle during their freshman year, their passion seemingly not as intense as their male counterparts. This reinforces a belief that there is only one male-dominated, path to becoming a computer scientist. Women, who do not follow this path, will feel like outsiders in their major (Hill, et al., 2010). According to Margolis and Fisher, this is a problem with academia. To solve it, the curriculum and culture needs to be addressed. Curriculum development in computer science at Harvey Mudd College (HMC), has addressed some of these cultural issues. HMC offers a range of freshman-level computer science courses with varying topics and substitute the programming language Java with Python, a user-friendlier program.

Similar problems were found in physic departments - the culture within a department affected the number of female physics majors. With more women faculty, greater support systems available to students, diverse teaching strategies, mentoring, social gatherings, and courses, physics departments may be able to capture female student interest at an early age (Hill et al., 2010; Whitten et al., 2003). Many students enter college with only a general idea of what they want to study. If a student is not prepared for a physics major, she would have a difficult time within the program. Some historic black colleges and universities have reached out to students who do not have the typical high school background for a physics major and have provided programs that helped those students become physic majors (Hill et al., 2010).

As a teacher, I would ask my female seniors about their plans for future fields of study. I found out that computer science and physics were rarely mentioned. Many female students had no idea what a STEM major entails, besides a vague notion of sitting in front of a computer all day. One student who was talented at math told me that her teachers suggested she major in business. When I suggested she consider math or computer science, she was surprised and said she would look more into it. Cultural stigmas or misconceptions concerning STEM majors limit student engagement and future experiences. By further exploring students' lived experiences within the STEM culture, we can use some of the fundamental principals of liberal feminist theory and critical theory and begin to break down these cultural views and build new ones.

An understanding of why fewer females than males are majoring in STEM and entering the workforce in STEM fields can be used to build strategies to create and maintain interest in STEM among females in high school and college. There is a considerable monetary incentive to pursue STEM careers; the initial salaries for STEM majors are high when compared to other degree-related fields (National Association of Colleges and Employers, 2014). Though salary is undoubtedly important, it may not be the sole factor in determining a career. Fore example, mentors and positive role models have been shown to increase the retention of young females in STEM majors in college (Corbett et al., 2008; Hill et al., 2010; Smith & Erb, 1986).

Research Questions

Through my classroom studies at Teachers College, my arduous literature reviews, and my personal experiences both inside the classroom and within the STEM field, I have developed the following research questions:

1. What captivates and motivates female students' interests in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?
2. What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college?
3. How do female science or STEM majors discuss their experiences of gender equity as science or STEM majors?

Organization of the Dissertation

This dissertation deals with a number of current issues on gender inequity in science education. As technology and science research spread globally, there is an increased competition among nations to become the world leader in scientific research and development. With women making up half the population, it is a matter of equity to have more women represented in STEM careers. A plethora of topics regarding science education are discussed, including informal and formal science learning, science motivation, the cultural significance of women in science, role models and mentors, and various struggles encountered as a science major. These topics lay the foundation for my theoretical framework.

In Chapter II, a review of the literature review and theoretical framework help support this study. I introduce both formal (in-school) and informal (out-of-school) science learning experiences and the cultural significance of women in STEM careers. Facilitating my research was a theoretical framework that draws on critical theory, social learning theory, identity theory, social constructivism, liberal feminist theory, and motivation theory.

In Chapter III, I present my research methods, focusing on the type of study conducted, the data collection and analysis, and the validity and rigor used to substantiate my research. Specifically, I describe the research design as primarily a case study. I uses both quantitative and qualitative analysis, administering two surveys to peek inside the lives of female science majors, focusing on their science motivation, gender inequities in science, support in their science endeavors, and their informal and formal science experiences. Open-ended questions attached to the surveys allowed the female STEM participants the opportunity to expand upon their answers. This also helped in the selection of female STEM participants for semi-structured comprehensive interviews. The heart of the data collection came from in-depth interviews that were transcribed, analyzed and coded, while looking for emerging themes and confirming existing ones. The interviews consisted of six female science majors in their junior and senior year. Each interview lasted between 25 – 40 minutes. There were a handful of semi-structured questions about their informal and formal science experiences, the support they may have received from family members, friends, mentors and role models, struggles and hurdles they may have encountered being a female science major, and any other encumbrances they may have experienced. The interviews were plastic and were able to go in multiple directions, depending on the conversation and the interviewee's experiences. Once all the interviews were transcribed, responses were coded and themes appeared that helped shed light on the formation of the interviewees' science identities.

Then in Chapter IV and V, present findings in the format of stand-alone papers. The first paper is a survey analysis of the female STEM participants' science motivation, informal and formal science education, and their experiences of gender inequity. The second paper takes a detailed look at the lived experiences of six female STEM majors and the roads they traversed to become junior and senior female STEM majors.

The final chapter (VI) summarizes the major points of the dissertation, highlighting the implications of my findings on issues regarding gender equity in science for young females, educators and society as a whole. The chapter also proposes questions for future studies. As a high school science teacher, I am aware of my limitations and perceived bias, but my commitment to gender equity and all equity within my classroom is paramount. I continue to encourage my students and colleagues to promote women in science.

CHAPTER II

REVIEW OF THE LITERATURE

What follows is a discussion of the literature used to construct the foundation for this study, and it provides support through experimental and theoretical research for gender equity in science education in post-secondary settings. This chapter discusses the cultural significance of science education for women — from the perspective of both formal and informal science learning of science for boys and girls through primary and secondary schooling; of access and equity in learning opportunities for women in informal and formal science settings; and of the cultural significance of science education for women. To facilitate the understanding of gender equity in STEM, I discuss theoretical frameworks of critical theory, social learning theory, identity theory, social constructivism, liberal feminist theory, and motivation theory to act as a guide to facilitate the understanding of gender equity in STEM.

Formal and Informal Science Learning

As opposed to formal schooling, informal scientific learning can be experienced everywhere — from television, to conversations with friends and family, visits to a museums and zoos, the Internet, newspapers, books, comics, or magazines. Informal learning is defined as learning outside a traditional, structured schooling environment (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). During the course of our lives, the road we traveled culminates into our lived experiences. Learning, specifically scientific knowledge accumulates from these mixed experiences, which occur both within and outside of formal learning institutions (Dierking et al., 2003). The Committee on Learning Science in Informal Environments (2009) released research showing that learning science from informal settings intensifies interests in science, influences achievement, and opens possibilities for future careers in science. The research found that (1) everyday experiences can support science learning for virtually all people; (2) designed spaces, including museums, science centers, zoos, aquariums, and environmental centers, can also support science learning; (3) programs for science learning take place in schools and community-based and science-rich organizations and include sustained, self-organized activities of science enthusiasts; (4) science media in the form of radio, television, the Internet and hand-held devices, are pervasive and make science information increasingly available to people across venues.

In 2009, the National Research Council released a report that placed a greater importance on science learning in non-school settings. One of the salient points of the report was that students spend a majority of their time outside the classroom. A multitude of organizations, government agencies and private companies have been working intensely on ways to develop, improve, and document informal learning environments (Bell, Lewenstein, Shouse, & Feder, 2009). The National Research Council Report has put forward "Six Strands of Science Learning", that encompass informal learning, which are: (1) experience excitement, interest, and motivation to learn about phenomena in the natural and physical world; (2) come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science; (3) manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world; (4) reflect on science as a way of knowing, as a system of processes, concepts, and institutions, and as a personal process of learning about phenomena; (5) participate in scientific activities and learning practices with others, using scientific language and tools; (6) think about oneself as a science learners and develop an identity as someone who knows about, uses, and sometimes contributes, to science.

School learning programs that charge tuition may be unaffordable for students of lower socioeconomic status (SES). A study looking at informal learning over the summer from students of high and low SES, from kindergarten through high school graduation, revealed that students from high SES were in more college preparatory classes, had higher graduation rates, lower dropout rates, and higher scores on the California Achievement Test (CAT) (Alexander, Entwisle & Olson, 2007).

Certain states have taken steps and created programs to help all students, especially low SES students. The Explora museum in New Mexico offers free membership to low SES families and hosts a “Family Science Night”. Explora also offers professional-development training for teachers. The Urban Advantage program at the American Museum of Natural History in New York City works in partnership with the botanical gardens of Brooklyn and Queens, as well as the Bronx Zoo. These institutions provide exciting opportunities for learning science and foster rich scientific-inquiry-based learning (National Research Council Report, 2009). Initiatives in states like California and Missouri have embraced and promoted high-quality STEM after-school programs.

It is difficulties to measure the success of informal learning. Methods, such as standardized tests, used to evaluate formal learning have also been used to evaluate informal learning. The results of these evaluations have even been tied to public and private funding (Bell, Lewenstein, Shouse, & Feder, 2009). One of the most important features of informal learning is the absence of testing. It is imperative that we develop methods of evaluation that mimic the way knowledge is obtained through out-of-school, informal learning.

My research focuses on Strand 1 and Strand 6 of the National Research Council Report (2009), and addresses the recommendations for assessing both of these strands. Because Strand

1 is concerned with personal interests and self-motivation, it is appropriate to use self-reporting techniques such as surveys and interviews (Bell, Lewenstein, Shouse, Feder, 2009). Strand 6 is an elusive goal in STEM education — creating an authentic inclusive environment has proven to be difficult. The "boys club" mentality in science has prevented women from feeling a sense of belonging (Corbett & Hill, 2015; Rosa & Mensah, 2016). The methods for assessing Strand 6 are similar to those used for Strand 1. Survey, interviews, self-reports, analysis of the learner's artifacts, ethnographic methods, and a longitudinal analysis of a learner's choice of schools, majors, after-school activities, and hobbies, can give researchers a picture of the effects of informal learning (Bell, Lewenstein, Shouse, Feder, 2009).

Access and Equity in Learning Opportunities for Women in Formal and Informal Science Settings

Out-of-school learning and experiences are a significant factor contributing to science education inequity between the sexes. Male students arrive at school with an advantage, having experienced more out-of-school science learning than their female counterparts (Flinders & Thornton, 2004). Teachers may perceive male students as having a greater interest in science than female students and may cater or pander to the former.

Traditional science courses have been taught as Science of the Abstract, which compartmentalizes individual subjects without crosslinking or relating them to the real world. Females have less success in retaining and maintaining interest in science when taught this way compared to Science in Context, which teaches science with real-world issues and allows for students to explore their personal interests in science topics (Munley & Rossiter, 2013). The Next Generation Science Standards (NGSS) promotes Science in Context, which is also one of the main components of informal science education. The NGSS has yet to be adopted by a majority of the states within the United States. Beyond the explicit study of science content, active involvement in the science community contributes to science learning (Barton & Brickhouse, 2006). Knowledge of the positive social contributions to society a career STEM careers can offer, can have a positive social effect influence women's choices in choosing STEM majors (Corbett & Hill, 2015). As stated previously, museums, zoos, aquariums and STEM programs facilitate informal learning. In a study that looked at six women in a focused STEM program, the women deciding to enter STEM majors after the program was more than three times higher then the national average of girls entering STEM majors (Munley & Rossiter, 2013). Many of these programs promote Science in Context over Science in the Abstract.

Two major STEM programs that I have participated in were the Waksmen Student Scholar Program (WSSP) and the Johns Hopkins Center for Talented Youth (CTY). Both programs focus on real-world applications and activities in an informal setting. Numeric and letter grades were not given to students, only comments and feedback on their work, with opportunities for resubmissions. As a teacher, I know that many of my students are unaware of the variety of programs available for girls and boys, as well as those just for girls. Having an easily accessible resource that lists all STEM programs can help make more girls aware of these opportunities.

Cultural Significance of Science Education for Women

Presently, the United States graduates both male and female students from high school with nearly identical educational backgrounds in mathematics and science, but fewer women are entering college with majors in STEM (Hill, Corbett & St. Rose, 2010). While the number of women working as biological scientists, engineers, chemists and material scientists has increased over the last forty years, the number working in computer and mathematical occupations has decreased since 1990. Though the amount of women entering engineering between 1960 and 2013 has multiplied by a factor of twelve, it still remains the most elusive STEM career for women (Figure 2.1) (Corbett & Hill, 2015).

Women in Selected Stem Occupations, 1960-2013

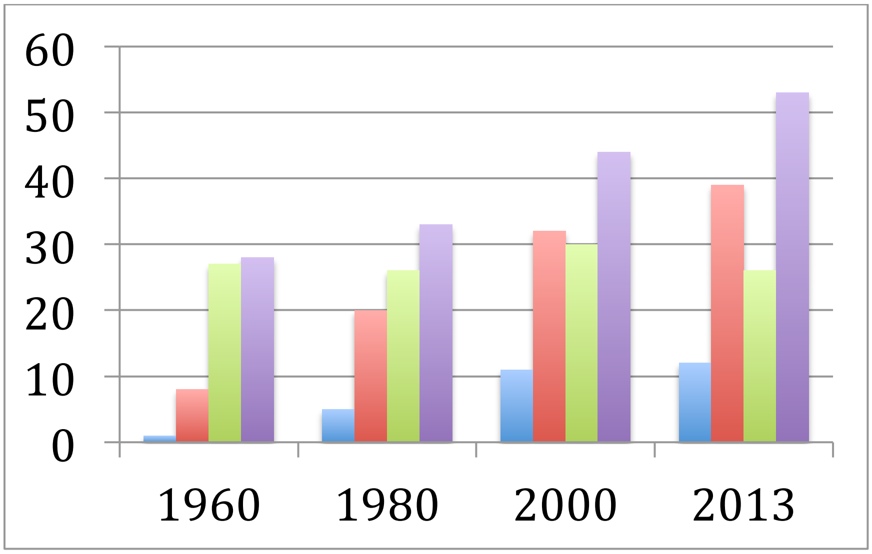

Figure 2.1. Percent of Women in Selected Stem Occupations (ordinate), 1960-2013 (abscissa). Engineers (blue), Chemists and material scientists (red), Computer and mathematical occupations (green), and Biological sciences (purple) Adapted from Hill & Corbett (2015).

There is an important psychological aspect to education — personal experiences affect the individual learner. The student also follows a course's defined goals and learns the content that must be obtained by the end of the course for all students (Dewey, 1974).

As illuminated by the early research done at Carnegie Melon by Margolis and Fisher (2002), the concepts of curriculum and culture as it relates to women in STEM have been a focus at both private and public universities across the United States. Harvey Mudd College (HMC) has taken an active role in recruiting and retaining women in STEM majors, specifically computer science. This can be seen clearly by comparing the national average of computer science graduates against HMC's (Figure 2.2) (Corbett & Hill, 2015). According to Corbett and

Hill, one of the possible reasons few women historically did not enter into a computer science major was their lack of understanding of what the major entails. If a student is aware of what a major entails and has had significant exposure to the field, she may be more likely to give it consideration when choosing a major. No state has a mandatory computer science programming class as a high school graduation requirement. According to Alvarado, Dodds, & Libeskind-Hadas (2012), both male and female computer science students listed exposure to computer science before college as a top reason they chose their major.

Female Computer Science Graduates Nationally and at Harvey Mudd College, By Graduation Year, 2000-2015

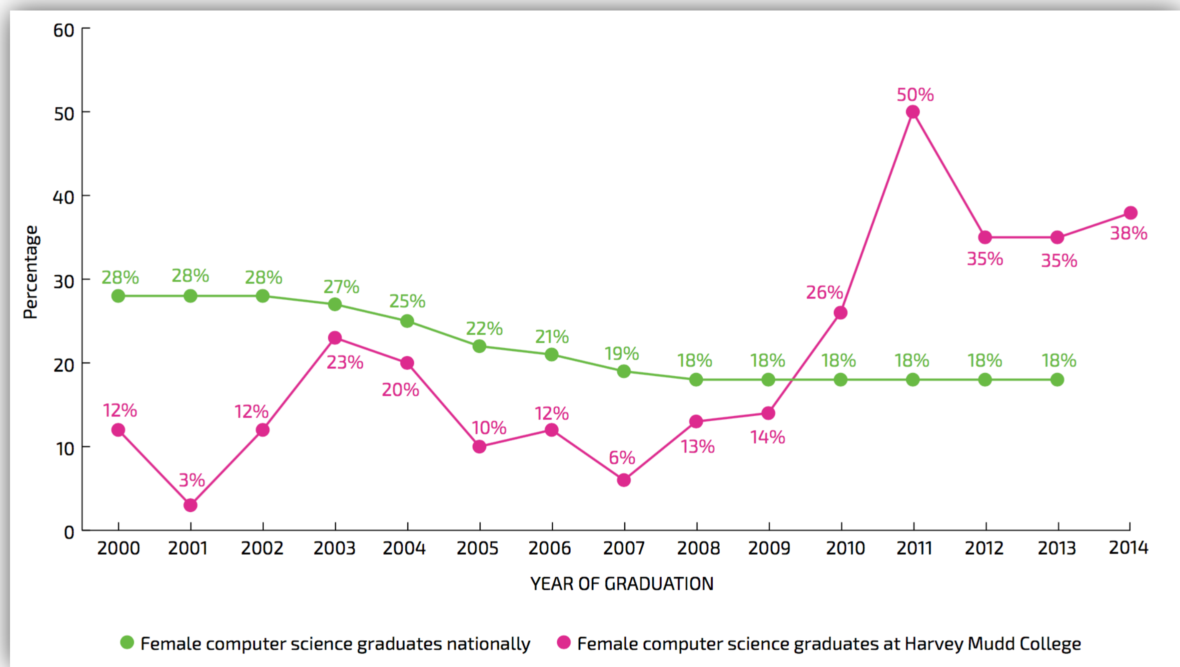

Figure 2.2. Source: Corbett, C. & Hill, C. (2015) Why so Few? Women in Science, Technology, Engineering, and Mathematics, *AAUW*. Washington, DC.

HMC initiated three main changes that focused on first year students: (1) revision of the introductory computer science course to present the breadth of the computer science field in addition to the basics of programing; (2) provision of research opportunities for women immediately after their first year of college to expose them to real computer science problems as early as possible; (3) giving first-year students opportunities to attend the annual Grace Hopper Celebration of Women in Computing conference hosted by the Anita Borg Institute for Women and Technology (Alvarado et al., 2012; Corbett & Hill, 2015). Concurrent with these changes, the introductory computer course was revamped: the programming language JAVA was replaced by Python, a more user-friendly language; the focus of the class was broadened to introduce the social relevance of computer science; the class was developed to cater to different levels of experience and exposure to computer science (Alvarado et al., 2012; Corbett & Hill, 2015). Besides academic changes, HMC let first-year female students attend the Grace Hopper Celebration of Women in Computing for free. This conference inspired female students, who were able to see other women who had succeeded in computer science. HMC has provided a model for other schools to follow, and indeed, several universities have revamped their introduction computer science courses, some with greater success than others (Corbett & Hill, 2015).

As far as HMC has come, there still is a large gap throughout the United States. Even with all these changes, HMC graduates still said that that prior computer science experience before college was a major factor in their decision to major in computer science (Alvarado et al., 2012). Many states mandate four years of high school English and Mathematics, and three years of high school science; however in 2015, only twenty-five states required a computer science course (not programming per se) in order to graduate from high school (Gross, 2015). Earlier exposure to computer science is a necessity.

Cultural Significance of Women in STEM Careers

A general stereotype between men and women suggest that women prefer work that helps others and has a social impact, but according to Corbett and Hill (2015), some men prefer to work in environments that help others and some women like to work alone for the greater good of themselves. These values are not entirely innate; society has taught girls from an early age that they are expected to help others because they are women, which leads them to believe that they should enter careers that allow them to help others (Chen, 2008). Still, on average, women do place a higher emphasis on working with others and helping than men (Diekman, Brown, Johnston, & Clark, 2010). When science careers were shown to be communal, or have a social purpose, women responded more positively to that career (Diekman, Clark, Johnston, Brown, & Steinberg, 2011).

In 2012, a survey on the importance of high-paying careers and a profession, women ages 18-34 ranked the importance of a high-paying career higher than men did (Patten & Parker, 2012). According to modern genetics, if women valued social purpose fifty years ago, and now value higher-paying careers as a greater priority, then we can rule out nature and evolution as a cause for the shift in women's interests. Human evolution is a slow process; it would take several hundred to several thousand generations for such evolutionary changes to occur, not fifty years (Campbell, Williamson, & Heyden, 2004; Corbett & Hill, 2015). For years large tech companies have been marketing their newest technologies as tools help people and make the world a better place. The HBO series *Silicon Valley®* parodies this attitude — every episode in the first season has a tech company employee who ends his product pitch with "*… and making the world a better place.*" According to Fouad, Singh, Fitzpatrick, and Liu (2012), they found women were more likely to leave a job in engineering if there was no communal aspect to that job.

Interestingly, these jobs do have social and communal aspects to them, but they are not considered part of the actual job. Such communal aspects include assisting others in the work place, mentoring, and working overtime to finish a job. These aspects of the job are looked down upon as not being “real” work, viewed as feminine by other engineers, and not given the value and importance they deserve (Corbett & Hill, 2015). Valuing these contributions and making them an essential part of an engineering role would have a significant effect on maintaining a more inclusive female work force (Diekman, Weisgram, & Belanger, 2015).

A large survey of over 5,500 women from 200 universities who graduated with an engineering degree from 1947-2010 show that more than half of the women remained in engineering careers, about twenty-fiver percent left the field of engineering, and the remainder never entered the field (Fouad et al., 2012). According to the survey by Fouad et al. (2012), the significant influencing factor between the group of women who remained in engineering careers and the ones who left was the environment within the workplace. Women who reported negative workplace environments were, (1) less likely to report opportunities for training and development that would have helped them advance, (2) less likely to report support from a supervisor or co-worker, (3) more likely to report undermining behaviors from supervisors, (4) less likely to report support for balancing work and non-work roles. A follow-up analysis was administered by Singh et al. (2013) and showed that women who had high job satisfaction and higher organizational commitment displayed high task self-efficacy (confidence in their ability to complete a job) and positive task outcome expectations (the belief that their work will result in a positive outcome). When Singh et al. (2013) looked at why men stay in engineering jobs, the results were strikingly similar. By changing the culture of the work environment to a more positive atmosphere that counters the four main reasons why women leave engineering, the results could benefit both men and women. Equity in the workforce for women may bring a stronger and more satisfied workforce for all.

Theoretical Framework

The following research study selects aspects that align with gender equity in STEM from a variety of theories in social science research. This case study will utilize a *bricoleur* approach of the theoretical frameworks by taking components of each that help align with the research (Levi-Strauss, 1966). Critical theory, social learning theory, identity theory, social constructivism, liberal feminine theory, and motivation theory will be used to conduct a narrative describing the lived experiences of females and their performance in two highly selective private universities — one coed, the other women only. Students are allowed to cross register between the two schools. The theories listed help provide a foundation for further understanding of the phenomena of gender equity in STEM. The synthesis of this foundation supports the research and integrity of this proposal.

Critical Theory

Critical theory emerged from the Neo-Marxist teachings of the Frankfort School in the 1920s. It describes the workings of class, gender and race to reinforce a society's dominant ideology. The hegemonic class constructs knowledge from its own perspective and for its own benefit, while suppressing others' voices. Critical theory challenges this construction of power (Stinson, & Bullock, 2012). Creswell (2012) suggests critical theory is a way of empowering human beings to surpass the limits assigned to them based on race, class, and gender. The hegemonic ruling class suppresses the rest of society either unintentionally or intentionally. The United States' Congress writes the laws that govern U.S. citizens. In 2014, more than half of Congress had a net worth of over one million dollars (Katz 2014). The race and gender break down of the House of Representatives shows that four out of five people in the House are White males, while the Senate is also 80% male and 94% White (Bump, 2015). Historically, when one oppressed group liberates themselves, they often oppress the group that was previously in power. However, it is important to liberate the oppressors as well (Freire, 1970). As we have seen with the Arab Spring in Egypt in 2012, once the oppressive government was overthrown, another took its place, and the death tolls were actually higher after the conflict. Freedom from oppression requires that all groups be liberated; otherwise oppression will persist in a vicious cycle.

. Science is at times presented as a universal language that transcends all cultures, but for many, science reflects the White middle class (Barton, 1998). This is known as western science. According to Fray (1987), the women's movement is a great model for critical theory, because the first two waves of feminism deal with the struggles of women and their goal of equality and equity within society, politics, race, education, and culture. Science is also not biased or value free; it represents viewpoints that are not universal and research that can seem one-sided and subjective (Hodson, 1999).

Social Learning Theory

For students, scientific knowledge is acquired by being immersed in the scientific community (Lemke, 1990). In science education, students should be immersed in the scientific community, learning how scientists think, following scientific methods and processes, reading science journals, becoming part of the learning experience, while at the same time making the material relevant for each student (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Social learning theory evolved out of other learning theories like classic conditioning, operant conditioning, and psychoanalytic concepts. Noam Chomsky (1959) argues that classic conditioning could not account for language acquisition, opening the door for advancements in cognitive science.

According to Reed et al. (2010), social learning must, (1) demonstrate that a change in understanding has taken place in the individuals involved, (2) demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice; and (3) occur through social interactions and processes between actors within a social network. The third point reinforces research that shows that working in groups with increased social interactions accords with girls' learning style and increases their academic success and interest (Baker, 2013). When a person becomes part of the community she feels like she belongs and is no longer an outsider. In 2009 the American Association of the University of Women (AAUW) showed that girls work better in cooperative activities, while boys excel in competitive activity (Flinders & Thornton, 2004).

Students become part of the scientific community when they approach problems in a scientific manner, allowing for multiple outcomes and solutions (Baker, 2013). When students work along side professional scientists within a lab setting, they become engaged with and part of the science community.

Within many professions, work is a process of collaboration between individuals and departments. Steve Jobs encouraged collaboration on the Apple campus by creating a single cafeteria that would serve as a meeting place for multiple departments, with the goal of creating dialogs that would lead to greater innovations and problem solving. Many research labs have collaborative meetings where different departments share their results and findings in front of other departments. Posters and presentations are followed by open discussions and dialogs. Outside insight becomes extremely valuable, because an outside eye can offer unique perspectives. Different people have different backgrounds and different understandings of how things work. These differences, through enculturation can add to a greater cognitive understanding and discovery. When people can learn from each other the benefits encompass a broad community (Reed et al., 2010). Bandura, Ross, and Ross (1961) have shown that students' behavior is altered after observing other humans, or models — humans learn from other humans through observation.

Identity Theory

One's identity is shaped by a multitude of factors. Throughout the day, our interactions change, the people and places we interact with change, and so can our identity within given groups during these interactions. Therefore "identity" can be defined by or within a given context (Gee, 2000). According to Carlone and Johnson (2007), female science identity explains how women make meaning of their science experiences as well as the identity society has structured around those meanings. In order to sustain interest in science and to understand how and why certain students stay with science while others leave, we need a greater understanding of the development of students' science identities (Carlone & Johnson, 2007).

At work I can identify as a teacher, a science teacher, and a White male science teacher; at school my identity is a graduate student; at the gym I can be identified as a bodybuilder; at a night club I can be identified as a DJ or a member of the electronic and house music scene; and when eating I can be identified as a vegetarian. All these different identities are part of the "Four Ways to View Identity" (Gee, 2000): (1) nature identity, (2) institutional identity, (3) discourse identity, and (4) affinity identity. My nature identity is White male; I was assigned this identity at birth. My institutional identities are high school teacher and nightclub DJ — identities I acquired by accepting certain job offerings. I determined my discourse identity in consultation with friends, asking them to assign me identity traits exhibited on our discussions. They collectively described me as loyal and persistent. My affinity identity labels me as a member of the house music party scene in Brooklyn, New York. In the context of this identity, I dress a certain way, go to certain events with the same large group of people, participate as both an audience member and a DJ, collect music from others, as well as follow and post about events and happenings within this scene.

The STEM community contains all four of these identity perspectives; one of the most important identity perspectives within this community is the one we have no control over — our nature identity perspective. Women are treated negatively within STEM because they are women, and that identity is almost impossible to change. Women should not be required to change their gender to be science majors. The male perception that women in STEM do not belong and do not hold the proper identity credentials required for a STEM identity can isolate and deter women. Since some women feel they do not live and breath science, they may feel like they are not part of that identity (Corbett & Hill, 2015). Disruptive science identities occur when women do not get recognition from the scientific community (Carlone & Johnson, 2007).

Social Constructivism

Constructivism is the process of building knowledge from experiences, knowledge that does not exist until experienced and made one's own. Dewey (1974) believed students should experience education on a personal level through inquiry — choosing their own path, making discoveries on their journey and engaging in real life experiences. The Piaget's work "La construction du réel chez l'enfant" (1954, "The construction of reality in the child") discusses the way a child builds its own knowledge through experiences in the world. Physical experiences promote cognitive conflicts in learners, which lead to conceptual change (Driver et al., 1994).

For students to attach personal meaning to these experiences, they need to go through a conceptual change (Pintrich, Marx, & Boyle, 1993). These subjective meanings and experiences are often a product of interactions between individuals, culture and society, a process described by the term social constructivism (Creswell, 2012).

Social constructivism states that knowledge is not created in isolation; it is the product of a communal effort through collaborations and discourse with other people. Learning is facilitated through conversations between individuals. Within these conversations a dialogic process occurs between less skilled and more skilled members of that community. The learner can efficiently process and internalize the information, making increasing cognitive understanding and use of the tools within the community (Driver et al., 1994). Not only is the dialogue between individuals important, but also the locations and settings of these conversations. Linn (2006) proposes a key tenet for integration of knowledge that includes enabling students to learn from each other.

Social constructivism, like many theories of learning, is an amalgamation of previous ideas and philosophies that take what has experimentally shown to work and utilizes them. Just as cultures change over time, so do learning theories and knowledge. Both situated learning and anchored instruction have roots within social constructivism. In situated learning, students are immersed in an authentic activity, which reflects the regular practice of that culture (Brown, Collins, & Duguid, 1989). An example of an authentic activity would be to have students work in a research lab within the scientific community. The learner not only learns about different tools, but how to use them in an appropriate context that may be unique or specific in a certain community or setting. Students learn by doing and knowledge is part of social interactions within the physical environment. Here the learner becomes enculturated within a specific community. Anchored instruction uses the formal educational setting to mimic what it's like to be in an apprenticeship and the experiences one derives from said apprenticeship, with a goal of inspiring thinking instead of memorizing facts (Cognition and Technology Group at Vanderbilt, 1992). Students can watch video segments that place them in an environment where they have to solve problems based on the information they were given by placing themselves in within the situation that was presented. Students have few limitations and multiple possible solutions.

Liberal Feminist Theory

The history of feminist theory can be divided into three main waves of feminism: (1) the first wave took place during the late 19^{th} through the early 20^{th} century, with a focus on suffrage and expanding opportunities for women; (2) the second, from the 1960s into the 1990s focused on sexuality, reproductive rights, the Equal Rights Amendment, workers' rights, neo-Marxism, the differentiation between sex and gender, and the role of wife and mother, and critiques of capitalism, patriarchy and normative heterosexuality; (3) the third wave began in the mid-1990s and focused on postmodernism, poststructuralism, postcolonialism, reclaiming gender identity, redefining the concept of beauty as subjects not objects, and breaking boundaries (Rampton, 2008).

Part of the "American Dream" states that with enough hard work and determination, anyone can become what he or she desires. However, laws, cultural norms, sexism, stereotypes, and discrimination limit access to a multitude of careers and education based on one's gender. One of the goals in liberal feminist theory is to create personal autonomy, where women can choose a life they want (Baehr, 2013). Liberal feminist theory analyzes the traditional gender roles assigned by males, and their affects on society and institutions in order to suggest solutions (Okin, 1989). Mensah (2011) states: "As most images of the scientist are White and male, science teacher educators who emphasize feminist pedagogy and critical perspectives in teaching science try to create learning environments that are inclusive, participatory, and critical of these images (p. 379). The word scientist has become synonymous with men. This is why we need to reexamine the discourse of the language within the STEM culture so that feminist theory is connected to science as well.

Motivation Theory

When a task needs completion, or work needs to be done, what drives someone to complete it, and in what capacity did they enjoy it, want to do it, take pride in it, and feel confident in doing it? Motivation is something internal that can initiate and maintain a student's curiosity (Glynn & Koballa, 2006). When trying to figure out what motivates students to learn, Pintrich (2003) comes up with seven key questions that are integral to understanding student motivation: (1) What do students want? (2) What motivates students in the classroom? (3) How do students get what they want? (4) Do students know what they want or what motivates them? (5) How does motivation lead to cognition and cognition to motivation? (6) How does motivation change and develop? (7) What is the role of context and culture? Motivation can help us understand why certain students succeed in the classroom and others do not (Pintrich, 2003). One of the most important things a teacher can accomplish is to teach students to want to learn (Druger, 2006). If students want to learn, motivation follows. Motivation in science can inspire children to become new scientists; it can also help all students enjoy science, and become scientifically literate (Bryan, Glynn, & Kittleson, 2011).

This study utilizes the Science Motivation Questionnaire II created and validated by Glynn, Brickman, Armstrong and Taasoobshirazi, (2011). Within this questionnaire, the creators developed five categories of motivation: (1) intrinsic motivation, (2) self-efficacy, (3) self-determination, (4) grade motivation, and (5) career motivation. These five different categories will be used to help understand what internal and external factors motivate young female students to learn science.

Intrinsic Motivation. This motivation type refers to one's goal of learning for its own sake (Schunk, Pintrich, & Meece, 2014). Ryan and Deci (2000) describe intrinsic motivation as one's way of exploring and learning, and is a natural force that all people posses. Humans are curious creatures, and they want to know new things. This learning can be about any subject: nature and how the world works, knowledge about sports teams, fashion and art. Humans want to know things solely for the sake of satiating an appetite for knowledge, and personal interests that help satisfy their drives (Deci & Ryan, 1985).

Self-Efficacy. According to Bandura (1986), self-efficacy is one's own belief in one's capability to achieve a task. Lawson (2007) argues that Bandura fails to incorporate prior characteristics like reasoning ability, while stressing the strong linkage between performance and learning. In the learning environment, students who have higher levels of confidence tend to perform better than students with lower levels of confidence. Glynn and Koballa (2006) point out that self-efficacy is not universal and subject specific; therefore, if a student has high self-efficacy for chemistry, it does not correlate with a high self-efficacy for other subjects like English. Female students tend to have lower levels of self-confidence in their science ability than their male counterparts (Hill, Corbett & St. Rose, 2010).

Self-Determination. In its most simplistic definition, self-determination is one's belief in the ability to make choices in one's learning (Bryan, Glynn, and Kittleson, 2011; Glynn and Koballa, 2006; Ryan and Deci, 2000). However, a much more complicated definition arises when one describes self-determination as having both a conscious and an environmental component stemming from a cause rather then complete free choice (Reeve, Hamm, and Nix, 2003). Students who believe they have control over their learning tend to perform better, and they exhibit an increase in intrinsic motivation (Glynn and Kobella, 2006).

Grade Motivation. Out of extrinsic motivation comes the category of grade motivation, which Ryan and Deci (2000) define as a motivation for a separate outcome, beyond the personal satisfaction created by learning for its own sake. For example, students may complete an assignment for the sake of getting a good grade on a test, making parents happy by completing an assignment, making a teacher happy, feeling smarter than classmates, and being able to apply that knowledge elsewhere. Grade motivation specifically deals with the drive to receive good grades — grades which can then lead to numerous rewards: getting into a good college, pleasing one's parents, and feeling smarter than one's classmates. Grades are also seen as short-term goals (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2009).

Career Motivation. Similarly to grade motivation, career motivation originates from extrinsic motivation, and Glynn and Koballa (2006) refer to it as *Goal Orientation*. Glynn, Brickman, Armstrong, and Taasoobshirazi (2009) group *Goal Orientation* with career motivation and suggest these motivations are long-term goals compared to short-term goals (grade motivation). London (1983) divides career motivation into three parts: career resilience, career insight, and career identity. Career resilience is an important component, because it allows for setbacks and missteps. Students may not receive an "A" on every test or may not attend their first-choice college, but that does not mean they need to give up. However, career insight provides a measuring stick that can help a person see if his goal is attainable or within his means. Instead of having a short-term goal like doing well on a test, career motivation requires students to perform well on a plethora of assignments in order to obtain their goal. It could take years just to get into a college of one's choice, and once in college, one may have to focus on a certain G.P.A. for graduation to get into graduate, medical, or law school.

Conclusion

Throughout our lives, we confront countless experiences that shape who we are. As a young child growing up in suburban New Jersey in the 1980s, I was fascinated by the nature shows on Saturday mornings. Before cable and the Discovery Channel, I was limited to a select few shows. My only other source of science was the library where I read as many books as I could on space and animals. My primary school did not spend much time during the week on science, and my high school science teachers had limited knowledge outside the content being taught. They did not respond well to my constant bombardment of questions and my unquenchable curiosity and science motivation about the world. Their strict rules and guidelines did not help either. However, I took it upon myself to read ahead in the textbook as well as look things up in the library that I found interesting. For me, it was my informal learning that lead me to major in science, but for others students it may have been a great science teacher or an interesting class that lead them on their path.

The utilization of the various theoretical frameworks allow for a comprehensive analysis of the research questions. This paper focuses on the inequities women face in STEM education and STEM careers. One of the most important theoretical frameworks that exist today to help explain and confront inequity and oppression by a hegemonic society is critical theory. It facilitates the oppressed in overcoming their assigned roles while encouraging the liberation of all groups. Creswell (2012) and Parker and Lynn (2002) believe racism and sexism are interconnected and see critical race theory as an important component of gender equity. When focusing specifically on gender, various feminist theories aim to promote gender equity as well as equality.

The ability to learn and study science is a product of social interactions. The combination of social constructivism, social learning theory, identity theory and motivation theory, plays an invaluable role in nurturing and sustaining one's science identity, while paving the way for a career in STEM. By comparing the lived experiences of women in science with the given theoretical frameworks, this study attempts to shed greater light on the variables that channeled these women into becoming STEM majors in college.

The following chapter (III) applies the theoretical frameworks in this chapter and designs a methodological style to test, collect and analyze data from the female STEM participants in this study. The goal of this chapter is put in place the tools required to study the lived experiences of female science majors, while uncovering the factors from both informal and formal science learning that helped shape their current science identities.

CHAPTER III

METHODS

Creswell (2012) stresses the importance of inductive-deductive logic in allowing the research to work in a multidirectional fashion, constantly checking and reassessing phenomena while looking for new patterns and themes. Both qualitative and quantitative approaches were used to answer the research questions for this study:

1. What captivates and motivates female students' interests in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?
2. What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college?
3. How do female science or STEM majors discuss their experiences of gender equity as science or STEM majors?

Qualitative Research Design

When looking to observe, interpret, and make sense of people in their natural world, one must include a theoretical framework, be sensitive to the people, places and cultures being studied, be able to collect and analyze data, and construct themes and patterns (Creswell, 2012). Data collection plays an important role in performing research. Hard sciences tends to focus more on numeric results or quantitative data, while social sciences incorporate numeric data with social data from interviews, observations and interactions, behaviors, emerging themes, and Qualitative data (the attempt to make meaning of various forms of data). Qualitative methods, or approaches used in the collection of data, are used in this study, and include narratives, case studies, and phenomenological studies.

Narrative. A narrative can act as either a method or the phenomenon being studied (Creswell, 2012). Narratives tell the stories of the lived experiences of one or two an individual, placing the meanings of their experiences in chronological order (Creswell, 2012). According to Casey (as cited in Creswell, 2012), narratives can be in the form of oral histories, life histories, biographical studies, and autoethnographies.

Case Study. A case study is a design in qualitative research that can either be a product of inquiry or an object of study, and it focuses on a bounded system through detailed interviews, surveys, and reports (Creswell, 2012). Yin (1989) suggests incorporating both quantitative and qualitative analysis in a case study. This current study is classified as an *instrumental case*, with the goal of providing additional awareness and understanding to an already existing dilemma (Stake, 1994) — the lack of women in STEM careers.

Phenomenology. A phenomenological case study was chosen using narratives and surveys about women majoring in STEM and gender equity in science education with the goal of providing a greater understanding of the lived experiences of female STEM majors. A phenomenon is an object of human experience, and a phenomenological study describes the lived experiences that several individuals have in common (Creswell, 2012). The phenomena looked at in this study were the lived experiences of women STEM majors that are in their junior and senior year. Other phenomena that have emerged are the factors, experiences, and influences that lead these women into STEM majors. Surveys help to narrow the search for suitable interviewees and to focus in on the lived experiences shared by the participants. A key source of data for a phenomenological study is an interview, which usually contains between three to four individuals (Creswell, 2012). The study findings provide future educators and universities additional insight on the matters of gender equity in STEM education (Stake, 1994).

Data Sources for the Qualitative Approach

Interviews provide a voice for people within the system. They give researchers a view into how these programs affect students. This study includes six semi-structured one-on-one interviews that were coded using the NVivo software, provided by Teachers College, Columbia University. All but one of the interviews were conducted face-to-face in a natural setting, a quiet room in a library at the university. The exception was conducted over Skype, while the interviewee studied abroad in England. The interviews focus on the following themes and experiences: (1) the experiences these women had as children growing up that influenced them to choose majors in STEM; (2) the informal science learning these women had growing up; (3) the support they had from family members, teachers, mentors, and friends about their interests in STEM; (4) their experiences of inequity and lack of opportunity as women in STEM; and (5) the resistance and isolation they may have felt as women interested in science and STEM. See Appendix 3.1 for the Interview Protocol.

The interviews lasted approximately 20 - 40 minutes and were audio recorded. Not all questions were static; some questions were changed depending on the direction of the interview. Member checking will give the interviewer the ability to go back to previous questions to confirm or check if there were any answers that conflicted with previous answers. The female STEM participants were asked if they could be contacted in the future for clarifications and possible follow-up questions.

Quantitative Research Design

This study takes advantage of mixing qualitative and quantitative research A Likert scale with a few open-ended questions provides additional sources of data, helps recognize a phenomenon and gives further insight into the lived experiences of women in a STEM program. It also provides a metric from which one can select participants for an interview.

Data Sources for the Quantitative Approach

Survey. The surveys used in the dissertation are part of a Likert scale that fit into the categories of both position or stance and sentiment and attitude (Anderson, 2011). The Likert scale follows the three main guidelines presented by Anderson: (1) each scale should be based on a conceptually defined dimension to be assessed, should be related to a research question, and should specify the focus or theme of the items in the Likert scale; (2) the number of options provided on the Likert scale should be considered in light of the respondents' attention capacity and the appropriate number to quantify the results; (3) careful attention should be given to the wording of each option to ensure that it is clear to the respondent depending on age, experience, etc. and that the options are consistent with respect to emotional or cognitive focus of the dimension that is being assessed. After the data was collected, relationships and patterns were established, while the mean and standard deviation were calculated. Guidelines for this Likert scale are with accordance to the presentation done by Anderson (2011) in his quantitative analysis class. The survey (Appendix 3.2) was posted on Qualtrics at Teachers College, Columbia University. The survey is accessible through this link: https://www.qualtrics.com/

The survey is divided up into three main parts: (1) questions about informal and formal learning experiences in science during middle and high school, (2) questions about gender equity as a STEM major in college, during high school and middle school, (3) questions about science motivation. As an example, interviewees were asked about their informal experiences with science growing up, and whether they were treated differently by their friends, family and peers as female students interested in science. The section on motivation in science was taken from previous studies on science motivation called the "*Science Motivation Questionnaire II©.*" An introduction section asks the young females what their age is, their major, minor and why they chose to major in STEM. A comment section was added after each of the three sections of the survey, allowing female STEM participants to expand on any of their responses. When young females completed their survey, they were asked to include their email for possible follow-up questions, and they were asked if they would be interested in a one-on-one interview.

Setting and Participants

The data collection took place at two highly selective private universities in the Northeast United States, where female STEM participants can cross-register. The following criteria must be met for the female STEM participants: (1) a junior or senior in college at the time of the interview, (2) eighteen years old or older, (3) majoring in STEM, (4) completed the Likert survey.

Recruitment Process

With the assistance of various deans at both universities, emails were sent out to all young females who are junior and senior STEM majors in early November 2015. Emails were sent out over various list servers with an explanation of whom I am and the research I would like to perform. After a few weeks, only a dozen students responded. Emails when then sent out to every department head, dean and professor in all the STEM fields at both universities. The survey was opened until December 31st, 2015. Attached was an IRB consent form. Female STEM participants were told that their input would help shed further light on gender equity in STEM.

The selection process began with a survey given to as many young females as possible who satisfied the criteria listed above. An incentive for the young females to participate was a chance to win a $20 Amazon® gift card. Once the female STEM participants finished the survey, data was analyzed, while looking for common and recurring phenomena and themes. Then six female STEM participants were selected from both junior and senior classes based on their completion of the survey, fulfillment of the requirements, and their interest and willingness to participate further within the study Table 3.1 summarizes the young females who participated in the interview process, listing their name, age, gender, major, minor, and current year in school.

Table 3.1 Summary of Interview Participants' Background

Participant	Gender	Age	Major	Minor	Student Status
Andrea	F	22+	Environmental Science	Political Science	Senior
Julia	F	21	Neuroscience & Behavior	English	Senior
Martha	F	20	Neuroscience	None	Junior
Esther	F	21	Astrophysics	None	Junior
Uli	F	22+	Biochemistry	NA	Senior
Wilma	F	21	Biochemistry / Pre-med	None	Junior

Female STEM participants were contacted within one month of the survey, using contact information provided on the survey. Interviewees each received a $25 Amazon® gift card. Some interviewees were contacted at a later date for any follow-up questions and clarifications. All data was collected by August 30, 2016.

All young females participated was be of their own volition, as required by the guidelines governing human participants as specified by Teachers College's Institutional Review Board. There were no external factors coercing the interviewees into participating. It was explained to them that their participation would help shed further light on the issues regarding gender equity in STEM education. I was able to find volunteers with the help of deans from various STEM programs, who allowed me to contact all the members within their programs through emails and list servers.

Data Analysis

Interviews were conducted with six female STEM participants; three juniors and three seniors. The interviews were then coded accordingly. Questions focused on in-depth analysis of their experiences growing up as women interested in science, how they became interested in science, their informal and formal science learning experiences, any experiences in gender inequity, support from their family, friends, mentors and advisors, and challenges they faced in pursuing their interest in science and STEM.

Female STEM participants were told that their names would be replaced by pseudonyms and that the university would be called "*A highly selective university in the Northeast of The United States.*" Interviews were transcribed using an online transcription software NVivo®, and the audio files are stored on my personal hard drive with access only to me by password-protected access. At the end of the study, all recordings will be removed. The majority of my data was from the interviews transcribed using the software by NVivo®. Connections and themes were made between participants' responses and lived experiences then summarized in my findings (Creswell, 2007).

The data from the surveys was tabulated as follows: The Likert survey contains 45 questions broken up into three sections, each question is answered on a scale of 1-5, from 1 (never) to 5 (always), for a total of 145 points. The surveys contained both closed and open-ended questions and were set up using Qualtrics, which tallied and graphed all survey responses in an easy-to-read layout.

Section one contains eleven survey questions, with a score range of 55 points. Participants who score from 0-14 who "strongly disagree to disagree" about their prior experiences in science both formal and informal, followed by 15-28 who "disagree to not affected,” 29-42 who “not affected to agree”, and 43-55 who “agree to strongly agree”. Section two contains nine questions and focuses on women as undergraduate STEM majors in college. The scores ranged from 0-15 who “strongly disagree to disagree,” followed by 16-25 who “disagree to not affected,” then 26-35 who “not affected to agree,” and 36-45 who “agree to strongly agree.” Section three, focusing on motivation in science, contains twenty-five questions and used the same scoring method as previous sections.

The data I collected contains both qualitative and quantitative analyses. The qualitative data was coded and analyzed using the methods described in Merriam’s, *Qualitative research and case study applications in education* (2009). The quantitative data was analyzed using the methods described in Hoy’s *Quantitative research in education: A primer* (2010). Table 3.2 represents a summary of the research collection and procedures.

Table 3.2 Summary Chart of Research Collection and Procedures.

Research Questions	Data Collection Procedures
1. What captivates and motivates female students' interests in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?	• Likert survey on Science Background and Equity Questionnaire through Qualtrics®, with comment section. • Science Motivation Questionnaire II© (Glynn et al., 2011) • Surveys were analyzed using Dedoose QDA software.
2. What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college?	• Likert survey on Science Background and Equity Questionnaire through Qualtrics®, with comment section. • One-on-one semi-structured interviews. • Data was analyzed using NVivo software.
3. How do female science or STEM majors discuss their experiences of gender equity as science or STEM majors?	• Likert survey on Science Background and Equity Questionnaire through Qualtrics®, with comment section. • Surveys were analyzed using Dedoose QDA software. • One-on-one semi-structured interviews. • Data was analyzed using NVivo software.

Validity, Reliability, Rigor & Limitations

Because of the subjective nature of a case study, I must place myself in a position that produces results through objective observations. One must adhere to the guidelines grounded in proven research and theories on qualitative analytic studies. Some of my challenges included (1) maintaining objectivity, (2) assessing the availability and reliability of data, and (3) overcoming personal research bias.

Sampling. The use of criterion sampling for the interviews is used once a common phenomenon is established from the surveys and who can help contribute the narrative of the story (Creswell, 2012). All young women that satisfy the criteria listed above will have the chance to participate in the survey. Ideally I would like to have equal representation by both juniors and seniors. Creswell (2012) suggests interviewing no more than 4-5 interviewees be conducted using the approach taken in the study.

Availability and reliability of data. The reliability of the study is enhanced by taking detailed notes during the interviews, recording the interviews, and transcribing the interviews (Creswell, 2012). I created an intercoder agreement, a "*blind*" coding, by contacting a fellow colleague to assist with the coding. After the interviews we compared our notes to ensure consistency in coding and to identify common or remerging themes.

Research bias. As a researcher and educator with vested interest in my work, I proceeded with an objective approach when collecting data through surveys and interviews. My survey population was as large as possible within the case I was studying, and it was as descriptive as possible. Creswell (2012) expresses the importance of clarifying past experiences, biases, prejudices and orientations that might effect the study. Because I was studying gender equity in science education, some of my questions were very specific in regards to the female STEM participants' personal experiences of gender inequity in science. Because I used integrated coding for my interviews, my themes were both inductive and deductive.

Numerous personal factors and experiences inspired and directed my research topics. My teenage years through my early twenties in the punk rock and hardcore music scene educated me about a variety of social inequities that were obscured from my childhood. Instead of being someone who stood by and kept his mouth shut, I felt a need to express my opinions. I need to make others aware of these inequities, with hope of instilling a greater understanding and a possible change in society. As an undergraduate, I enrolled in a women's study class to learn more about the struggles of women and how I can go about changing things. As a scientist in the lab, I noticed the dearth of women and overwhelming "boy's club" environment. While teaching in the classroom I quickly noticed how more boys enjoyed and participated in science compared to girls. I have done my best to call on both boys and girls equally and express the cognitive science regarding male and female intelligence. Even at the school where I teach, some male teachers make sexist remarks, and I am compelled to challenge them. With a goal of being an agent of change in this world, I am hoping that my research can have a positive contribution to gender equity in STEM.

Rigor. Some qualitative research seeks recognition and adherence to quantitative research; however, Creswell (2012) sites the terms *credibility, trustworthiness, dependability* and *confirmability* with Lincoln and Guba (1985) who adhere to these elements of rigor for more qualitative, naturalistic research approaches. To ensure credibility, I performed an in-depth literature review on theoretical frameworks that were used to back research up in gender equity. My female STEM participants were all women from two highly selective private universities in the Northeast, where students can cross-register, whose ethnicity, race and religious beliefs are unknown to me. In order to confirm the results, I did internally validation of the findings, while seeking external validation from my peers. Due to the nature of an interview, reliability is more challenging to reproduce; qualitative researchers tend to assess dependability through the use of an auditor (Creswell, 2012).

Limitations. The information gathered during an interview is based on the interviewee's personal recollections of their past. According Creswell (2008), an interviewer needs to be cautions about the interviewee's stories, because the topic may be emotionally traumatic, the interviewee may embellish the story to have a more dramatic ending, fear telling the truth could lead to retaliation, or the person being interviewed my not be able to recall it properly. The female participants in this study may have issues recalling stories from their past because they happened so long ago and their memories could become distorted (Leiblich, Tuval-Mashiach, & Zilber, 1998). According to Riessman (1993) all stories told during a narrative contain elements of truth in them. Finally, the scope of this dissertation focused on gender equity and many of the questions asked in the interview were on this topic. Probing for additional types of questions were not asked that could expand and offer more meaning such as asking about race or socioeconomic status. Thus, this would limit an expanded view of identity (Mensah, 2016) for the women in the study, since many of them were women of color.

Organization of the Findings

The findings of the dissertation, they are written as two, stand-alone papers. I organized the results of the Likert survey in Chapter 4. Reoccurring themes and phenomenon are addressed through organization of and construction of models that link relationships together. Patterns and distributions are established as well as calculating standard deviation, while be aware of polarizations.

In Chapter 5, the interviews from the six participants were coded, assessed and analyzed. I discuss their experiences with gender equity in science education, in middle and high school as well as college, their informal science experiences, and their social science experiences with their family, friends and classmates.

FINDINGS

CHAPTER IV

SCIENCE MOTIVATION DEVELOPMENT AND PERSONAL EXPERIENCES FOR FEMALE STEM MAJORS FROM MIDDLE SCHOOL THROUGH UNDERGRADUATE EDUCATION

Abstract

Understanding what motivates women to major in science, technology, engineering and mathematics (STEM) is an important step in unraveling the reasons why there are so few women in STEM-related professions. Motivation can make the difference between starting something and finishing it, looking ahead to the future instead of the present, seeking rewards from hard work, learning new things to increase one's own knowledge, and doing well to receive good grades. In order to establish a baseline of comparison, the Science Motivation Questionnaire II© was used. This survey differentiates motivation into five main categories: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. The results both agreed with results from existing data as well as diverged on other aspects, which is examined in greater depth. Students scored the highest in career motivation and lowest in self-efficacy. Implications for creating greater awareness of STEM majors, their social importance for young women, and increasing their self-efficacy can be a positive influence on young women entering STEM majors. Besides motivation, the significance of the quality of teaching and gender inequity the students encountered implicate an increasing motivation and assistance from teachers and an in-depth analysis of gender equity with the classroom and institution.

Key words: STEM, career motivation, financial stability, low self-efficacy of women in STEM, gender equity in STEM, science teacher's role.

Introduction

For many young women who aspire to be fully involved in the modern world, the field of science all too often seems inaccessible or only remotely accessible. How much of this is due to societal norms and pressures, and how much may be ascribed to personal characteristics, attitudes and life goals is an important arena for research. This study focuses especially on how attitudes, particularly motivation, may be significant factors in young women choosing to major in the sciences and enter science professions.

Attitudes in Science

The role of attitudes in shaping human behavior has been studied since the 1970s (Osborne, Simon, & Collins, 2003). According to Eccles' expectancy-value theory, education-related decisions are molded by attitudes (Else-Quest, Mineo, & Higgins, 2013), thus raising the issue of how attitudes may influence choices for careers such as science, especially among women. Substantial evidence indicates that gender differences in attitudes, not intellectual prowess, are responsible for gender disparities in STEM (Else-Quest, Mineo, & Higgins, 2013). Klopfer (1971) made a list of behaviors in science education that were intended to be a guide in quantifying attitudes about science, some that may be appropriate to understanding motivation of women to enter science. They include the following: (1) the manifestation of favorable attitudes towards science and scientists, (2) the acceptance of scientific enquiry as a way of thought, (3) the adoption of "scientific attitudes," (4) the enjoyment of science learning experiences, (5) the development of interest in science and science-related activities, and (6) the development of an interest in pursuing a career in science or science-related work. When looking at science motivational surveys from non-science majors, many of these positive attitudes are missing

(Glynn & Koballa, 2006), suggesting that they may also apply in understanding women's motivation in considering non-science or science as a career. It would appear, overall, that a more substantial examination of the role of motivation in encouraging greater participation by women in science is needed.

Motivation

When specifically looking at motivation to learn science, we must understand the reasons why students, or in this current study young women want to learn science. Motivation is defined as "an internal state that arouses, directs, and sustains students' behavior" (Glynn & Koballa, 2006, p. 25). Students' values and interests that align with science place a greater importance on their ability to make connections to science (Jammula, 2014; Mahfood, 2014). Baker (2013) explains the importance of young women learning science when they are able to make real-life connections with the content.

Glynn, Brickman, Armstrong and Taasoobshirazi (2011) separate science motivation into five main categories: *intrinsic motivation, self-efficacy, self-determination, grade motivation,* and *career motivation*. First, *intrinsic motivation* represents one's own goal of learning for the sake of learning, for self-enjoyment, at one's own pace without a reward, and the notion of perceived control (Schunk, Pintrich, & Meece, 2014). Second, *self-determination* represents the control students believe they have over their learning of science, and that if they work hard they will achieve the results they desire. Students who believe they are better at math than English tend to perform better at the former compared to the latter. Third, *self-efficacy*, which is aligned with competence, is the belief the person has in their ability to do well, which is similar to self-confidence; people with high self-efficacy tend to have greater motivation when compared with people with lower self-efficacy (Bandura, 1997; Pintrich, 2003; Pintrich, & Schunk, 2002).

Bandura (1997) states that self-efficacy is broken down into four main categories: (1) mastery of experiences, (2) vicarious experiences, (3) verbal persuasion, and (4) physiological and affective states. Becoming increasingly successful at a given task or achieving mastery of a subject produces a more durable sense of self-efficacy. Vicarious experiences consist of experiences through the eyes of others — one can see oneself being successful in a similar or same situation. The simple act of a person encouraging another person through reassuring verbal suggestions can promote self-efficacy, while reducing the stress associated with an activity creates a positive psychological effect with increased self-efficacy (Gunning & Mensah, 2010).

Finally, the last two strands of motivation are included under the umbrella of extrinsic factors, or motivation to learn for some end goal, e.g. receiving a good grade or landing a desirable job. These factors are divided into two distinct entities, the first one, *grade motivation*, focuses on short term objectives, like doing well on an upcoming test, trying to receive an "A" in a class, or aiming for the honor roll. The second type, *career motivation*, focuses on the big picture, a goal much further down the road. This would include aiming for a dream job or being accepted into one's first-choice college. Aside from intrinsic, self-efficacy, self-determination, goal motivation and career motivations, another view on motivation focuses on communal and agentic motivation. Communal motivation influences behavior — such as helping others — that has a social aspect, while agentic motivation leads one to work independently and focus on self-advancements (Diekman, Brown, Johnston, & Clark, 2010). According to Corbett and Hill (2015) women prefer careers that allow them to interact with and help others. Girls prefer working in a cooperative classroom setting where they can interact with their fellow classmates (Baker, 2013; Brickhouse, Lowery, & Schultz, 2000). Unfortunately, science education and careers foster and emphasize an agentic environment, leaving women at a disadvantage.

Social Constructivism

The importance of socially based learning environments that are apparently conducive for learning by women, is consistent with the social constructivist theories largely proposed by Vygotsky (1978). He states that learning occurs predominantly through collaborations and discourse with other people. When working within a group, learners can discuss, process and internalize what they have learned while increasing their understanding (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Most research settings are in labs with groups of individuals working on similar projects. Universities and corporations have seminars where different lab groups present their research and then open up for questions and answers, with the goal of adding additional insight. Besides helping the company, women seem to work better in social and communal settings and prefer to choose careers where they have opportunities to interact with others (Corbett & Hill, 2015). These social interactions facilitate social constructivism, while also being conducive to the learning style of women. By improving the instructional strategies in science education, the achievement gap can be narrowed, while promoting gender equity in STEM (Baker, 2013).

Feminism

Given the emphasis of this study on promoting women in science, some theoretical emphasis on "Feminism" is deemed appropriate. Feminism is presented in academia with confusing and complex definitions (Beasley, 1999). According to St. Pierre (2000) feminism is an amalgamation of other theories that are used to suit it's needs. Within the feminist movement, there are different branches of feminism that do not agree with each other. Hooks (2000) writes describes that many of the people she encounters believe that feminists are a group of angry men-hating women that want to be like men; however, she defines feminism simply as "…a movement to end sexism, sexist exploitation, and oppression" (p. 1).

The words equality and equity seem synonymous; however when given examples of both, one can clearly see the differences. Students in the same town and the same classroom receive identical instruction, which is described as equality. However, that instruction may be skewed to favor one gender over the other by the type of instruction, class dynamic, number of group activities, and regurgitation of gender stereotypes, which makes the instruction equal, but not equitable. It was not until the late 1800s that women were allowed to own land and not until 1920 were women allowed to vote in the United States. Title IX was enacted in 1972, which gave men and women equal rights to education and which prevented schools from discriminating against women (Corbett, Hill, & St. Rose, 2008). Currently, more women are graduating college than men, but women are underrepresented in well paying STEM fields (Hill, Corbett, & St. Rose, 2010), thus adding more impetus to fully understand how to open further opportunities for women in science.

The following research questions guided this study: What captivates and motivates female students' interests in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?

Methods

Research Approach: Data Collection

In order to determine what captivates and motivates female students into majoring in STEM, two surveys were administered. The first one was created by myself and named the "Science Background and Equity Questionnaire" and the other survey, the Science Motivation

Questionnaire II©, was created by Glynn and Koballa (2006) and Glynn, Brickman, Armstrong and Taasoobshirazi (2011). The surveys were placed on the Qualtrics website as one large survey broken up into three sections. They were sent out in emails and posted on various list servers in science departments with the help of various deans, professors and department head at both universities. There were free response questions at the end of each section for students who wanted to elaborate further. The questions asked on the Science Background and Equity Questionnaire were about formal and informal learning experiences, gender equity issues, parental and peer support, and their perceived future in STEM. The requirements for recruiting the female STEM majors considered the following criteria; they had to identify as female and be either in their junior or senior year (four freshmen females completed the survey, but their results were not used).

The data collected from the Science Motivation Questionnaire II © survey were used as a baseline to compare the science motivation of science majors to other science majors in Glynn and Koballa (2006) and Glynn, Brickman, Armstrong and Taasoobshirazi (2011) studies. This survey was also used because it has been validated and modified over time, and it has been used in other studies by Campos-Sanchez, Lopez-Nunez, Carriel, Martin-Piedra, Sola, and Alaminos (2014), Chumbley, Haynes, and Stofer (2015), Mahfood (2014), and Saltra and Koulougliotis (2015) to name a few. This survey is based on a Likert-scale of 1 to 5, 1 being never and 5 being always. The 25 questions were broken down into five major components with five questions for each component. The components were: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation (Table 4.1). Scores were tallied and ranged from 25-49 as “never to rarely,” 50-74 as “rarely to sometimes,” 75-99 as “sometimes to often,” and 100-125 as "often to always" motivated. It is worth noting that none of the students were in the "never to rarely" and "rarely to sometimes" motivation categories.

Table 4.1 The Five Categories and Their Corresponding Questions for the Science Motivation Questionnaire II.

Intrinsic Motivation	**Self-Efficacy**
• The science I learn is relevant to my life. • Learning science is interesting. • Learning science makes life more meaningful. • I am curious about discoveries in science. • I enjoy learning science.	• I am confident I will do well on science tests. • I am confident I will do well on science labs and projects. • I believe I can master science knowledge and skills. • I believe I can earn a grade of "A" in science. • I am sure I can understand science.
Self-Determination • I put enough effort into learning science. • I use strategies to learn science well. • I spend a lot of time learning science. • I prepare well for science tests and labs. • I study hard to learn science.	**Grade Motivation** • I like to do better than other students on science tests. • Getting a good science grade is important to me. • It is important that I get an "A" in science • I think about the grade I will get in science. • Scoring high on science tests and labs matter to me.
Career Motivation • Learning science will help me get a good job. • Knowing science will give me a career advantage. • Understanding science will benefit me in my career. • My career will involve science. • I will use science problem-solving skills in my career.	

The Science Background and Equity Questionnaire focuses on informal and formal learning experiences as well as personal experiences. The survey contains 20 questions split into two parts. The first part is based on female STEM participants' experiences and views before they entered college, while the second part is based on their experiences in college as STEM majors. The former consists of eleven questions and the latter nine, all based on a Likert-scale of 1 to 5, 1 being never and 5 being always. Scores for the first part were tallied and ranged from 11-22 as “never to rarely,” 23-33 as “rarely to sometimes,” 34-44 as “sometimes to often,” and 45-55 as “often to always.” The second part was scored from 9-18 as “never to rarely,” 19-27 as “rarely to sometimes,” 28-36 as “sometimes to often,” and 37-45 as “often to always.” There were a few open-ended questions with this survey. One asked for the reason participants chose to major in science, and two other questions asked if they felt a need to further clarify or explain any of their answers to a survey questions. The last question asked for an email address to be used to contact participants interested in a 20-30 minute follow-up interview as chance to win a $25 Amazon® gift card. The open-ended questions were used as a selection process for in-depth interviews. This section was optional and not all participants filled it out.

Research Approach: Data Analysis

The Likert surveys were analyzed using the Qualtrics© online software. This software tabulated age, school year, major, minor, mean, variance and standard deviation for all the multiple choice and Likert questions. The responses for the first survey on science motivation were scored based on the female STEM participants’ responses to their degree of intrinsic, self-efficacy, self-determination, grade motivation and career motivation. The second part of the Likert survey assessed the young women on gender equity, support from family, friends, and teachers, and their future in STEM through their years in primary school, secondary school and college.

The open-ended questions were analyzed using the Dedoose QDA software through an open-coding process. This was a “bottom-up” process where data is collected, prepared, read through, and then coded (Creswell, 2008). The topics covered in the open-ended questions ranged from the young woman's explanation of why they chose to major in science, explanation and clarification on any gender inequities they felt, if there were any teachers that stood out in a positive or negative way, if they felt that being a science major was overwhelming, and any support they may or may not have received from their parents, friends or teachers. Responses that aligned with specific survey questions were analyzed together, and then they were compared with other responses while looking for emerging and recurring themes.

Through an external audit from fellow doctoral students in a qualitative methods class, Science Background and Equity Questionnaire questions were screened and comments were analyzed, while making corrections where need be (Creswell, 2008). My advisor, Dr. Mensah also looked over and commented on the Science Background and Equity Questionnaire, while making constructive critiques. I compared coding from previous projects and made adjustments to ensure consistency. Member-checking, when possible was used to confirm findings from female STEM participants to increase reliability of data (Creswell, 2008)

Data from the open-ended responses was entered into the Dedoose website. The Dedoose QDA software was utilized for open coding of the data. From the analysis and coding, there were nine separate themes that were uncovered after reading through the students' responses multiple times. These themes included: positive and negative school science learning, desire to learn science, career motivation, gender equity issues, hard work and pressure.

Findings

The findings from both Science Background and Equity Questionnaire and the Science Motivation Questionnaire II© are separated into three main sections. The first section discusses the young women's major, age and year in school. The second section is based on an analysis of the numeric scores the young women received after completing the surveys. This section provides findings from the two separate surveys. First, the Science Motivation Questionnaire II©, which focused on five themes within motivation — grade motivation, self-efficacy, self-determination, intrinsic motivation, and career motivation; and second, Science Background and Equity Questionnaire, which focused on gender equity, support from family, friends, and teachers, and female participants' future in STEM. The last section takes a closer look at the open-ended response questions at the end of each section, which allowed the female STEM participants to expand on their survey answers. The Dedoose QDA software was utilized for open coding of the data.

Part 1

The female STEM participants' age, major, year in school and minor are shown below. A total of 37 started the survey, but one student stopped after 43 seconds and did not answer any of the questions.

Student Background

The female STEM participants' responses to the background questions are presented in Tables 4.2, 4.3, 4.4, 4.5, and 4.6. All of the young women were at least 18 years old, with more than half of them 21 years old or older. The most popular major was computer science at 31% followed by chemistry / biochemistry at 22%. Of the 36 female STEM participants who answered the survey, only 32 of them filled out their school year. Four young women said they were freshman, and one student did not put her year, but her age was 21. The rationale for this question was to identify any female STEM participants' that may not have read the email and attached letter and filled out the survey despite not being in their juniors and seniors year.

Table 4.2 Female STEM Participants' Age Including Freshmen

Students' Age	18	19	20	21	22+
Number of Students	4	2	9	13	8
Percentage	11%	6%	25%	36%	22%

Table 4.3 Female STEM Participants' Age Excluding Freshmen

Students' Age	19	20	21	22+
Number of Students	2	9	13	8
Percentage	6%	28%	41%	25%

Table 4.4 Female STEM Participants' Major Including Freshmen

Major	Response	Percentage
Biology / Micro or Molecular biology, Biotechnology / Genetics	3	8.3%
Chemistry / Biochemistry	8	22.2%
Engineering (all types)	5	13.9%
Computer Science	11	30.6%
Physics / Astrophysics	3	8.3%
Math	3	8.3%
Other	3	8.3%
Total	36	99.9%

Table 4.5 Female STEM Participants' Major Excluding Freshmen

Major	Response	Percentage
Biology / Micro or Molecular biology, Biotechnology / Genetics	3	9.4%
Chemistry / Biochemistry	8	25%
Engineering (all types)	3	9.4%
Computer Science	9	28.1%
Physics / Astrophysics	3	9.4%
Math	3	9.4%
Other	3	9.4%
Total	32	100.1%

Table 4.6 Female STEM Participants' Year in School

Students' Year in School	Freshman	Sophomore	Junior	Senior
Number of Students	0	0	17	11
Percentage	0%	0%	60.7%	39.3%

Part 2

Both qualitative and quantitative analyses were used to measure female STEM participants' motivation, perception of gender equity in science, and support from others. Scores from the Science Motivation Questionnaire II© and the Science Background and Equity Questionnaire act as a small window opening into the world of women STEM majors. The surveys looked at recurring themes and patterns female STEM participants may have formed during their lives that lead them to becoming a STEM major. The four freshmen are not included in the following results because this study is only focusing on junior and seniors. This reduced the number of participants to 32.

Student Science Motivation

A quantitative analysis was performed on 32 junior and senior undergraduate female STEM participants (one student did not list her year, but was 21), which focused on five themes within motivation — grade motivation, self-efficacy, self-determination, intrinsic motivation and career motivation. Out of a maximum of 125 points, the 32 young females averaged a 99.125, which is right on the boundary between "sometime to often" and "often to always" in regards to their motivation to learn science. None of the young females' science motivation scores were in the "never to rarely" and "rarely to sometimes" categories. When my results were compared to Glynn et al. (2011) Science Motivation Questionnaire II© study, common themes emerged with female STEM majors. Both studies had female STEM majors self-efficacy ranking the lowest, while career motivation ranked the highest in my study and second highest in Glynn's et al. (2009) study. (Table 4.7, Table 4.8 & Table 4.9) and (Figure 4.2). The difference in self-efficacy between the male and female science majors in Glynn was shown to be statistically significant with $t(365) = 5.58$, $p < 0.001$, and when comparing self-efficacy with the male science majors from Glynn's study to the female science majors in this study, the results were also significant with $t(157) = 2.03$, $p < 0.044$. However, when comparing self-efficacy with the female science majors from Glynn's study to the female science majors from this study, there was no statistical significance with $t(270) = 0.94$, $p = 0.35$.

Table 4.7 All Female STEM participants' Science Motivation Frequency Scores

Level of Motivation		Frequency	Frequency Percent
25 - 49	Never to Rarely	0	0
50 - 74	Rarely to Sometimes	0	0
75 - 99	Sometimes to Often	17	53.125%
100 - 125	Often to Always	15	46.875%
Totals		32	100

Table 4.8 An Analysis of The Motivation Component

	Female Science Majors (n =32)
Intrinsic Motivation	
M	15.91
sd	3.95
Career Motivation	
M	16.19
sd	4.16
Self-determination	
M	15.06
sd	4.10
Self-efficacy	
M	12.99
sd	4.38
Grade Motivation	
M	14.21
sd	5.12

The scores on each component can range from 0 to 20

Table 4.9 An Analysis of The Motivation Component From Glynn et al (2009).

	Female Science Majors (n =240)	Male Science Majors (n =127)
Intrinsic Motivation		
M	13.98	14.38
sd	3.08	3.20
Career Motivation		
M	16.04	15.77
sd	3.13	3.19
Self-determination		
M	15.20	14.50
sd	2.98	3.29
Self-efficacy		
M	12.40	14.30
sd	3.19	2.93
Grade Motivation		
M	17.09	16.72
sd	2.16	2.74

The scores on each component can range from 0 to 20

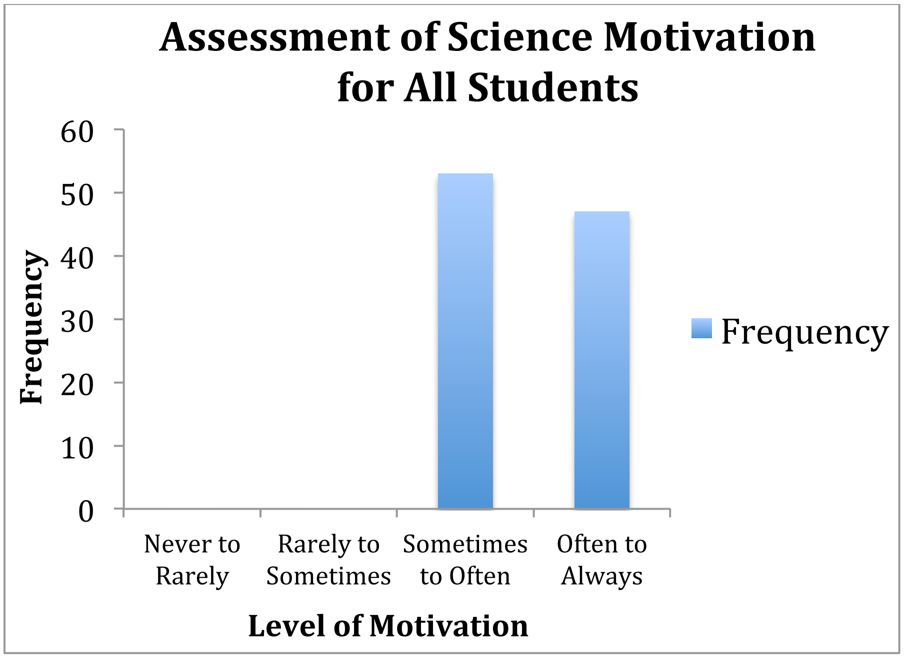

Figure 4.1. Assessment of Science Motivation for All Female STEM participants

Science Background and Gender Equity

Quantitative analysis was performed on the same 32 junior and senior undergraduate female STEM participants. The first part of the survey concentrated on gender equity, support from family, friends, and teachers, and participants' future in STEM. It focused on their experiences growing up both in and out of school as well as before they entered college. These female STEM participants had a positive outlook on their views and experiences with STEM growing up in school, out of school, at home and with their friends, showing almost 47% of the female STEM participants scoring between "often to always" with these perceptions and none of them having a view of "never to sometimes" (Table 4.9).

Table 4.9 Female STEM Participants' Views Before They Entered College, on Gender Equity, Support and Future in STEM.

Level of Personal Experiences		Frequency	Frequency Percent
11 - 22	Never to Rarely	0	0%
23 - 33	Rarely to Sometimes	4	12.5%
34 - 44	Sometimes to Often	13	40.625%
45 - 55	Often to Always	15	46.875%
Totals		32	100

Once these female STEM participants started college, their views shifted. The data for Table 4.7 was constructed in the reverse method as Table 4.6, meaning that an "often to always" score meant the female STEM participants had a negative view regarding gender equity as STEM majors in college. More than three quarters of the female STEM participants had "rarely to sometimes" experienced negative feelings about their major in regards to being treated fairly by their instructors or lacking support from their friends and family, while almost 10% had a "sometimes to often" had these experiences, and just over 12% stated they "rarely to never" had these experiences (Table 4.10).

Table 4.10 Female STEM participants' Experiences as STEM Majors

Level of Personal Experiences		Frequency	Frequency Percent
9 - 18	Never to Rarely	4	12.5%
19 - 27	Rarely to Sometimes	25	78.125%
28 - 36	Sometimes to Often	3	9.375%
37 - 45	Often to Always	0	0
Totals		32	100

Within the first part of the survey on gender equity, support from family, friends, teachers, and female participants' future in STEM, the four subcategories were (1) personal opinions about a future in STEM, (2) feelings of being treated as equals to men, (3) support from family and friends, and (4) inspiration from teachers. The data shows that most of the female STEM participants had a positive outlook on their future in STEM, support from family and friends, and gender equity, while their lowest score was in the inspiration from teachers category (Table 4.11).

Table 4.11 An Analysis of Female STEM Participants' Views Before They Entered College, on Gender Equity, Support and Future in STEM.

	Female Science Majors (n =32)
Personal opinions about their future in STEM.	
M	14.89
sd	6.48
Feelings of being treated equal to men	
M	14.22
sd	5.02
Support from family, friends and teachers.	
M	15.66
sd	4.90
Inspiration from teacher.	
M	12.19
sd	6.72

The scores on each component can range from 0 to 20. A higher score represents a positive outlook.

The second part of the survey dealt with an additional three categories based on female participants' experiences as STEM majors in college. These three subcategories are (1) feelings of equity in STEM, (2) having to prove one's self greater than men, and (3) support from family and friends. The data within the second table showed a major shift in equity when it came to working harder than men to prove that they belong, where all 32 young women on at least one occasion felt this way, which aligns nicely with their limited ability to socialize with their friends (Table 4.12). There was no significance in the female STEM participants' perception of being treated equally by their male and female professors (Table 4.13). However, there were significant differences in the amount of opportunities women think they had, how much harder they felt they had to work, and the greater amount of hardships they faced when compared to their male counterparts. As mentioned before, the female STEM participants also felt like they lacked time to socialize, which can be from the rigors of a science major (Drew, 2011)

Table 4.12 An Analysis of Female STEM Participants' College Experiences as STEM Majors.

	Female Science Majors (n =32)
Feelings of equity in STEM	
M	14.84
sd	3.66
Having to prove yourself more than men	
M	12.07
sd	4.90
Support from family and friends	
M	16.83
sd	4.11

The scores on each component can range from 0 to 20. The lower the score, the more the **Female** STEM participants' felt things were equitable.

Table 4.13 A Comparison of Equity by Male and Female Professors in College

	Female Science Majors (n =32)
	Teachers
High school and middle school	
M	14.84
sd	4.05
College	
M	16.19
sd	4.16

The scores on each component can range from 0 to 20

Part 3

Open responses to Science Background and Equity Questionnaire and the Science Motivation Questionnaire II © created a broader picture of the experiences of the participants in STEM majors. The open responses gave insight into the female STEM participants' views and experiences on gender equity within STEM. The survey questions helped in the selection of six female STEM majors to interview.

Emergent Themes

Upon review of the open responses to the surveys, certain themes started to materialize. These themes included positive and negative school science learning, desire to learn science, career motivation, gender equity issues, and hard work and pressure. Of the thirty-two female STEM participants that took the survey, some female STEM participants left very brief statements like "Bio is cool" or chose not to leave a response at all (this section was optional). Other young women composed paragraphs of information ranging from personal experiences with a teacher, career motivation to lift the rest of their family out of poverty, switching from art to science, wanting to become a doctor, the gender composition of the university's faculty, and following in their parents' footsteps.

Positive School Science Learning Experiences

There are many factors that play a role in a student's education; however, much of the scrutiny and liability falls on the teachers' shoulders. Teachers do play a major part in a student's learning. For example, there were a handful of short passages about a teacher the female STEM participants had that really impacted their passion for science in a positive way. Most of their memories were during high school, but a few female STEM participants recalled some middle school experiences. One student said:

> I had a very supportive science teacher in 8th grade who encouraged me to pursue science. He would share books and scientific articles with me, and I ended up helping him design an advanced-level science course that piloted the following year and that he still teaches. He also advocated on my behalf to the school to get me into a different

science class so that I could avoid another teacher who was apathetic about teaching science material. My 8th grade science teacher was the one who made me think I could study science and become a research scientist if I wanted to.

Another student said: "I was lucky that I grew up in a district where the public schools are some of the best in the country. My science teachers particularly were phenomenal. They were always supportive and engaging, making learning enjoyable."

Negative School Science Learning Experiences

Unfortunately teachers and school can have a negative impact on a student's science learning experiences. A few female STEM participants described about how teachers and fellow male students treated them unfairly (more on this in the gender equity section below). Only two female STEM participants recalled an example of a negative science learning experience they had, one of which was the same student who had the great experience with her 8th grade science teacher. She said:

> I had a terrible science teacher for 9th grade, who I think turned many people off of science. In my experience with her, she graded my assignments differently than my peers and became angry at me if I tried to participate. I do not know why she behaved this way, but I think if I did not have such strong encouragement the year before I may have abandoned science.

The second student stated she felt that male students were obnoxious during class, which detracted from her learning experience.

Desire to Learn Science

One of the many goals of a science instructor is to motivate and inspire students with the wonders of the science world. Sparking a student's interest is one of the most rewarding parts of being a science teacher. Unlocking the mysteries of what causes a student to desire to learn science may help increase under-represented groups of people, such as women, while promoting gender equity in science and expand science literacy for all.

The female STEM participants were asked why they chose to major in science. Many of the young women's responses were succinct, such as: "science rules," "science is super cool," "Bio is cool" and "I love science." Some students said they took a class or two in high school or college that made the subject interesting. However, many of the young women went into greater depth. One young woman suffers from multiple sclerosis and writes: "I was diagnosed with MS and I realized I know nothing about how the body works." Some female STEM participants yearn to add to the science community and crave a greater understanding of the world they live in: "I want to contribute to the future in science discoveries and improvements," "I'm deeply fascinated by the processes which define our existence," "I am a curious person that loves solving problems" and "I like to learn how the world around us works." A more profound response by an astrophysics major is as follows:

> Astrophysics is the fire that fuels my soul. I find fewer things are beautiful as our existence due to, and partly in spite of, the evolution of this universal reality. I'm studying this because I find no other path as elucidating as this to understand our perception as a function of the symbolic logic we apply to the physical world around us. Physics, however, does not represent the totality of what humanity is capable of and I believe that our conceptions of the world arising from simply consciousness played a key role in grounding ourselves within the system and the art we create is an important representation of our understandings of this universe as well.

Some female STEM participants enjoy the challenge of problem solving. One student wrote:

> I enjoy problem solving, which is exactly what computer science is. I like subjects, such as math and science that have definitive solutions to problems, unlike more humanity-based majors that can have more subjective results.

Finally, another student said: "I like mathematical reasoning."

Career Motivation

Since the great recession of 2008, quality jobs with livable wages have become increasingly hard to find. Compounded with rising college tuition, society has placed heavy emphasis on careers in STEM. Manufacturing jobs and low-skilled labor are leaving the country. Budget cuts are taking already depleted funds from the arts and humanities as well as outsourcing animators and web designers to other countries. However, highly skilled jobs in STEM are growing at ever-increasing rates. A well paying job can move someone up the socio-economic ladder. Doctors are well-respected people and careers in medicine pay very well.

Some female STEM participants have parents and relatives that are in STEM fields and who can share their experiences, motivating, and influencing their children into STEM careers. One student wrote:

> Up until about a year ago, I'd planned to major in some kind of biological science and become a doctor. My father is a doctor, and so was his father, and so was his father. There seemed to be a lot more women in that field than in computer science. I only just realized how much I loved computer science because there weren't really any opportunities for me to try it until I came to college, and I didn't know of any women that were in the field that I could use as a role model.

A handful of female STEM participants simply stated their career ambitions, as this respondent wrote: "I want to go to medical school and be a doctor." One young female expressed the career choices science majors offer by saying: "A science major gives me more flexibility in career choices." Other young females STEM participants come from lower economic statuses and see STEM as a gateway to making money. One young female wrote: "There is a lot of money in cs (computer science) and my family doesn't have a lot. I have also managed to convince myself that cs (computer science) is flexible. I can work in finance or a health startup with the same degree." Other female STEM participants were the only ones in their family interested in STEM careers.

Gender Equity Issues

Women and men differ in many physical ways — in person these differences may be immediately apparent. However, when it comes to mental capacities and cognitive abilities, there are no measurable differences, even when studied rigorously by neurobiologists, cognitive scientists, molecular biologist and many other scientists. Young women graduate with a higher grade point average in mathematics and science than men, they score marginally lower on the mathematics section of the ACT and SAT than young men, and more women graduate from college than men in the United States (Hill, Corbett, & St. Rose, 2010). Laws like the 14th and 19th Amendment, the Equal Pay Act, Title VII of the Civil Rights Act of 1964, and Title IX of the Educational Amendment of 1972 have been put into place making it illegal to discriminate against women, giving women the right to vote, own land, and allowing equal access to college and scholastic sports. Currently, in the fields of computer science, mathematics, physics and engineering, women make up less than 20% of the workforce. On top of that, women are paid less than their male counterparts doing the same job.

This section asked female STEM participants if they ever experienced sexism or gender equity issues during their lifetime with regards to science. Many of the young women did not experience or notice these issues until high school and college. A young woman said when she was in AP Chemistry in high school there where many times were she did not get to do the experimental parts of a lab and was assigned the recording or secretarial role by her male lab partners. She felt the teacher could have done more to help. Another young woman said:

> As I've grown older, I've come to realize the sexism in science. Most PIs (principle investigators) are male, most chairs and leaders in medicine are male, etc. However, this hasn't stopped me from wanting to pursue medicine.

Another female STEM participant spoke about the physics department being a "boys club" and noted that all her physics professors are older White males that generally favor male students. As a result, she feels a greater pressure to succeed in physics.

Sometimes gender equity issues are not so clear; female STEM participants may not feel that a situation is sexist, yet they know that something is not right. A student wrote:

> I don't really ever feel directly disrespected, but there are times that it feels like men's voices are always heard and mine isn't. Men are generally more willing to speak up and are confident in their answers even when they're guessing, whereas I (and a lot of girls I know) am more hesitant unless I am 100% sure that I have a solution. I've also heard some TAs being ignored or doubted by male students because they're pretty/don't "seem like they know what they're doing."

Besides male students treating each other unfairly, teachers can also be part of the problem, be it directly or indirectly. One student wrote:

> In high school I don't believe I received a proper scientific education. It was partly because of the cohort of students I was among; the top students were a group of men who

> were obnoxious. The top student of the class was a woman, but everyone seemed to perceive her as an anomaly.

Another student wrote:

> I encountered two types of science teachers that treated girls unequally (the majority treated us equally though, which is great). The first type that validates male students' class contributions more than female students' contributions. The logic is, what comes out of a girl's mouth doesn't make as much sense as what a boy says, even though they have the same content in essence. The second type actually is biased towards girls. Girls got better participation grades and were graded more leniently. Both were male teachers.

Certain school clubs and activities may not discriminate against or keep women from joining; however, if the club is made up of all men, women may feel intimidated or as if they do not belong. A student wrote: "Often the all-male clubs in high school were intimidating (like robotics club, physics club, math club, etc.), but there were never any actual problems with the people not treating me equally."

Hard Work and Pressure

The female STEM participants in the survey are junior and seniors, and have made it through the weeding-out process of the first two years. Despite their success, some female STEM participants spoke of the lack of time for a social life as well as the importance of eventually starting a family and the potential for conflict between their career and family. One student wrote: "Although my experience hasn't been horrible by any means, I do feel there is more pressure for me to succeed." A second young female commented on the issues of motherhood:

> I find it inevitable that females have a harder time pursuing any type of graduate degree/further education simply because we have the burden and joy of bearing children. One thing I've always struggled with is what kind of degree I want that will allow me to have children.

Another female STEM participant discussed the lack of free time she has and believes she is too deeply invested to change her majors by saying:

> I would enjoy CS so much more if it wouldn't eat up my social life. It really is fun to build things, but I want to step away from it all once in a while. It really makes me doubt my major, but I'm too far in now.

Discussion and Implications

Within the discussion, the numerous findings examine the reasons that junior and senior college female STEM participants chose to major in STEM, as well as shedding light on their experiences as STEM majors. Through surveys and open-ended responses, the findings show the importance of motivation, positive and negative learning experience, a desire to learn science, gender equity issues, hard work and pressure to help sculpt their science identities. An early interest in science grows with a student, the importance of out-of-school experiences, parental support, and a desire to understand how the world works, are reasons for their motivation in a STEM major.

Motivation

Since these female STEM participants have reached their junior and senior years, they have had a chance to change majors. Some had; for example one student had switched from economics and English to chemistry and neurobiology. Another female STEM participant felt stuck in her major because it was too late to change it. Almost 75 percent of college students change their major at least once before they graduate (Gordon, 2007). However, when motivation is high, students remain in their chosen field of study, as with the juniors and seniors of this study. Motivation comes from internal factors within a student (Glynn & Koballa 2006). A goal of motivational research is to identify those factors and present them to students, in the hope that students pursue what motivates them in college. The survey results for science motivation were all in the range of "sometimes to often" and the "often to always." These results are understandable, as all of the participants are science majors in their junior and senior year and would be expected to demonstrate a moderate to high level of motivation. Not every student will be motivated to learn science, but maintaining interest is important in cultivating a scientifically literate society for all people (Bryan, Glynn, & Kittleson, 2011). The female participants in this study as well as the ones in Glynn et al. (2009), showed the lowest score in rating their self-efficacy; therefore, more work needs to be done on improving the self-efficacy of female science majors. When analyzing Bandura's (1997) modes of self-efficacy, the lack of vicarious experiences for the young female STEM participants in this study stood out. A few female STEM participants mentioned the lack of women in science as role models and professors. Role models provide a metric with which to judge one's own capabilities and offer help and reassurance as one strives for success (Gunning & Mensah, 2010).

Even though women make up about 50% of all undergraduate degrees in STEM, they only represent 25% of the STEM workforce (National Science Foundation, 2009). In a survey of 5,500 women with engineering degrees, a little more than 50% were working in STEM, around 25% never worked as engineers and another 25% left the field (Fouad, Singh, Firtzpatrick, & Liu, 2012). All female STEM participants had an option to elaborate on any of the survey questions about why they chose to major in science, and a majority of the respondents stated they always loved science, science is cool, have a burning desire to understand how the world works, they value the multiple career choices available to STEM majors, or they want to become a doctor. Career motivation ranked the highest in Science Background and Equity Questionnaire and was mentioned numerous times in the "I am majoring in science because" open-response. Careers in STEM offer high-paying and high-status jobs. However, women only make up about 25% of the STEM workforce (Simon, Wagner, & Killion, 2016). The gender pay gap is actually less in STEM fields for women than in other careers; STEM fields offer earning potential and economic security (Hill, Corbett, & St. Rose, 2010). Because some of the female STEM participants mentioned their lack of knowledge of various careers in STEM, a greater priority and emphasis about the career opportunities within STEM should be made available to them.

The Teacher's Responsibility in Motivating Students in Science

Mandated curriculum coverage and passing of required exams may hamper teachers who use creative ways to motivate students, but there are methods of presenting material in a thoughtful and exciting way that can stimulate the interest of the learner (Mubeen & Reid, 2014). According to Glynn and Koballa (2006) students must find personal meaning and value in an activity for them to be motivated. Female STEM participants' responses varied in what motivated them to major in science, but all fit within one of the five types of motivation cited in the Science Motivation II© survey analysis. Students that claimed a teacher as a motivating factor cited in their responses a personal connection made by that teacher by, for example, suggesting outside reading material, future courses to take, making the class challenging and exciting through interesting activities, and going through the material in a thorough, but clear and easy to understand manner. There were some negative comments about teachers, but not in an unmotivated way. These comments were mostly concerned with favoritism of male students and treating female students differently from their male counterparts. One female participant had a highly positive experience with a science teacher, but the following year she had a negative experience with another science teacher. For her, the positive experience outweighed the negative one. Science teachers have the ability to positively affect a student's perception of a scientist; however, they can also have a negative impact on the student (Mensah, 2011a).

Creating More Opportunities to Learn Science for Female Students

Some of the female STEM participants in the open-ended questions mentioned teachers telling their students that women and men are equally smart and capable in science, another mentioned an outside-of-school science program at the American Museum of Natural History that supported her science learning. One participant's parents subscribed to science magazines for her to explore her interests further, while other young women joined science-based clubs at their schools. Not all students are given these opportunities, and if we would like to engage and recruit more women into science careers, we need to provide these opportunities as well as others not mentioned by the students, such as mentoring with professionals, corporate involvement with the community and beyond, government-designed programs, and better gender equity training for teachers (Rosa & Mensah, 2016).

Resources to Support and Improve Interest in Science

Everyone would like opportunities that can positively change their lives, and the more opportunities someone has, the greater the chance that person of reaching a goal, finding something they enjoy, or being exposed to something wonderful they never knew existed. Unfortunately, not every student receives the same opportunities both inside and outside of school. Some of these opportunities are attributed to social economic status, parental involvement, mentorship by a family member, geographical living environments, proximity to research facilities and universities, and gender stereotypes (Chin & Phillips, 2004; Robellen, 2011). In order to give all students the same chances, states and governments need to be more aware of these issues, allocate funding for specific programs aimed at exposing and engaging students in all disciplines and facets of science and reveal structures that hinder women in science (Rosa & Mensah, 2016). Teachers should be made aware of outside science programs and camps for students and share them with their students, funding needs to be increase to help students who cannot afford camps or programs, and with the use of technology, virtual camps with mentors from all over the country in STEM fields should be encouraged to participate. Role models for women in science are a scarce resource that has been shown to be successful in helping women major and graduate in STEM (Hill, Corbett, & St. Rose, 2010; Corbett & Hill, 2015; Halpern et al., 2007; Mensah, 2008; Munley & Rossiter, 2013).

One of the salient themes that appeared numerous times was the high level of interest students had in science, whether it be a deep desire to understand how the world works, the love for solving puzzles, or understanding an illness because of a personal experience with that illness. Interest differs from intrinsic motivation; interests are more focused and students have a greater control over them (Pintrich, 2003). One female STEM participant was not even aware of her interest in computer science and the exiting problem solving it involved until she was exposed to it in college. Greater focus must be placed on presenting various career opportunities that science has to offer, which can unlock hidden interests inside young women.

Conclusion

Each female STEM participant contributes a personal perspective as to why she chose to major in science and the path that guided her to her current major. Although female STEM participants' experiences varied, there were commonalities that require further attention and discussion. Many female STEM participants acknowledged a positive teacher experience, a parental or family member that supported their interest and helped cultivate their desire to learn more and explore science beyond the classroom, and a determination and foresight to acquire skills needed for a well-paying career in the future.

The overwhelming scientific evidence shows that women are as capable as men of major in science. The evidence includes grade point averages, AP scores, SAT and ACT scores, and overall cognitive abilities. When comparing science motivation from previous studies, one issue that was consistent was how highly women regarded career motivation. Many of the women surveyed mentioned career as a reason they majored in STEM. As these women are all STEM majors in college in their junior and senior year, many have figured out that they have what it takes to major in STEM. However, their self-efficacy is still lower than that of male science majors, though higher than male nonscience majors. As mentioned earlier, women hold themselves to higher standards, including the women in this study who are more than halfway done with majoring in STEM at two top universities. Self-determination for women was higher, which may align with why women feel the need to prove themselves more than men, due to their lower self-efficacy. This was briefly mentioned in the open-ended section and is discussed at greater lengths in the next chapter. However, the research does show that women feel the added pressure to work harder and they hold themselves to a higher standard (Hill, Corbett, & St. Rose, 2010). Only around 15.1% of female students major in STEM (National Science Foundation 2009). The retention rates make that number even lower by the time the students become seniors. The lived experiences of these women give us important information that can help shed light on what factors influence a person's choice to major in STEM.

FINDINGS

CHAPTER V

UNDERGRADUATE WOMEN MAJORING IN SCIENCE AND THE LIVED EXEPRIENCES THAT LEAD TO THEIR SCIENCE IDENTITY

Abstract

This paper focuses on the lived experiences of six undergraduate female science majors during their junior and senior year of college. By observing the lived experiences of undergraduate female science majors, I attempt to uncover their science identities by asking about their formal and informal educational backgrounds and science identities. With the use of critical theory, social learning theory, identity theory, and liberal feminist theory, the identities of these students were analyzed. The roads traversed by these women vary greatly; however, they all ended up becoming science majors at either of the two universities surveyed. Some students grew up in a science-rich family where one or both parents were scientists or doctors, while other students had no family members or friends that majored in science. They came from high and low socioeconomic families. The findings suggest that having interest in science at a young age was crucial for young female STEM participants' passion in science. The findings also highlight the importance of having a positive role model or mentor to facilitate and guide and interest in science. Both formal and informal environments that expose young women to science at an early age can have lasting beneficial effects, while the continued guidance and support throughout their lives adds addition safety nets to ensure completion of a STEM degree.

Key words: Mentorships and role models in STEM, sexism and gender equity in STEM, women in science

Introduction

As global competition in science innovation tightens, highly educated people become a valuable resource. If numerous studies in human cognition have shown that women are equally as intelligent as men, then why are we only using half our available resources? There are abundant obstacles that we as a society need to overcome in order to attract more women science majors, have them enter careers in science, and retain them within a scientific career. From early on, boys and girls are treated differently, from their parents, family, friends, their culture, society, and country they live in. We assign roles and identities, choose hypothetical careers for them, determine what sports or activity they should play, decide what type of camps they should attend, tell them how they should dress and how they should act all based on gender without asking them, and usually before they can even speak. These roles are seen in schools in the division between young boys and girls into same sex groups within the classroom and on the playground, where boys occupy more physical spaces in which girls are seen as a negative association and contamination (Thorne, 1993).

By peering into the lived experiences of female science majors, we have the opportunity to see what steps and paths guided them to major in science. Was it parental influence, informal science experiences, great schools and teachers, or complete randomness? Research has shown certain reasons why women leave STEM careers or never enter them, such has choosing a family over work, sexism in the workforce, low self-efficacy, not knowing if their work results in a positive outcome, not being treated as equals, being given meaningless or overly simplistic tasks, and not living up to the perceived identity of a scientist (Corbett & Hill, 2015; Fouad et al., 2012; Heilman, Wallen, Fuchs, & Tamkins, 2004; Singh, 2013; Singh et al., 2013). Research on why women do not enter STEM majors or why they change their major to something else points to the lack of female role models in science, the minimal amount of female science professors and advisors, the feelings and first-hand experience of science as a "boys club," the amount of work science majors have compared to other majors, and the lack of types and careers offered with a science major (Hill, Corbett, & St. Rose, 2010). When looking for reasons why female students lose interest or never had interest in science in primary and secondary school, commonalities arise with regards to a bad teacher, a class that was no longer fun, feeling like science is a boys thing, feelings of not being as smart or capable as their male counterparts, few female science role models, and family and friends telling them science is for boys and boys are better at science (Hill, Corbett & St. Rose, 2010). Organizations like TWIST (Towards Women In Science & Technology) published professional development and teaching strategies for improving gender awareness in teaching (TWIST, 2012). By understanding where these women came from, we can help fill in gaps in gender equity in STEM, confirm previous data, and add to the research on gender equity in science.

Literature Review

Girls and Women and Formal Science Settings

If society is serious about attracting more women into science careers, then it needs to start embracing the scientific literature on how girls learn and where they learn, and start to structure schooling in such a way to make learning more equitable. There are two general settings to learn science. The first is the formal setting, which consists of traditional and structured schooling areas. The second one is the informal setting, which is defined as learning outside a traditional and structured schooling area. These informal settings include television, conversations with friends and family, visits to a museums and zoos, surfing on the Internet, reading newspapers, books, comics, or magazines.

The first attempt to bring equity into the curriculum occurred between the late 1970s and the 1980s, moving away from the idea that female students were expected to adapt to a male-centered sexist curriculum and towards adapting the curriculum to the needs of the female student (Scantlebury & Baker, 2007). According to the American Association of University Women (AAUW) in 2009, women work better in cooperative and group activities. Student focused activities, real-world experiences that are relatable to girls, and hands-on activities with enough supplies that allow for everyone to participate have been shown to increase female success in science (Baker, 2013). The teacher's ability to shatter the misconceptions and falsehoods that boys are better at math and sciences can positively increase the overall performances of female students on tests (Hill, Corbett, & St. Rose, 2010). Often, when lab groups are made up of mixed genders, the boys like to do the more hands-on parts and delegate the writing and secretarial work to the girls in the group. However, when lab groups are single-sex, the groups work better with greater understanding (Bennett, Hogarth, Lubben, Campbell, & Robinson, 2010).

Gender Inequities Within the Science Classroom. Within formal science settings, female students have been treated differently, have fewer role models (especially female professors at universities), learn from male-centered textbooks, are given the "secretarial" type positions during lab, and manipulate lab equipment less (Brotman & Moore, 2008). Female students showed lower interest and had an unflattering view of the scientific lifestyle (Miller, Blessing, & Schwartz, 2006). In a study done with over 400 sixth graders, females perceived science as more difficult and more suitable for boys, male students had higher interests in science-related topics and jobs, the girls liked topics and activities where they were making things, like bread-making, sewing and knitting, and planting seeds, and finally boys liked careers that were easy and controlling of others, while girls sought out careers which helped others (Jones, Howe, & Rua, 2000).

Girls have a lower self-efficacy in their ability to be successful in science, but with increased opportunities for finishing certain scientific tasks, self-efficacy can be improved (Baker, 2013). This increase in self-efficacy has a positive impact on careers women choose in science (Zeldin & Pajares, 2000). The use of female role models and guest speakers within the classroom can increase interest in science for female students (National Science Foundation, 2003).

Inequity and stereotypes are not restricted to the classroom. In a study on parents and their perceptions on gender, they perceived science competence, performance in science and the importance of science as male-centered (Andre, Whigham, Hendrickson, & Chambers, 1999). In a study that asked 79 students ranging from grades 10-12 what their favorite courses were (biology, mathematics / physical science, social sciences, English or other), Miller, Blessing, and Schwartz (2006) reported that male students preferred mathematics and physical science, whereas female students were more evenly dispersed.

With testing in the formal classroom comes a higher emphasis on competition instead of cooperation. Girls work better in cooperative environments, thus leaving girls at a disadvantage in traditional, competitive, formal school science learning settings (Wilkins, Gaskin, Hom, & Andrews, 2005). Unfortunately for girls, their interest in science begins to diminish after elementary school (Brotman & Moore, 2008; Mensah, 2011a).

There are a multitude of steps that can be implemented in order to decrease gender inequity within science education: create a more gender-equitable curriculum through collaboration between men and women, while stressing the social and communal importance of science; train preservice teachers during their college education on gender inequity and sexism within the classroom (Brotman & Moore, 2008). The burden should not just be placed on the university; gender-sensitivity trainings should be held by teacher professional associations (Scantlebury, 1995) and addressed through the schooling experiences of students, even at the elementary-school level. After an eight-week training on gender equity, teachers showed a decrease in gender bias within the classroom (Jones, Evans, & Byrd, 2000). Besides classroom time, some schools offer extracurricular activities and clubs for students (Brotman & Moore, 2008). A greater effort should be made to increase gender diversity in some male-dominated science clubs.

Girls and Women and Informal Science Settings

Informal learning originally focused on outside-of-school learning environments like museums, but a more accurate and modern definition should include self-motivated and self-guided learning lead by one's desires and interests, voluntary learning, and learning that is done through the duration of one's life (Dierkling, et al. 2003). Munley and Rossiter (2013) describe learning science as either science-in-context or science-in-the-abstract, where science-in-the-abstract focuses on concepts in specific subjects, while science-in-the-context focuses on the exploration of real world issues. Traditional formal science focuses more on science-in-the-abstract, while informal science learning focuses more on science-in-context. Female students find science-in-context more interesting and palpable (Uitto, Juuti, Lavonen, & Meisalo, 2005). With a higher emphasis on and pressure from standardized tests, students become anxious, stressed, and deterred by formal education. Conversely, many informal settings do not place high emphasis on testing, giving feedback instead of letter grades, while focusing on the learning experience instead of the final outcome (Robellen, 2011). According to Munley and Rossiter

(2013), museums and science centers are highly effective informal learning areas for female students, forming positive relationships with working scientists. This helps nurture the girls' science identities, leading to a continued interest in science and increased likelihood of choosing a science majors.

Parents play an important role in informal education as well. When parents were observed in informal settings with their young children, both parents (mother and father) went into greater detail when explaining science to young boys compared to young girls in informal science settings (Crowley, Callanan, Tenenbaum, & Allen, 2001). In a study that looked at students interested in STEM, the students who persevered and achieved good grades had parents who were supportive and facilitated internship opportunities (Aschbacher, Li, & Roth, 2010).

Not all public schools are equal. Usually schools within wealthy communities have higher student performances on standardized tests and a greater number of students attending college. Informal learning opportunities are not equal too, and many students in lower socioeconomic classes lack access to them (Banks, 2007). Some opportunities are on the Internet and television, but not every child has access to those resources. Science camps range from free to extremely expensive. Parental involvement may be needed to pick up and drop off a child or for chaperoning. Towns near universities, museums and science research facilities may have greater access to informal learning centers. If the teachers, schools and parents are unaware about what opportunities are available, the student may have no way of knowing they even exist. Some students need to work over the summer in order to save for college or help pay the family's bills.

How The Nature and Practice of Science Effects Females' Science Views

During my sixteen years as a high school science teacher, the move to more student-centered learning and hands-on activities has been substantial. The teachers in my school have been told to move away from lecturing, with no more than 15 minutes of notes or PowerPoint presentations, and have increased the time spent on student-lead and student-based activities. Recently, a handful of universities have tried to move away from teacher-centered and lectured classrooms and added open-ended projects, group assignments, and increased participation with student-professor communication (Corbett & Hill, 2015).

Drew (2011) writes in The New York Times that science majors change their minds because science is "*Just So Darn Hard.*" Many students, especially girls, express their dislike for science because it becomes too difficult (Carlone, 2004; Miller, Blessing, & Schwartz, 2006). Science education at the university level is a biased, highly structured, western, and post-Renaissance practice (Hodson, 1999). Because of the hard work needed to become a scientist, many scientists possess a feeling of elitism and may look down at non-scientists, treating and speaking negatively to those who do not know something science related. The feeling of exclusivity and comradeship between science majors may be perpetuated by the sheer volume of facts needed to be memorized to become part of the science community (Emdin, 2012; Rosa & Mensah, 2016). Numerous male students come into their freshman year in college with a greater outside-of-school experience and different views on careers and education, and professors may see female students as not as serious as their male counterparts (Hill & Corbett, & St. Rose, 2010).

When attempting to define what science is and what it should be, the people who have been making these decisions historically have been White men from western civilizations.

Science is also not bias-free or value-free. It represents viewpoints that are not universal and research that can seem one-sided (Hodson, 1999; Kleinman, 1998). These bias claims are further justified by respected scientists (Kleinman, 1998). The nature and practice of science can be viewed as a social construct. Brotman and Moore (2008) elucidate the point that historically, scientists were men, which influenced what we define as science. Science is also seen as objective and free of emotional attachments from the scientist, which is not the case (Brotman & Moore, 2008). If female students can see the emotional, social and cultural values that are included in science, it may become a more attractive major for female students (Jammula, 2014). By training teachers to posses a greater awareness of culture and diversity and to engage students in a more relevant manner, they can help increase the interest of students in science (Mahfood, 2014; Mensah, 2011a). Jammula (2014) suggests that teaching physics in a variety of perspectives can capture the interest of students of various identities.

Science Identities of Female Students

In this paper, I have been using the words female, woman, and girl interchangeably. However, it is worth noting that these terms are misleading and have different connotations when it comes to identity. The terms male and female have been associated by society with the traits of masculinity and femininity, but females can have both masculine and feminine qualities and males can have feminine and masculine qualities (Crenshaw, 2014; Gilbert & Calvert, 2003). Women interested in science may struggle with being negatively perceived as being too masculine if they like science (Brotman & Moore, 2008). A salient point regarding gender and identity is the notion of understanding the differences between male and female and masculinity and femininity. It should be acceptable to be a male and have both masculine and feminine qualities without being judged or viewed as unflattering and called homophobic names, and if we can undo these stereotypical identities, we may be able to attract more women into science (Gilbert & Calvert, 2003). In this paper, I continue to use the terms interchangeably, because five out of six women identified as cis-female, while the sixth female STEM participant never replied. This is an important topic on identity in science that should receive more attention but is beyond the scope of this paper. However, one student did ask if I planned on interviewing any transgendered individuals; I replied: “not that I know of,” and we both thought that would be a great idea for another study.

When we were young children, many of us had parents and teachers telling us we can be and do whatever we want when we grow up, especially if we work hard and want it bad enough. We also see this idea on television shows and in movies. There are countless stories of people who overcome all odds to fulfill their dreams. Unfortunately, based on our gender, race, social economic background, and where we were born, the odds of success and achievement may be stacked against us. For example, in 1974, women made on average 59 cents for every dollar earned by a man; as of 2014, that rate is at 79 cents for every dollar made, which is far from equal (Hill, 2016). The number of female CEOs dropped to 4% in the Fortune 500 (Zarya, 2016). The number of women earning bachelor degrees in engineering is 19% and 18% in computing in 2014 (Corbett and Hill, 2015). In 2007, only 39% of women received bachelor degrees from all STEM fields, 27% received doctorates, and in 2006, 16% of tenured faculty members and 26% nontenured faculty at four-year educational institutions were women (Hill, Corbett, & St. Rose, 2010).

When girls enter the science classroom, they have identities as students, as well as female science students. According to Brickhouse, Lowery and Schultz (2000):

> How students engage in school science is influenced by whether and how students view themselves and whether or not they are the kind of person who engages in science. It is therefore crucial to understand students' identities and how they do or do not overlap with school science identities. (p. 441)

Popular conceptions of what a scientist is and looks like may not be alluring to boys or girls interested in science (Mensah, 2011b) because many people in society view scientists as nerds, uncool, geeks, and males. Television shows such as *The Big Bang Theory* further exemplify these views. Therefore, Brotman and Moore (2008) and Jammula (2014) point out the importance of accepting and embracing identities outside of the mainstream and stereotypical gender identities.

Brickhouse and Potter (2001) examined the lived experiences of two young women in an urban setting and discovered that if they adhered to the ideal identities in an urban school, then they would have had an easier time fitting in, and these students found difficulty with accepting the identities associated with school science communities when they showed interest and aptitude in science. Students need to know who they are and what they aim to be; they can then go about fulfilling their goals by integrating and participating within the communities they long for (Brickhouse & Potter, 2001). A study by Carlone and Johnson's (2007) show that the recognition from others within the science community and personal recognition as a scientist was important in forming a science identity for women.

The issue of girls performing poorly in science classes is a social problem of inequity, which can be fixed (Brickhouse, Lowery & Schultz, 2000). Girls seem to have a harder time developing a science identity, and an easier time developing an identity as a reader (Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006). Unfortunately, this reinforces the stereotype that girls perform better in reading and writing, while boys excel in science and mathematics.

Mahfood (2014) discusses the importance of the role the teacher plays in facilitating the creation of their students' science identities by learning about their students' experiences and actively promoting greater participation and class contributions from female students. Science identities can be nurtured from parental support, teacher interventions, professional development, preservice teacher training, curriculum design, students' friends, and societal views. The old adage "you must first love yourself before you can love others" is echoed in science identities. In order to help students find their science identity, teachers must be aware of their own science identities (Bianchini, Cavazos, & Helms, 2000; Mensah, 2012). In order for teachers to increase their knowledge of their students' experiences, culture and gender, teachers must first recognize their positionality identity, their own social role in relationship to their students (Mensah, 2012). Positionality identity is amorphous, changing with the gender, class, race and culture of a person's social surroundings (Tetreault, 1993). Science teachers' positionality identity can be shaped by the make-up of their students' gender, class, race and culture. When science teachers recognize their positionality identity within the science classroom in relationship to their students, they can develop stronger relationships to science and foster relationships with their students (Mensah, 2012).

Research Questions

One way to better understand why certain women like science and eventually major in science is through interviews that reveal the lived experiences of women in their junior and senior year at college pursuing science majors. In this study, I focus on their formal (in-school) and informal (out-of-school) science experiences, the influences of their family and friends, and their experiences of inequity as female science majors. Using both critical theory and identity theory as the theoretical framework for this study, I examine the formal and informal learning experiences these women encountered in order to add to the collective work of gender equity in science. The research questions for this study are:

1. What captivates and motivates female students' interests in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?
2. What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college?
3. How do female science or STEM majors discuss their experiences of gender equity as science or STEM majors?

Methods

Setting, Participants and Selection

The Science Motivation Questionnaire II© and the Science Background and Equity Questionnaire were sent to department heads and faculty at a highly selective college in the northeastern US, as well as its all-female sister college. Students are allowed to register for classes at both schools. An embedded link with a brief introduction to the study was attached to the survey in the emails that were sent out from the deans, department heads, and faculty members at both schools. The Science Motivation Questionnaire II© has been created and validated by Glynn and Koballa (2006), and Glynn, Taasoobshirazi, and Brickman (2007). This survey was based on a Likert-scale of 1 to 5, 1 being never and 5 being always. There were five major components of this survey: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. Scores were tallied and ranged from 25-49 as "never to rarely," 50-74 as "rarely to sometimes," 75-99 as "sometimes to often," and 100-125 as "often to always" motivated.

Science Background and Equity Questionnaire focused more on informal and formal learning experiences as well as personal experiences. An external audit from fellow doctoral students in a qualitative methods class as well as my advisor, Dr. Mensah, were screened and comments were analyzed, and corrections where made as needed (Creswell, 2008). The questionnaire was split into two parts. The first part was based on female STEM participants' experiences and views before they entered college, while the second part was based on their experiences in college as STEM majors. The former consisted of 11 questions and the latter nine, all based on a Likert-scale of 1 to 5, 1 being never and 5 being always. Scores for the first part were tallied and ranged from 11-22 as "never to rarely," 23-33 as "rarely to sometimes," 34-44 as "sometimes to often," and 45-55 as "often to always." The second part was scored from 9-18 as "never to rarely," 19-27 as "rarely to sometimes," 28-36 as "sometimes to often," and 37-45 as "often to always." There were a few open-ended questions with this survey that collected data on the student's age, major and minor and college year, and the answers were coded using the Dedoose analysis software. Two questions in particular assisted with the self-selection process for semi-structured in-depth interviews by looking for interesting comments and responses that resonated with the author. The first one asked "I am majoring in science because:" while the second question came after the Science Background and Equity Questionnaire and asked "You may respond to any of the questions above that you feel need further clarification or an explanation."

The analysis of the open-ended questions were coded, recoded and revised while making connections between texts to decipher the response of the female STEM participants within the

Dedoose analysis software. Before starting the interview, the findings from the open-ended question by the female STEM participants were confirmed through the use of member-checking to increase reliability of data (Creswell, 2008). From the analysis of the Science Background and Equity Questionnaire open-ended questions, coding produced nine separate themes that were uncovered after reading through the students' responses multiple times. These themes included positive and negative school science learning, desire to learn science, career motivation, gender equity issues, hard work and pressure.

Of the ten students emailed for follow-up interviews, six responded and agreed to be interviewed. The interviews were semi-structured and lasted between 20 – 40 minutes. Five of them took place in a private room at the Gottesman Library at Teachers College. One student was studying abroad in England, and her interview was done using Skype. These interviews took place during the spring of 2016. Interview questions and procedures were made using the guide created by Creswell (2008) on *Conducting Interviews* (pp. 228-229)

The interviews (Appendix B) focused on the lived experiences these young women had from their earliest memories of science to their current position as STEM majors. All female STEM participants were asked the same sixteen open-ended questions, but different questions were added based on the responses students gave and the flow of the interview. Questions were added or altered if further clarification was needed, or if a deeper insight into an interviewee's lived experiences was needed. Interviews were recoded on my smart phone, uploaded to my computer and then transcribed. After transcribing all the interviews, I read along my transcriptions while listening to the audio recordings to increase accuracy of my transcriptions.

Once transcribed, I used the NVivo ® software with guidance from the theoretical frameworks and literature. The interviews were read multiple times and anything that seemed interesting, unique, or repetitive between participants was highlighted and coded. Coding was an evolving amorphous process that moved in multiple directions. Certain themes were looked for like gender equity, what sparked their science interests, formal and informal science learning experiences, family, teacher, and friend support, while other themes appeared organically like mentors and role models, communal and social values, financial issues, careers and life after school. Once the themes were uncovered, they were grouped together and organized to form coherent stories of the lived science experiences of female science majors.

Findings

Students were asked a series of open-ended, semi-structured questions that allowed them to share their personal experiences as females interested in science and pursuing majors in STEM. The amalgamation of this data attempts to paint a picture of events and circumstances that steered these female students to become science majors in their junior and senior year of college. Students that were interviewed shared many commonalities and some experiences overlapped; however, each female STEM major brought a unique story and set of occurrences that facilitated their science identities and future career paths. First, I introduce the six female STEM majors and provide the results from the first survey instrument, or the Science Motivation Questionnaire II © (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011), by reporting their science motivation scores. Second, I provide a compilation of the lived experiences of the female science majors. They voice their trials and tribulations on their journey to receive a bachelor's degree in a STEM field.

Science Motivation Scores

Students' background information was analyzed and showed only one out of the six students majoring in a field of physics (astrophysics), four out of six students majored in field of biological science, which includes one student majoring in biochemistry with a pre-med focus, and another student with an environmental science major (Table 5.1). Biochemistry and environmental science overlap with both chemistry and biology when looking at the courses required for the major, but for this study, both biochemistry and environmental science are included as a branch of biological science. Only one out of six students is majoring in the field of chemistry. The findings of the majors for these six STEM majors aligns with the research provided by Hill, Corbett and St. Rose (2010), which shows more than half the undergraduate degrees that women achieve in STEM are in biological sciences, and physics and computer science have under-representation of women.

Table 5.1 Summary of Interview Participants Background

Participant	Gender	Age	Race / Ethnicity	Major	Minor	Student Status
Andrea	F	22+	Caucasian / White and Latina	Environmental Science	Political Science	Senior
Julia	F	21	Half Hispanic / Half White	Neuroscience & Behavior	English	Senior
Uli	F	22+	Hispanic / Peruvian	Biochemistry	NA	Senior
Martha	F	20	South Asian-American and half white	Neuroscience	None	Junior
Esther	F	21	African-American / non-Hispanic	Astrophysics	None	Junior
Wilma	F	21	Asian / Chinese	Biochemistry / Pre-med	None	Junior

The results of each student's overall score mimic the expected results due to the fact that all these students are science majors in their junior and senior year. Interestingly, Esther had the highest science motivation, and her major is astrophysics. Andrea had the lowest science motivation score, and her major is environmental science. Five out of six or 83% of the students were "*often to always*" motivated, while one students, or 17% of the students were "*sometimes to often"* motivated to learn science. The data is summarized below in Table 5.2. The average science motivation score for all six students was 104.5 out of a maximum score of 120.

Table 5.2 Interview Participants' Scores on The Science Motivational Questionnaire II ©

Participant	Age	Score on Science Motivational Survey	Interpretation of Score
Andrea	22+	89	Sometimes to Often
Julia	21	107	Often to Always
Martha	20	105	Often to Always
Esther	21	116	Often to Always
Uli	22+	107	Often to Always
Wilma	21	103	Often to Always

When breaking down the scores into the five separate categories, *self-efficacy* was the lowest with an average score of 18.2 out of 25, and the highest were between intrinsic and career motivation, which were almost tied at 22.5 and 22.33 respectively, while an overall average science motivation score for all six students was 104.5 out of 125 (Table 5.3). The research produced by Hill, Corbett, and St. Rose (2010) showed women hold themselves to a higher standard than men, especially when they receive the same scores on tests, which correlates with the data below under the category of self-efficacy. Even though these women are almost finished with their degrees and attending highly competitive universities, their self-efficacy score had the lowest average. An interesting finding showed Uli with the highest intrinsic (25) and self-efficacy motivation (22), but she had the second lowest career motivation (20).

Table 5.3 Interview Participants' Scores on The Five Components of Motivation to Learn Science

Name of Student	Intrinsic Motivation	Self-Efficacy	Self-Determination	Grade Motivation	Career Motivation	Total Motivation Score
Andrea	22	15	19	15	18	89
Julia	24	19	21	18	25	107
Martha	20	15	22	25	23	105
Esther	24	21	24	22	25	116
Uli	25	22	23	17	20	107
Wilma	20	17	20	23	23	103
Average	22.5	18.2	21.5	20.0	22.33	104.5

The following section includes the interviews that were conducted with these six students, along with the themes that emerged from them. I used an integrated approach, which is a combination of emerging and predetermined codes (Creswell, 2014). After reading over the interviews, eight main themes arose, which include the following: gender issues, leisure activities, community and social interactions, friends' influence, role models and mentors, future plans after graduation, education, family and interest in science. Before discussion of those themes, I present a brief background of the students from the beginning of their interviews and the original survey.

Backgrounds of Female STEM Majors and Their Science Identities

The students came from two highly selective schools in the northeast of the US. One school is coed, and the other school is all women. Students have the ability to cross-register and take classes at each school. This section is guided by my research questions based on what captivates and motivates female students' interests in science or STEM. What experiences nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college? What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college? What experiences, both formal and informal, have guided their choice or selection of a science or STEM major in college? This section contains a brief description of their interests and background, including where they grew up, what they like to do in their free time, some information about their family members, and what they plan on doing after graduation.

Science Identity Development

With the hope of attracting more women into science majors and careers, we first need to comprehend female science majors' science identities. According to Carlone and Johnson (2007), a science identity is formed by one's science experiences and interactions within society as well as how one is viewed by society. During the interviews and surveys, the students were asked what moment or moments sparked their interest in science and how have they nurtured their love for science. Some students knew they wanted to be scientists since they were in primary school, others decided in high school, and some did not decide until after they started college. All six female science participants possessed high levels of self-determination, self-efficacy, intrinsic motivation, career motivation, and grade motivation to arrive at their current science identity.

Andrea. (Senior, attends the coed university). Andrea is an environmental science major and is minoring in political science. She grew up in Austin, Texas and has one older sister. Neither her parents nor her sister work in STEM careers. However, her grandmother would ask her about the world and help explain how it works through a scientific lens. Andrea did not realize her grandmother's use of the scientific method until much later in life. One of the moments Andrea recalls that excited her about science was the publicity and possibilities of the Large-Hadron Collider. She did not understand the physics of it at the time, but anticipation of uncovering new things excited her. Before college she enjoyed reading novels, but she currently reads more science-related articles from journals like *Scientific America*® and *Wired*®. As she enjoys being outside, her hobbies and interests align with her major. She is an active member in the American Academy of Environmental Engineers and Scientists. Her outside-of-school free time is limited, but she feels it is self-imposed because she chose to take five classes over four and to write a senior thesis. When Andrea graduates, she plans on developing her thesis research further for publication, and then in a year or two she will either pursue a research Ph.D. or enter law school. She would also like a career that allows her flexibility to take care of her family. Her love of science stems from a desire to understand the universe at different scales and levels, and she is motivated by the ways in which scientific discoveries can impact daily life.

Esther. (Junior, attends the coed university). Esther is an astrophysics major, who spent her first ten years growing up in the Florida Everglades; she then lived in Michigan until entering college. She has one younger brother who entered college in the fall of 2016 as a biology major. Her mother works in writing and communication, while her dad is a lawyer and history enthusiast. Esther loves to travel and is currently spending the semester abroad in London, England. She believes that a STEM career will allow her to travel frequently for work-related conferences in sciences. Growing up, she loved to explore the Everglades, observing nature and the different types of animals living there. She believes that not having Internet access growing up lead to her spending more time at the library and reading books. She credits her teachers for being very helpful and acknowledged their ability to explain science in a simple and clear fashion. In her free time, she likes to volunteer at the university's observatory, where, because it is open to the public, she can educate the community about astronomy. She also volunteers back home in Michigan at an observatory. Besides traveling, Esther enjoys cooking, eating new foods, and playing the clarinet (she admits to not having enough time to play in a band during school but plays in a community band back home over the summers). After graduation, Esther would like to take a year off to travel and decide exactly what to major in before settling into a masters / Ph.D. program. Career-wise, she is unsure if she prefers to work in academia, the private sector, or find a way to work in both.

Julia. (Senior, attends the all-women's college). Julia is a Neuroscience major with a minor in English. She grew up in Northeastern New Jersey. Neither parent was involved in STEM fields. Her father worked for the United States Post Office for 35 years, and her mother is currently a receptionist; neither went to college. Julia has an older sister, eight years her senior, who is a nurse, while her younger brother just started college as an Information Technology major. Julia credits her sister with being her inspiration and telling her to go to college and follow her dreams. When Julia was very young, she recalled dressing up and pretending to be a scientist. Later on her interest changed and she would read and write in her free time; she entered her freshman year in college as an English major. Julia described her interest in science as one that went into a latency stage. It was not until her freshman year in college that her interest in science was rekindled and she changed her major from English to Neuroscience. In her free time, she enjoys reading, running, and exploring the city where she goes to college. She would love to travel, but does not have the money yet to do so. She describes herself: "I'm an inward person, so I like to do things that, you know, give me time to myself." She is the editor of the local university's science review and is passionate about the ability to communicate science to the rest of the world. She also volunteers at the university's Youth Adventures, which works alongside Science and Engineers for a Better Society, and takes local kids on science-oriented trips around the city. After graduation, Julia would like to go for her Ph.D., run her own lab, and be a leader or mentor for science within her community. Julia summed up what excites her by saying:

> I like the fact that you were able to come up with your own ideas and you're sort of at the forefront of knowledge. So you're really the one asking the novel questions. Thinking about new ways in order to cure diseases or learn about what exactly it is that causes us to think, to behave in the certain ways because our mind is us basically.

Martha. (Junior, attends the all-women's college). Martha is a Neuroscience major who played violin for thirteen years. She lived in Austin, Texas her entire life, until she moved away for college. She has one younger sister who is still in high school. Her father is a computer scientist who does information architecture at a university, while her mother has an M.D. She comes from a family of doctors on her mother's side. Both parents have valued and nurtured her science learning since she could remember, and she recalls her mother always explaining things about the human body in scientific terms. For fun, Martha enjoys running and is training for a half marathon. She recalls being able to make a personal connection between science and running when she learned in biology about the lactic acid cycle. As part of her financial aid, she has worked in a research lab as a work-study student since the first month of her freshman year. Martha was a self-proclaimed recluse in high school, devoting most of her free time to school in order to graduate in three years instead of four. Martha was the only one who expressed doubt in her intelligence a few times. She said the main reason she went to an arts high school was there was less academic competition, making it easier for her to graduate top in her class. She is planning on applying to medical school, so most of her free time now is spent studying, working in the lab, and running when she gets a chance. Most of her friends are science majors that she sees during class and in the lab, but rarely goes out with them outside of school. She would like to take a year or two off to do research and study for her Medical College Admission Test (MCAT) before applying to medical school, but she has doubts about her ability to get into a medical school.

Wilma. (Junior, attends the coed university). Wilma grew up in a small town outside Birmingham, Alabama. Her major is biochemistry and she is on the Pre-Med track. Her father is a professor of pathology at a university and her mother is a computer programmer. She recalls spending a lot of time in her father's pathology lab watching him and being excited and curious about the things he did. She has been fascinated with science for as long as she can remember. Her parents did not let her choose a non-science major; nevertheless, she truly enjoyed science and did not want to focus on anything else. Wilma plays intramural volleyball at school and likes "going out, typical college stuff." She also does research in a lab and volunteers. She is a member of the American Medical Students Association and enjoys reading scientific articles, specifically articles about cancer. She also has a younger brother, who had brain cancer when he was ten; an experience, which she said, really sparked her interest in cancer. She is not a fan of the humanities and does not like reading fiction. She explains: "That isn't where my heart is. I would rather look at a diagram or look at numbers or a formula. And that's like much easier for me to understand than if I see a paragraph I probably have to read it five times to understand it." She hopes to graduate and enter into an M.D. / Ph.D. program studying cancer. Having children and job security are some of her major concerns, and she thinks an M.D. will give her better flexibility and a good paying-job, allowing her to be a mother one day.

Uli. (Senior, attends the coed university). Uli grew up in Lima, Peru. She has an older sister and a younger brother. Her parents never attended college and no one in her family works in STEM. Uli's love for science started during her high school chemistry class, but she originally went to college as a business and economics major, thinking she could make more money in business. She had two years of college in Peru as a business and economics major but didn't finish the program. She attended community college in the United States as a biochemistry major and transferred to a four-year college, majoring in biochemistry. She does not have much free time, because she works full time and commutes to college from another state. Most of her free time is spent working and studying. She does not belong to any club or group within the school and does not have the time to intern or work in a research lab. Uli would like to find a well-paying job after graduation, but feels her biochemistry degree will not be sufficient. She is interested in entering the business side of science and getting an M.B.A. instead of a M.S. or Ph.D. in research science. She would prefer to stay in science research if money was not an issue. As with Esther, Uli loved the way her teacher explained the material and made it interesting and exciting. When asked what she loves about science, she said: "That fact that there's so many things, new things to discover and it's interesting for me how the whole body works, molecules. It feels like a puzzle and the puzzle still hasn't been finished so that's why that's interesting for me."

Emergent Themes

The openly candid replies from the semi-structured interviews painted an elaborate picture of the learning experiences interviewees encountered along their journey. Science identities started developing from a young age and flourished into a passion and love for science as the women grew-up and progressed through school. With the assistance of teachers, parents, siblings, relatives, mentors and internships and fueled by their desires to study science, these students experienced a vast spectrum of development along their way. After analyzing and coding their interviews, many themes started to emerge, such as experiences during formal education in middle and high school, informal education during middle and high school, family influence and support, mentors and role models, financial constraints, careers, internships and research, and sexism and gender equity. These themes are discussed in the following sections.

Early and Middle School Learning Experiences

Of the six students interviewed, five went through schooling in the United States and one attended primary and secondary schooling in Lima, Peru. The experiences these six students had during their primary and secondary schooling ranged from positive to indifferent to negative. The students were asked to go back as far as they could recollect, and most students were able to extract some vivid memories from their primary schooling. Two students, Martha and Andrea, are from the same city in Texas, but attended different schools. One of Martha's earliest memories of science occurred in the 3rd grade when her class raised crayfish and germinated plants. She was fascinated by how life started and grew from the tiniest of things to a complex organism. She stressed the hands-on experience as being one of the most important parts of the unit. Martha later attended a magnet / gifted middle school where she said she learned more science than in high school, which was a performing arts high school. Andrea's earliest and fondest memories of science came during 6th grade, when she was part of her school's University Interscholastic League. The League is run by the state and is similar to school sports in that each school has its own team. She originally set out to compete in an English writing competition until a classmate told her she could not do science, so she set out to prove her wrong and really found an interest in science after that. Andrea fondly remembers her 8th grade science teacher who encouraged her to get involved in science. He would give her supplemental reading to do that really sparked her interests.

Esther had more of an indifferent middle school experience, with no teachers or events that stood out. She recalls the lack of hands-on experiences and how the teachers taught more about the history of science. She had a long-term substitute for most of 8th grade, and most days she and her classmates just watched videos about Earth Science. Julia described her early schooling as at a below-average school because her school did not put much emphasis on science education, and most of her science learning occurred on her own through reading books. She ended up moving to another part of New Jersey for middle school and had better experiences there. During 7th grade she did a dissection lab and it went well, which she recalled as a very positive experience. Wilma recalls leaning some basic information about science in primary school and noted the lack of lab work. She thought the science as it was taught was not stimulating. Uli attended a very small school in Peru with about twenty other students. Her school did not have equipment for labs and science was barely taught.

High School Science Learning Experiences

Martha was accepted into a highly selective academic magnet middle school; however, she chose to enter a high school for the performing arts instead of a magnet high school. She gave a few reasons for her selection. First, the arts high school was across the street from her house; second, she knew she would be one of the top academic students in the arts high school; third, she played violin; and fourth, she wanted to graduate in three years. She did end up graduating in three years and was at the top of her graduating class. However, she thought middle school was more challenging, and when she arrived at college she felt she wasn't as academically prepared as her classmates. A positive experience came from a teacher that taught both biology and anatomy and physiology class. The teacher had a very hands-on approach. Martha shared, "He was amazing. He would really make sure everybody in the room understood what was going on through practical applications and then also drawing and dissecting all these things." On the opposite end of the spectrum was her chemistry teacher, whom she described:

> He was probably 80 years old or more and pretty much just put out all these chemicals on the bench and then like let us run wild and we have worksheets we were supposed to do, but like mostly, Chemistry class is just people mixing things and hoping things would explode, and sometimes it did. It was not educational at all.

Even though a high school may have a certain number of clubs, many schools are open to students starting a new club if they can get enough students involved and can find a teacher to advise the club. Andrea started an environmental club within her school that started out with a group of students interested in discussing environmental issues. Andrea had a negative experience with her Biology teacher who felt the teacher had a bad relationship with the entire class. Andrea's personal area of conflict with this teacher arose when she had to write a paper on evolution, and the teacher made it mandatory to spend an equal amount of time writing about intelligent design. Even though it was not mandated by the state, the teacher was still allowed to assign coverage of intelligent design. Andrea stated that her Biology teacher "didn't deter her from science" and she ended up taking A.P. Biology and really enjoyed that class. She went on to take A.P. Physics I & II, and really loved the fact that the teachers were husband and wife, which allowed for a seamless flow of teaching methods and content from one class to the next. One of her favorite classes was A.P. Environmental Science, but the class dynamic caused her some conflict:

> I had a really good experience with it, but it's very much how much you put into it is what you get out of it. A lot of people took that [class] who weren't interested in science

> or weren't dedicated towards it. They took that [class] their senior year just to kind of fill their schedule. So you had a huge bilateral grade distribution.

She felt bad for the teacher because he put a lot of effort into the class and many students did not care about the class.

Julia's high school learning experiences were underwhelming and she relied more on herself than the school for learning. "So I sort of grew up in a public high school system and was not really like, bolster to study science and mathematics. So in my free time I would go home and read and write." Julia was part of the yearbook and literary clubs since no AP science classes were offered. She had a negative view of her high school experience, "Yeah, but my high school, I didn't really enjoy it all. So there is nothing very positive to say about it." She planned to enter college as an English major.

Esther attended primary school in Florida, but moved to Michigan for high school and vividly recalled a few great experiences she had. Since she could remember, she always wanted to major in Astrophysics, but she almost changed her mind after taking a Genetics and Physiology class. She loved that her teacher treated the students like real scientists and that the class was able to perform a lot of fun experiments. She said: "I just had phenomenal teachers in high school particularly." However, her physics class was even more impactful and steered her towards her current major:

> I think one of the major moments for me where I knew it was what I wanted to do, that I was going to have fun with it was probably. I want to say high school. I had this amazing physics teacher who is very, you know, charismatic, who's very helpful. And I just remember one of the first things we did was like that little marble down a roller coaster experiment. I thought it was the coolest thing we could literally calculate where that

marble was going to fall based on where we started it, the number of loops that it ran around. It was just like so cool to me you know, that we could use that stuff in paper to predict things that were going to happen out in the physical world. So I think that it was like a really big, like oh, wow I really enjoy science. I want to keep doing this moment.

Wilma describes her public school as not one of the best schools. She did not really have any defining moments, but enjoyed taking A.P. Biology, Physics and Chemistry classes the most. She said: "You had to learn more, think more, it wasn't just like definitions and like stating facts. It was more like you could put your own thoughts into it."

Uli enjoyed her chemistry class because the teacher made the class interesting and the material was easily understood. The same teacher also taught her biology class. Her school was very small and they did not have any labs or projects. Her Biology and Chemistry teacher came to her school from a much larger school. He brought microscopes in and showed the students what an onion cell looked like under a microscope. This moment resonated with Uli. There were no other science classes taught at her high school.

Informal Science Learning Experiences

Education does not start and end with school. Humans are constantly learning new things about the world they live in. Because of curriculum and budget restrictions, schools try to narrow down what students need to learn while adhering to the state and national guidelines. Some students are content with the science knowledge they received from schools, others want to know more and take active roles in a quest to satiate their inquisitive minds. In this section, informal science learning includes all learning done outside the actual school science classroom; therefore, learning from the experiences of parents and other family members, volunteering experiences, and school clubs, science camps, and other activities outside of school count as informal learning experiences.

Martha's mother is a doctor and she recalls from a very young age that her mother always tried to explain things in a scientific manor to her, especially in regards to physiology:

> My mom, whenever she would explain something about my body or something like that, she would always explain it in medical terms and like get us to really, my sister and I, to really understand things in terms of biology.

Martha knew she wanted to be a doctor when she was very young. She did well in her science classes and entered various science fairs. She volunteered at a local hospital, shadowed doctors, and volunteered with the Special Olympics during high school. She had a desire to learn more about the human body and various diseases and illnesses. Each summer she would attend science camps. Her high school had a volunteer program that would only run during the school year; however, Martha and another student worked with the school to have the volunteer program run during the summer as well.

When Andrea was young, she was fortunate to have her grandmother who facilitated her informal science education.

> My grandmother was around a lot and so when I was really young and she would take me and my sister outdoors and do different crafts and science experiments, but they were never identified as this is science, but looking back, it was like, oh, we are following the scientific method that type of thing.

In middle school, Andrea joined a school club that competed against other schools in various academic fields. She originally was going to choose English and writing-based subjects, but because a student said that she could not do science she decided to do it to prove that classmate wrong. There was a lot of outside reading and work involved, but thankfully she received extra support from her middle school science teachers. In high school, she started an environmental club that started out with a group of students interested in discussing environmental issues. They would do clean ups around the school and implemented a school-wide recycling program where students help sort the different materials and place them in separate containers.

During Julia's early childhood, she would take out little physics books and pretend to be a scientist, but neither of her parents went to college and could not help her, so she decided to read about science on her own. She did not attend any camps and does not have many memories of learning science outside the classroom besides what she read. She did not realize she wanted to major in science until her first semester in college.

Esther grew up in the Florida Everglades, where she and her brother would wander around exploring and observing all the different types of plants and animals that lived there. Her house was so remote that she didn't a good Internet connection at home. Instead of looking information up online, she was forced to go to the library to read. She would take out books on lab experiments and try to do them at home. Her primary school had an after school program for students that took kids to nature observatories and had a lot of activities with interactions between animals and humans. She also spent her summers at a science camp at the local museum where they focused on paleontology with a wide range of different science experiments that encompassed many different scientific disciplines. She said that most of her after school time was devoted to science while her parents could not watch her.

Wilma's father is a professor of Pathology at a university. She spent a lot of her time in her dad's lab looking at dissections, and then went back to school and told all her friends what she had seen. During her summers in high school, she attended a few science camps, but just before college she was accepted into the National Youth Science Camp, which selects only two recent high school graduates per state.

Research and Internships

An integral part of scientific research is bench work, where students have the opportunity to apply laboratory techniques they've learned about during lectures as well as things they have yet to encounter. Many universities require students to participate in some form of research, either at their school, a nearby lab for class credit, or literary research. Some students complete the requirement and stop their research, while others stay on for longer with the chance to take what they have learned further with hopes of getting their name on a published paper. Students can use their research and incorporate it into their senior thesis, and some students are paid as part of their work-study program to be in the lab. Both Martha and Julia had an amazing research experience and shared two interesting and enlightening stories about their experiences.

Martha had a choice to go to school within Texas and pay instate tuition, which is half the price of her current school, or help fund her own tuition for college if she went out of state. She chose to go to a more highly selective school out of state. She applied for a work-study grant, and she entered a research lab within the first month of her freshman year. Her research was in a neuroscience lab and it relied heavily on computational biology. She had no real experience with computer programming, but her research advisor told her in order to work in her lab she would need to learn how to program. Martha took an introductory class on the Python computer language, and she continues to learn how to code on her own. She admits the work is tough, but she loves what she does. Besides doing cutting-edge research in neuroscience, Martha's research advisor pushes her to do her best and gives her many life lessons about being a woman in science. Her advisor is female and has experienced a lot of gender inequity during her time as a scientist and tries to inspire more women to become scientists. Besides gaining valuable experience, Martha hopes her research and a recommendation will help her get into medical school.

When Julia started college, she entered as an English major. However, during her freshman year, she registered for a research seminar and noticed other female students who were passionate about science. The class had required the students to do lab rotations; students worked in a handful of different labs to get a feel for the research that goes on in each lab. She wrote an article for the school paper about a neuroscience professor, and she became interested in the research he was doing. She emailed him to see if she could start researching in his lab and wound up working in his lab for one year. Julia then made a decision to attended a research fair and met another research professor that changed her life: “And it was the luckiest decision I have ever made, because these past two years have been absolutely transformative in terms of me as a scientist.” The neuroscience program is under the psychology department, and Julia feels that the course work does not go as in-depth into neuroscience as much as she would like. She’s had a few graduate school interviews, and she often felt that if it were not for her work in the research lab, she would not have had the adequate educational background needed for graduate school. She is very thankful that she was able to work in a lab and learn so much.

Though Martha and Julia had very good experiences with working in a research lab, this was not the experience of others. Esther found some difficulties in trying to land her first research experience. Most research labs want someone with experience, and as an undergraduate student, “It’s not easy getting the initial experience you need.” Esther also noted:

> It’s hard for women to get their foot in the door for that first research experience to get to the next one. So I think that is probably one of the more challenging, one of the largest challenges that I’ve had to personally overcome.

Currently she is studying abroad in England; last summer she did research in Utah, and this current summer she will be researching in Michigan. She has had the opportunity to travel around the world doing different research projects. Being a proactive student and president of the Astronomy club at her school, Esther wants to help make achieving research positions for students easier by establishing connections between professors and students.

Wilma started volunteering during her sophomore year in a lab at the medical school affiliated with her university. The following year she used that research for college credit and plans to continue working in the same lab until graduation.

Andrea does not work in a lab, either; her research is based on scientific literature and does not involve laboratory work. She decided to pursue a senior thesis project by using her research and plans on graduating in the spring of 2016. She would like to expand on her research and try to add to it for a possible publication after graduation.

Mentors and Role Models

Many of us have had someone who we once looked up to, admired, and aspired to be. Some people are fortunate enough to have these people in their lives. It could be a family member, a teacher, professor, a boss or someone within your community. This section tells the story of two students who spoke explicitly about their mentors and role models.

Julia has two people that she admires: her older sister and her research advisor. She credits her sister with giving her the advice and motivation to work hard while instilling the importance of going to college. Her parents did not go to college and did not have a lot of money, so this advice resonated with Julia. Julia's choice on graduate school is partly do to the fact that she wants to stay with her advisor. Here is Julia's praise and admiration for her advisor:

And so she's like barely 30 or 30 now and already has her own lab and [is] already like a very established scientist. And she does that by working so hard and came from the same place that I did and that like her parents didn't go to college and she sort of had to work for everything she has. And I think [the reason] we get along so well is because we're so similar and she's very organized that she's literally taught me ways in which to live my life basically. So we get along very well and she is my role model as a scientist and as a person. But she's also very passionate about the research she does. I think it has very real world relevance. Yeah, she's just a bad ass.

Martha's mentor, her lab principle investigators, is an advocate for women in science who constantly reinforces the idea that women can be great scientists and should never settle for anything less. She pushes Martha academically and gives her advice on how to be a woman in science. Martha recounted an experience from her lab meetings:

> Well, she really does tailor her advice to us to be for women in science and she talks about women in science at every lab meeting, you know like for example she says a lot of people when they're making presentations, scientific presentations of their data. It'll be like a ten-minute talk and they'll put like cartoons and jokes to keep people interested on what's going on. And she says, "Women shouldn't do that because people don't take women seriously to begin with and so when a woman puts a joke into her PowerPoint it makes people take you even less seriously." And so she says, "Take the jokes out of your PowerPoint; just be an engaging speaker."

Unfortunately, Martha feels at times that her mentor may put too much pressure on women in her lab by expecting the students to live and breathe science in order to be successful — anything short of that is unacceptable. Here is Martha speaking about a negative experience between another student and her mentor:

> She was a work-study student. You know, same situation as me. She was very bright and super great at Computer Science. We actually ended up taking a Computer Science class together and she was really interested in what we were doing and did a really great job. But then she said to my mentor in a private setting that she was more interested in working with people or maybe children and more of a Psychology or behavioral kind of thing, because we have like the Children Development Center at college and a bunch of other opportunities. She was thinking well maybe nursing would be interesting. Like she wanted to have more experience with actual people because we pretty much sit in front of the computer in the lab and my adviser completely flipped out. And she said, "Why don't you have as much ambition as Martha?" I'm a pre-med student too and I'm interested in helping people too like, you know. It was not a fair comparison and, you know, that she should be ashamed of herself, you know, as a woman in science you know it's not ambitious enough and she pretty much fired her for expressing this interest in doing something else, and there were a bunch of other things that were just very insulting to her and insulting in a personal way too. You know, she wanted to spend her summer doing a hiking backpacking thing instead of working in the lab, and my adviser said that that was terrible even though it was the summer after her first year of college. So I think that in conclusion there's this happy medium where we can advocate for women in science and then not crush the humanity out of them.

Family Influence and Support

Most parents want their children to be successful; however, the amount of support given varies tremendously, with the availability of financial resources playing an important role. Some of the interviewed students had parents that were highly involved in their education, some to the point of being over-bearing, giving them little choice in what to major in. Others had hands-off parents who did not stress the importance of going to college. The pre-med majors, Martha and Wilma, have parents who are doctors — one is a Ph.D. in science and the other is an M.D. — and they each played an active role in their respective daughter's science education. The parents of Julia, Andrea, Esther and Uli do not have a STEM background or career. They were not very active in their child's science education; rather, they encouraged their child to do what makes her happy.

Wilma's father worked in a lab and was a professor at a university. Wilma remembers spending much of her time in her father's lab observing him. She was always fascinated with what he was doing. There were a lot of dissections because the lab specialized in bone pathology. Wilma thoroughly enjoyed her time there and would tell all her friends what she saw and learned. She knew at twelve years old that she wanted to be a scientist like her father:

> So my dad's a professor so I've always gone to his lab and he hasn't really given my brother or I a choice. So we've always been pushed towards the sciences and when I was twelve my brother got brain cancer and so that kind of solidified it for me. I've had no choice whatsoever in my education. But I also liked it at the same time so I wasn't rebelling.

Her father expressed the amount of work and stress involved in being a research professor and convinced her to become an M.D. instead. Her parents sent her to various science camps when she was middle and high school.

From the time Martha was little, her parents always supported her interest in science. Her mother, being a doctor, would always try to explain things about her body in a scientific way. Her father works in information architecture and always placed a priority on science education. Martha shared this about her father:

> My dad has always really valued science and would always do the science fair projects with me in elementary school from the time I was five years old. And so like they just really stimulated that in me, and then I always did fairly well in my science classes, and I knew I wanted to be a doctor since the time I was pretty young.

Even though Martha's parents supported her science education, they knew how expensive college was. Martha and her parents agreed that if she were to go to an out-of-state school, especially a private one, she would have to either become a lawyer or doctor to pay for it.

Andrea's parents were supportive in her decisions to study what she liked and did not push science or any other subject on her. She credits her grandmother with her awareness of nature and using a scientific mind to understand it. Of her parents, Andrea said:

> My parents were very great in sort of saying, "Hey, study whatever you want to study." And was so great about not putting pressure on [me]. You need to get in to like whatever school or you need to make these certain grades or, you know, like there's different kinds of pressures that I saw a lot of people in my high school and a lot of my friends experienced.

Esther's parents were similar to Andrea's, hands-off but supportive of their daughter's interests:

> None of my family really has a science background. My mom was in writing and communications and my dad's a lawyer, history buff. Like, you know, neither of my parents was into science but they always nurtured that. They let me grow in the kitchen with my experiments. And they let me go to science camp and all of that. So I think it was mostly supportive capacity as opposed to direct involvement with my passion for science.

Some people like Wilma liked the fact that their parents were heavily involved with their science background and students like Andrea liked that her parents were hands-off. However, Julia wished her parents were more hands-on. She discussed her parents' lack of college education, which limited the help and attention she received when she was younger. Julia thanks her older sister for being the role model she needed to convince her to go to college and receive a good education. Of her family's attitude towards science and education, Julia explained:

> So I grew up in north Jersey and when I was younger I actually really was into science. I take out little Physics books and pretend I was a scientist and tell my parents I want to be a scientist. But neither of my parents went to college and neither of them really knew what that entails.

Community and Social Values

A common theme that appeared during the interviews was the interests the students showed in helping others. This aligns with research that shows that women's career goals focus more on working and helping others than men (Corbett & Hill, 2015). All of the students, with the exception of Uli, either currently volunteer or plan on volunteering to help other people understand science. Their goals are the same, to help educate people on science; however, some students prefer to work with children or young girls, others focus on the entire community. Esther is very active throughout the year working at various sites to help people learn and appreciate science. She describes what she does:

> In addition to all of my classes and research, I'm also very active in public outreach. So at the college particularly we have the outreach program that I volunteer often with which is about every other Friday where we open up observatory to the public. We have a little lecture for them. They can go look up on a telescope. We have a 3D wall [with] all kinds of stuff. And I also do that over the summers when I'm at home. I work at a local museum where I do outreach for kids making science programs stuff like that. So I'm kind of like all around involved in science when I'm not researching in school I'm doing outreach in the community.

Andrea started doing community work at a young age. She started an environmental club in high school that initiated a recycling program at her school. She currently is a member of the American Academy of Environmental Engineers and Scientists, which works with girls in high school and middle school and tries to get them more involved in science. The group also works with students within her university to help them build careers.

Julia's future plans involve becoming a leader within the scientific community and to become a mentor to someone else. Currently, she really enjoys working with children and making science enjoyable for them.

> I'm also a volunteer for the College Youth Adventures, and I'm really passionate about that because we get to teach kids about, you know, places around the city, but I lead the scientific-oriented trips. So we work with like Science and Engineers for a Better Society

> and trying to make science fun to the kids. So I think when I move on to my grad school I really want to continue doing the communication and sort of like the mentorship side of science.

When Martha was younger she would volunteer at the local hospital, and she was a cofounder of the year-round Teen Volunteer program at her school. She also volunteered at the Special Olympics for three years during high school. She said: "If I were to do women's health I want to be on the forefront of researching women's health or [in] an advocacy [role] reaching out to underserved populations, not just in any old gynecological practice or something like that."

Financial Constraints and Careers

College is often seen as a gateway to a better life: a degree from college can lead to a well-paying job. According to the Pew Research Center (2014), the income disparity between high school graduates and four-year college graduates has never been greater, with nearly a $20,000 pay gap. However, the cost of college has also increased tremendously. Over the last 30 years, excluding room and board for private nonprofit colleges, tuition has more than doubled and public four-year colleges have increased eight-fold (College Board, 2016). All the interviewees, except for Uli, live on or near campus and do not commute from home. The average cost at both of these universities is over $50,000 a year. For half of the students interviewed, the cost of college was not a big deal, but almost all of them were concerned about graduating and being able to make enough money to support themselves and have a family.

Uli is the only student interviewed who commutes from her home in another state. Living at home is the only way she can afford to go to school; living on campus is too expensive. She is also the only interviewed student who works full-time and who tries to take mostly night classes so she can work during the day. She was originally a business and economics major in her native country of Peru because she thought that would give her the best chance at making good money. She left school and Peru after two years and came to the United States. She started working and did not go to college for a few years; when she returned to school she first enrolled at a community college and at that time decided to major in biochemistry. Uli will graduate in a few months after her interview and does not think she will go into a career in biochemistry because she believes the pay is too low. She would love to attend graduate school, but needs to make money right away and cannot afford to not work full time. She is currently looking for jobs in business, specifically businesses that hire scientists. When asked what she would do if money were not an issue, Uli responded that she would love to continue school and do research in biochemistry while pursuing a Ph.D.

Martha wanted to get away from Texas and go to school in the northeast; however, the cost of in-state versus out-of-state tuition was a difference of over $30,000 dollars a year. She and her parents decided that she needed to go to either medical or law school so she could eventually earn enough to pay back her school loans. She receives a work-study grant and has been working in a lab since freshman year. The cost of medical school will be another burden for Martha. She would like to volunteer for either the Indian Health Service or the Rural Health Service to help cover the cost of medical school.

Julia discussed growing up without a lot of money, attributing her family's low income to her parents' lack of college educations. She wanted more, and her older sister told her that she needed to go to college if she wanted a better life than their parents could provide. She believes she will not become rich as a scientist, but she'll be happy doing the work:

> I feel like a lot of scientists don't make a lot of money at all. So I'm definitely not going into it for the money and that's kind of like nerve wracking, but also like I love it so

much that it doesn't matter. And I know a lot of people who are going into consulting just because it pays a lot. But for me it's really, I just lived my whole life not being rich so I'm fine like doing what I love being the same sort of situation.

Esther did not mention any financial issues or constraints. She plans on taking a year off to travel and to research which field of astrophysics she will pursue. She has yet to decide if she wants to end up in academia or enter the private sector. She sees the private sector having greater budgets for bigger projects versus academia where budgets are usually more constrained and dependent on grants. She did not mention salary or job security. Wilma is similar to Esther in that money does not seem to be an issue and was not mentioned in her interview. However, when talking about future careers, she said she originally wanted a Ph.D., but her father convinced her get a M.D. because it should be easier to get a job and make a steady salary. She plans on applying for M.D. / Ph.D. programs after graduation next year. Andrea did not mention any financial constraints and would like to take a year or two off to work and see what she wants to do next. She's thinking of either law school or a Ph.D. in STEM.

Sexism and Gender Equity

Gender inequity exists in all walks of life; in the private sector women make around $0.79 for every dollar men make (Hill, 2016). The history of science has been one of male dominance, with only a handful of notable women scientists. This is not to say that woman have not contributed to the advancement of science, but most of the scientific discoveries up until the 20^{th} century have been credited to men. Most science majors were men for the better half of the 20^{th} century, and some labs and programs still hang on to an "old boys club" mentality. However, things have improved; more women now graduate with an undergraduate degree than men, woman earn more biology degrees than men, and the number of chemistry degrees is almost the same for both genders. On the other hand, fewer than 20% of computer science, engineering and physics majors are women (Corbett & Hill, 2015).

In this section, the women interviewed were asked if they had ever experienced gender inequity in science, both in school and outside of school. Some students vividly recalled being treated differently because they were women; others were not sure, but think they might have been treated differently. Some could not recall being treated different because they were female. None of the students recalled anything prior to middle school, but started noticing women were being treated differently than men during the remainder of their formal education for research / internships. Besides gender inequities, many of the students felt the power of gender stereotypes when it came to women in science and mathematics courses in high school. They noticed differences in the way possible careers in science were presented to women.

Starting with middle school, Martha noticed lab groups were segregated by sex, and she noted that the girls usually thought they were smarter than the boys. Andrea joined an academic competition team in middle school and originally was going to compete in language arts, but when a student said she could not do the science content area, she took that as a challenge to prove to everyone that she could do it.

Once in high school, most of the women interviewed noticed a lot more boys taking the A.P. science and mathematics courses. Students also started to see teachers treating boys differently than girls. Andrea noticed a lot of her female friends were not taking advanced science and mathematics courses because they believed they were too challenging. Julia wanted to take A.P. Physics, but there was only one other girl in the class, and she doubted her abilities and never took the class. She believed the class makeup discouraged girls from taking the class. She reflected that she wished she could have challenged the gender dynamic and asserted herself more. Martha noticed some inappropriate remarks by her biology teacher, commenting on her school attire. She explained:

> Nothing that was ever completely sexual but creepy, you know, in that kind of generation gap kind of way for a fifteen-year old, sixteen-year old girl. So that was an obstacle and sometimes it would be distracting in class for me to be concerned about him, you know, looking at me the wrong way when I was supposed to be learning. So that was an obstacle.

Martha also noticed that her male physics teacher was too friendly with the boys. She said he would get "very bro'ey with the boys," and he acted more like an older friend than a teacher, but he was and not like that towards his female students.

During their time in college, all students interviewed, with the exception of Andrea and Wilma, noticed that they were treated differently because they are women. The most awareness came from Esther within the physics department. She recalls her experiences as a student:

> The Physics Department was very much a boy's club. A lot of older men, who were the professors and the mentors, who aren't always as open to helping out female students. They're not necessarily always as accessible I feel. I feel as if the men in my classes had a better rapport with their professors than the women in those classes.

Julia noticed that the same three men in her *Animal Behavior* class were always speaking and participating in class, which she partially attributes to the makeup of the class. Julia finds it odd that most of the professors she has encountered at the all girls college are men. However, she believes the male professors treat women fairly and equally, saying "I think that male professors at my school are particularly aware of those gender dynamics [and they] are actually like proponents for it. Or proponents for like women being participatory and they don’t discriminate at all. I’ve never gotten [that] experience.”

Martha is taking most of her science courses at the coed school and she sees the men participating more than the women in class. She recalls: “In my coed classes, any time anybody ever raises their hand it’s almost always the guy.” Uli doubts herself and thinks it might just be in her heard. She discusses her experiences: “I don’t know I feel like, yeah, it is, its just maybe it’s just me. But it’s like professor tends to go more towards guys than girls. It’s not a lot but I feel, I think I encounter[ed] that a couple of times.”

Andrea questioned if being a woman played a part in her full name not being placed on a research paper that she helped publish. She was bothered that no one consulted her about the spelling of her name:

> This oversight may not have been related to gender and ultimately did not have a big impact on me personally, but other women may have wanted to add their middle name or initial to make their name more identifiable in case they decided to change their name after marriage or use an initial to avoid having their gender known/assumed, i.e. J. Smith v. Jane Smith v. Jane A. Smith v. Jane A. Smith-Jones v. Jane A. Jones v. J.A. Jones. This can be important due to the advantages of having a consistent, recognizable name over the course of one's career and due to potential gender bias in the review process or in other scientists deciding to cite that work.

Andrea recounted an ambiguous experience of gender inequity when applying to a summer research position. The post was a last-minute offering, with two positions open. She replied right away with her résumé and research experiences. She felt very confident in her qualifications. She also told one of her male friends about the position, as there were two positions open. Her friend applied two weeks later than she did and did not have any research experience. Andrea received a rejection email, and her male friend received the research position. He was shocked that he received it over her. He did not really want the position and turned it down. He even told her that he did not understand how he received the position over her. He knew she was better qualified. Right after he rejected the position, they emailed Andrea back asking her if she wanted it. Andrea questions weather this was sexism at work or not by saying: “So again, you know, I don’t know what the person who’s hiring, you know, like what influenced their decisions. But we both are like, was that sexism or not? It’s hard to know.”

Esther discussed some of her challenges acquiring her initial research opportunity. She talked about the difficulties of having no experience. She experienced the frustrating paradox of trying to land an entry-level position that requires experiences, while stressing that she was a “non-skilled woman.”

A major obstacle women and men need to overcome is the issue of treating women as sex objects and not valuing them as people. This can severely affect a woman’s work and may cause her to quit. At times, Julia has been uncomfortable in the lab when men look at her. Here she discussed how she felt: “I feel like there’s a lot of like, men looking at women in a certain way in labs and it’s like, stop. (Laughs) So there’s also that dynamic but I look into that.” Both Wilma and Martha have female research advisors and feel lucky to have them. Martha feels that her advisor is such a strong advocate for women in science and has been around for over 30 years in academia. Her advisor is constantly giving the female researchers pointers and tips on how to survive and be successful in science. Unfortunately, her advice is only a band-aide on the underlying sexism and gender inequity going on in STEM research. Instead of challenging the system, she is going along with it, allowing these behaviors to continue.

Reaction and Recognition from Others

Regardless of what people say about not listening to others and following your dreams, people's opinions and acceptance does matter to us and their approval, though often not needed, can be very helpful. Some of the students had no negative feedback or issues with their friends or people within their majors, some had positive experiences, but others encountered some obstacles that could have easily dissuaded them from continuing on in science. There is some overlap between friends, colleges and authorities within the scientific community. Because many students are segregated into classes based on achievement and majors, they see each other often and end up as friends.

The only student to experience something negative from a fellow student was Andrea. When she was in 6th grade she was thinking about what competition to participate in an academic league. When she asked what was the most interesting topic to pursue, a student chimed in and said the science one was too hard for her. Instead of backing away, Andrea stepped up to the challenge and found a love of science. Andrea and Wilma's friends and peers in high school perceived to be science too hard or challenging and backed away from it. Uli and Julia have friends from back home and outside of school who were shocked that they ended up as science majors. Esther noted that most of her friends from high school went on to be science majors.

Discussion

In this study, six female science majors shared their experiences growing up and becoming STEM majors. The many themes include the influences of experiences during formal education in middle and high school, informal education during middle and high school, family influence and support, mentors and role models, financial constraints and careers, internships and research, and sexism and gender equity. The nuances of their individual experiences highlighted their persistence in science, while certain patterns and commonalities began to appear that helped shape their science identities.

Starting with their experiences in formal education during middle and high school, the students seemed to enjoy certain aspects of science education and disliked others. They all thought that learning concepts and memorizing facts was not stimulating or exciting. Most students said that their most memorable science learning moments were hands-on lab activities, especially dissections. They also found a closer relationship with science when they were able to make personal connections to things they learned. A majority of students favor hands-on activities, and when the material is relatable, girls show an increase in success when performing such activities (AAUW, 2009; Baker, 2013; Hill, Corbett, & St. Rose, 2010). Even though all of the students were able to recall a memorable activity that sparked their interest in science during school, four out of six of the students had an overall negative view of their formal schooling. They felt that their school was not a top-performing school.

Implications

For many people entering a major or field, acceptance by the establishment is crucial in setting up one's career. In STEM, acceptance can come from professors, research advisors, internships and mentors. Even though science is a constantly evolving field with an ethos of new discoveries, some of the practices and behaviors of scientists have limited the expansion and acceptance of new ideas that may conflict with old practices and traditions. Many famous scientists, like Galileo, Ptolemy, Democritus, Tesla, and Mendel, were once ostracized or ridiculed because their ideas were too radical or contradicted current wisdom and belief. Science has been a male-dominated institution for over a thousand years; the acceptance of female scientists has been slowly, but steadily, increasing over the last 100 years. More women now graduate with degrees in biology than men, and chemistry degrees are almost equal between men and women. However, subjects like physics, engineering, and computer science are still way behind in the number of women to men graduates (Corbett & Hill, 2015).

A majority of the female STEM participants had a teacher that they liked and who helped foster a love for science. These teachers went out of their way to help students and explain concepts, made positive comments, and encouraged the further pursuit of science. Some students discussed not taking certain advance placement classes because they were not aware of them, did not know anyone taking the class, or the class seemed like it was more for boys than girls. Teachers and guidance counselors can play an important role in encouraging students to take more science classes and advance placement mathematics, physics and computer science classes that are underrepresented by female high school students. A survey conducted by Google (2014) found that a factor most likely to encourage girls' interest in computer science was encouragement by educators as well as family and friends. Individuals, such as teachers and guidance counselors who effectively monitor their students ,can create a better environment for students (Valla & Williams, 2012).

Besides the formal science education that takes place in schools, an important source of science learning is the informal science education that is taken up by individuals and their parents or guardians. Informal science education is not always free and available to everyone. If one includes going to the public library and reading science books on one's own as a source of informal science education, then five out of six students received informal science education. Some students went to prestigious science camps far from home, while two students learned from science experts. Other experiences, such as volunteering in a hospital and learning from doctors and nurses, learning science as part of an after school day care program, and spending free time reading books about science, are all ways the female STEM majors interacted with science outside the formal school setting. All the students enjoyed their informal experiences, but the amount of science they learned from those experiences varied.

Most college STEM majors have to partake in some research for credit as a graduation requirement. The research can be in a lab setting or can be solely literature based. Five of the six students have partaken in lab-based research, and all of them have walked away with positive experiences. All but one of them continued on with their research after they earned their credit. The research and intern positions allowed them to not only apply what they have learned, but learn new things that were never taught in class. The students believed their research helped them prepare for graduate school and gave them a better chance of getting into a top medical school.

All interviewees discussed the lack of money in their STEM fields; they all said that if money were not an issue, they would be perfectly happy working full-time in a lab. Because of financial considerations, some students are thinking about careers outside of science, like law and business. They believe that the skills and knowledge they learned in science can be applied to their new careers. The students who want to go to medical school see a medical career as a financially lucrative one, with excellent job security when compared to research scientists.

Aspects of Science Identity Development

A majority of the interviewees said that their interest in science, their personal quest to explore and understand the world, began at an early age. They were fascinated by the ability of science to predict events around them, allow them to learn more about their own bodies, and learn about their environmental surroundings. Besides their own persistence to learn, they all had someone in their lives that helped them, mentored them, and gave them confidence to move forward in their science education. They credited their parents, grandparent, teachers, research advisors, and mentors — who were also role models — in supporting their choice of STEM majors and careers. Creating early exposure to science for young women may help spark their interests in science (Corbett & Hill, 2015). Valla and Williams (2012) discuss how introducing STEM early on during middle and elementary school can improve gender diversity in those fields.

The interviewees reveled that an important part of their science identity is the social value of science and the opportunities it affords for communal interactions. One salient reason for liking science was its ability to help others. All the students wanted to make the world a better place to live, from solving brain cancer, curing diseases, discovering new medicines, and uncovering distant planets. Carlone and Johnson (2007) discuss the importance of altruistic science identities and science as being a "vehicle for altruism" for women. Relating science to young women can help them make a personal connection to science, which can increase their interest in science (Baker, 2012; Brotman & Moore, 2008).

Sexism and Gender Equity Experiences

When students were asked about their general experiences being a female science major, some responded with disturbing examples of gender inequity and sexism without being specifically prompted to mention such episodes. However, after being asked specifically to mention episodes of gender discrimination, all interviewees responded with at least one negative incident. For example, one student did not receive a research position that was first offered to a less qualified male friend, leading her to question if this was an example of gender discrimination. Other students pointed out that most of their professors were men, that men were treated differently in class, that their male peers seem to have an easier time acquiring a research position, and that male students had better relationships with their male professors. Interviewees noticed that the further they progressed in their schooling the more predominate gender inequity became. This could be from having a greater awareness of gender, or as we get older, gender equity starts to decline. Both young boys and girls should be taught about gender discrimination at a young age and throughout their formal education. Education makes it easier to identify instances of gender discrimination and can assuage feelings of uncertainty as to whether certain behavior is discriminatory or not. Education can also help male students empathize and see things from a different perspective.

The last, and most interesting, finding was that veteran female research professors have had to modify the way they behave and present themselves in order to garner respect from their male peers, as opposed to earning respect for their accomplishments or scientific research. Female scientists modify their behavior for the sole reason of being taken seriously by their male colleagues. It is unfortunate that the advice from the veteran female research professors, which is good-hearted, is perpetuated down to the next generation of scientists. Women should not have to cater to men's needs in order to be taken seriously. Advocacy for women in science by women in science is needed. The amount of women professors and women in STEM careers is even lower than the number of degrees earned by women in those fields (Corbett & Hill, 2015). This is significant because the recruitment and retention of women in STEM majors and careers can be positively influenced with female role models (Durry, Siy, & Cheryan, 2011).

Conclusion

Throughout the analysis and coding of the interviews, strong links appeared between numerous categories, many of which have been discussed in the literature. According to Hill, Corbett, and St. Rose (2010), women tend to hold themselves to a higher standard than their male counterparts, which results in a lower self-efficacy. Self-efficacy had the lowest average out of all five components of science motivation, and one student mentioned that she was not sure she was smart enough to be accepted into medical school. Even though the interviewees scored the lowest on self-efficacy, they were not deterred in their pursuit of success. Their self-determination and career motivation averages were much higher.

All the interviewees showed a strong communal and social value connection to science and society. Scientists are often seen as stoic recluses, while careers in science do not seem to foster social and communal values. If the STEM work environment can display more emotional, cultural and social values, it may be more attractive to women (Brotman & Moore, 2008). Many of the interviewees see volunteering, in addition to working in STEM, as a way to satiate those needs for community involvement.

As there are fewer women in STEM, there must be more men, and these men make up a majority of the science professors at college and most of the management positions at STEM companies. One would like to believe the age of discrimination based on gender is behind us, especially in universities and within STEM careers, but all the interviewed students noticed some of their male professors treating female students differently. The strongest complaint was in the physics department, labeled “the old boys’ club.” Of all the STEM fields, Physics has one of the lowest levels of representation by women, with engineering following close behind. Both degrees require extensive physics courses. The persistence of this “old boys’ club” attitude and behavior could easily deter women from getting degrees within these fields. This discrimination can also be felt outside of the classroom when students apply for research positions and internships while still in school.

These women have accomplished something they all should be proud of: they were accepted into highly selective universities, made it past their first three years, and either just graduated or are about to graduate with a degree in STEM. However, one-third of the students have expressed desires to not enter STEM careers, among them the student with the lowest science motivation score. Statistically, almost half of the four remaining women will leave STEM careers (Corbett and Hill, 2015). Those numbers should be unsettling and demonstrate how much further we still need to go to achieve gender equity in STEM education and careers.

CHAPTER VI

SIGNIFIGANCE OF RESEACH AND CONCLUSIONS

Summary of Major Findings

The purpose of this study was to uncover the lived experiences of junior and senior undergraduate female science majors during their formal and informal education, their science motivation to learn science, their science identities, and any experiences in gender inequity they may have encountered. The research questions for this study ask:

1. What captivates and motivates female students' interest in science or STEM? What are experiences that nurture and facilitate their growth and interest in science or STEM throughout primary school, secondary school, and college?
2. What experiences, both formal and informal education, have guided their choice or selection of a science or STEM major in college?
3. How do female science or STEM majors discuss their experiences of gender equity as science majors?

Motivation and Interest to Learn Science

When I first proposed my research, my goal was to try to increase interest in science, women majors in science, and careers in science for women. There are a variety of reasons people will give as to why they like or dislike something, but to truly understand their motivations, one needs to unlock a deeper comprehension of the individual's journey that facilitated the development of their science identities. All these female STEM majors seemed to show a desire from an early age to understand how the universe works and unlock its mysteries. The female STEM participants had both positive and negative formal and informal science educational experiences, with some having to overcome larger hurdles than others. During the course of their educations, the interviewees' career motivation changed. Andrea, Uli, and Julia have graduated in the spring of 2016 and the Esther, Martha and Wilma are entering their last year as female undergraduate STEM majors.

In order to obtain a basic background from junior and senior science majors, two surveys were given, one the Science Motivation Questionnaire II© to assess science motivation and the Science Background and Equity Questionnaire to gauge experiences as well as views on gender equity in science. All the students' science motivation scores ranged from *sometimes to often* and *often to always* meaning that their motivation for science was high. However, their self-efficacy score was the lowest. The second survey asked female STEM majors if they felt any gender inequity during primary and secondary schooling and then again in college. Students seemed to experience and perceive a much greater amount of gender inequity once they entered college.

The open response questions followed the two surveys asking the students to go into more detail or further explain any of their questionnaire choices. From the responses, the STEM majors who left their email address and said it was ok to follow-up with possible interview questions were eventually contacted. Out of the ten students contacted, six replied and agreed to an interview session. It was during these interviews that the lived experiences of the students began to unfold. Light was shed on their science identities, exposing a variety of paths through both formal and informal experiences that guided them to becoming STEM majors.

Some students, such as Wilma, Esther and Martha, had very extensive informal experiences. Wilma and Esther went to science summer camps and attended science after-school programs, while Wendy and Martha had their parents, who are in STEM fields, teach them about science. Others female STEM majors, like Uli and Julia, barely had any informal science learning experiences. Esther and Andrea expressed great admiration and appreciation for one or more of their formal science teachers, while Martha and Julia expressed displeasure. Support from family and friends were universal, but the degree in intensity and involvement varied tremendously. Financial burdens and job security produced a contrasting reasoning for STEM careers that pushed Uli away from a STEM career and Julia and Wendy towards a STEM career. Both mentors and role models had positive impacts on the interviewees' decision to enter STEM majors and persist in STEM careers. All students felt a desire to help and work with others in some capacity, either through their work directly or on a voluntary basis outside their future careers. Subtle to strong gender inequity experiences reverberated throughout the interviews, with some students much more outspoken than others. Within this small window I was allowed to peek into their lives, and their science identities began to take shape from an early age all the way through to their college education.

Discussion and Implications

An accumulation of the data presents connections between students' science identities and motivations. Their science identities were cultivated by a combination of informal and formal science learning experiences, the location and environment the students grew up in, and all the people they encountered along the way. The pedagogical skills of many of their teachers left positive and lasting memories that helped shape their science identities. Motivation in science has both waxed and waned throughout their lives. Both their grade and career motivational goals have helped them acquire the attributes needed to become junior and senior STEM majors at two highly selective universities.

Informal science education has been well documented to facilitate interest in science as well as further scientific knowledge (Barton & Brickhouse, 2006; Committee on Learning Science in Informal Environments, 2009; Munley & Rossiter, 2013; National Research Council Report, 2009; National Science Foundation, 2001). Students interviewed had a variety of different informal experiences that shaped their perceptions of science. Financial constraints, parental knowledge, and formal educational assistance were key factors in the availability and access to informal science opportunities.

The desire for social and communal interactions was a salient theme in the interviews. Esther, Julia, and Martha all volunteer within their community to inform and inspire future generations of young boys and girls to love, appreciate and understand science. Early exposure to science is an important factor in encouraging more young girls to become interested in science (Valla & Williams, 2012). During high school Julia and Uli seemed unaware of the diverse careers that a STEM degree can lead to, and career motivation ranked the highest for all 32 female STEM participants. A feeling of uncertainty by the female STEM participant when attempting to identify gender discrimination and sexism was an unexpected discovery. Positive role models, where available, created an environment of increased motivation, vicarious experiences, and science identity.

The implications for this research cover a broad spectrum that benefits both the individual and society as a whole. In today's labor market, well-paying jobs are on the decline, while the need for highly skilled workers is rising. Careers in STEM create one of the most lucrative opportunities for students coming out of college. A common catch phrase used by the tech industry is "making the world a better place," along with buzzwords like "innovation," "life-changing," and "artificial intelligence." In order to turn these visions into realities, highly educated scientists are in demand. Unfortunately, over 70% of the STEM workforce is made up of men. This can limit innovation with products not addressing the needs and desires of women (Hill, Corbett, & St. Rose, 2010). By creating more women scientists, we can create better paying jobs for them as well as making sure products designed for women meet their wishes and requirements. Science is not the panacea for all the world's problems. Many scientists strive for a better understanding of the world with altruistic intentions. However, as history has shown us, many good intentions may have devastatingly bad unintentional results, which could be the results of a lack of diversity and cultural understandings (Pelto, 1987; Jasanoff, 2003). Having greater diversity in STEM may help the various needs of different cultures and genders.

All the female STEM participants interviewed had an interest in science from a very young age. Science can seem like magic to some and the notion of giant creatures called dinosaurs that once roamed the Earth opens up countless imaginative ideas. However, adolescent girls show much less interest than boys do in science (Turner, Conkel, Starkey, Landgraf, Lapan, Siewert, Reich, Trotter, Neumaier, & Huang, 2008). Some commonalities among the interviewed students that resonated with the work in the literature review — and which could have profound implications, — including the importance of great teachers, informal learning experiences, supportive family members, positive role models or mentors, the social and communal aspect of STEM, and the ability to explore and see nature.

When boys enter college, they usually arrive with more formal and informal science-learning experience than girls. Boys take a higher number of AP STEM-related exams like calculus, chemistry, computer science, and physics (Hill, Corbett, & St. Rose, 2010), while boys arrive in school with a much more out-of-school learning experience in science than girls (Flinders & Thorton, 2004). According to Hill, Corbett, and St. Rose (2010) freshman women may notice that many of their male counterparts in their science classes seem to be more prepared and have a larger knowledge of the subject. This may be a cause for a perceived disadvantage and lower self-efficacy in. Besides affecting the self-efficacy of the women in the class, the professors of STEM, who statistically are mostly male, may assume that the men are more eager and interested than the women in science. The National Science Foundation (2001) discusses how informal science education can increase opportunities in science for underrepresented young women.

Many colleges have been implementing mentor programs and research opportunities for their students in various degrees. The most common program makes student perform at least one semester of research. Esther discussed the difficulties of landing her first research position because many of the positions wanted someone with experience. This was frustrating to her — if you need experience to get experience, what do you do? As an example, universities like Harvey Mudd College provide women research opportunities right after completion of their first year. Having more opportunities or programs that mandate scientific research for STEM majors, while providing them with guaranteed opportunities, should be a major concern addressed by all universities. In addition, a greater advocacy for women in science by women in science can increase mentorships, which has an overall positive impact on retaining women in STEM.

Martha and Julia described their research advisor as both a mentor and role model. Although mentors and role models are available, their numbers and availability is limited. According to the National Science Foundation (2009), the number of female STEM faculty members at four-year educational institutions are 24% engineering, 35% physics, 23% computer science, and 64% biological, agricultural, and environmental life science, with nearly twice as many non-tenured to tenured female STEM faculty. The pressure on non-tenured faculty to publish research may out-weigh the desire to mentor students. For example, one of my high school female students told me that the program she enrolled in provides young women with assigned mentors. However, because the mentor had so many students, my student's interaction with her mentor was scarce at most and she eventually gave up trying to contact her. Many private sector companies already provide mentorships and intern research positions to college students, but when their employees work over 60 hours a week, it leaves little time to mentor other people in an effective capacity. Some companies dislike the idea of spending weeks training someone and then have them leave after a semester. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) offer funding and summer programs for women and other underrepresented groups pursuing science (Rosa & Mensah, 2016). Teachers and guidance counselors need to make female students aware of these funding opportunities for young women who want to major in STEM.

Besides focusing on young women, the implication of teacher education and professional training cannot be overlooked. Teachers at all levels need to be aware of what a gender equitable curriculum should entail in order to address the needs of all the genders within the classroom. Students, both boys and girls, should be taught how to recognize sexism and gender discrimination from an early age. Teachers can make students more aware of the various careers within science, while discussing the social and communal aspects as well. This should be incorporated into all levels of education, from primary, secondary, undergraduate, and graduate classes. Teachers need to educate their fellow teachers and address any biases and discriminatory actions they see. Teacher learning should occur at all levels, from preservice teaching, professional development, professional learning communities (PLCs), and faculty in-service.

There was no gender-equity specific science education course in my graduate school. Not only should this course be offered, but it should also be part of one's required classes.

Future Research

The purpose of this study was to uncover the lived experiences of junior and senior undergraduate female science majors during their formal and informal education, their science motivation to learn science, their science identities, and any experiences in gender inequity they may have encountered. Using the lived experiences of women science majors, I uncovered the real life stories of six women from when they first started to love science, and the events they encountered that helped propel them into science or STEM majors.

Low self-efficacy was a glaring issue with the young female STEM majors in this study as well as ones from Glynn et al. (2009) and the AAUW's report *Why so Few* by Hill et al. (2010). It would be worth further investigation to compare the self-efficacy of female STEM majors who have participated in research with female advisors and mentors against female STEM majors who had male advisors and mentors for the same duration of time using the Science Motivation Questionnaire II© to see the extent of vicarious experiences, mentors and role models on self-efficacy. There may be an underlining factor that has yet to come to light causing young female STEM majors to have a substantially lower self-efficacy in science motivation compared to their male counterparts.

From the ages of five to eighteen, children spend around 18.5% of their waking hours in a formal educational setting (National Science Foundation, 2011). Since this time is so limited, a greater effort is needed to insure a positive and fulfilling formal science learning experience. Currently 32 states across the country allow for a computer science class to count toward high school graduation, but no state specifies computer science as a graduation requirement (Code.org, 2016). Only 40% of schools in the entire US offer computer science as a course. New York City announced in September 2015 that within ten years, all of its city's public schools must offer computer science to all its students. There are no specific plans available on whether or not it will be a graduation requirement and what type of computer science courses they will offer. Advanced placement (AP) computer science class has the greatest gender gap compared to all other AP courses. Many colleges are switching over to Python® computer language due to its more user-friendly learning experience, but still many high school do not teach it. According to Code.org (2016), women who try computer science in high school are ten times more likely to major in it in college. More research should be done that examines the number of women coming out of these states that take computer science and then major in computer science versus the number of women that do not take a computer science class. There are financial constraints because students will need continuous access to computers as well as have Internet access. My high school I teach at, recently gave brand new laptops to all their students; those students who met financial requirements received free Internet access that could only be used on the school's laptop.

Future research can focus on a longitudinal study of the percentage of girls that have access to informal science learning experiences and end up majoring in science compared with girls that do not have such access. As not informal science learning experiences are equal, it should be a goal of researchers to isolate and replicate the informal science learning experiences that produce more young women majoring in STEM. Researchers should interview exiting students from informal science learning environments and find out what they liked the best and least about their experiences. Informal learning centers also need to make students aware of the vast career opportunities in STEM as well as the communal and social aspects of those careers.

Many programs, like Johns Hopkins' Center for Talented Youth (CTY), allow students to sign up for one specific course for four intense weeks, seven days a week with five hours of lecture and three hours of lab, without the opportunity to explore other subject areas. With that amount of intensity for students' aged 12-17, the program has the ability to cover a wider range of subject areas, and to expose students to a greater diversity of STEM fields.

A number of women leave science majors for various reasons, and a study should be done on the retention rate of students who have research positions early on in college and ones that do not in order to see if there is any relationship that could help lead to more women remaining in science majors. Having to choose between a family and a career has been a constant burden plaguing women since they entered the workforce. Careers in STEM, especially technology fields like engineering and computer science, require employees to work well over 40 hours a week, leaving little time to raise and spend time with a family. Recently, some large companies like Amazon have announced longer maternity leaves with the hope of attracting more women. A study on STEM career retention rate when compared to maternity leave length and work hours per week could help illuminate the need for government-mandated paid maternity leave.

At the high school level, there are more limited research opportunities and mentorships available, and even though local universities try and provide opportunities for high school students, their time and numbers are reduced. Research on the effects and availability of mentoring and science research for high school students should be further explored. These opportunities may be available, but the students may never find out about them. If students or their parents are not actively looking for these opportunities, then it is up to the teachers and the school to raise awareness about their availability. As a science teacher I occasionally receive emails from my supervisor about research and mentoring programs for students, but some of them get lost in the email and there is no accountability or mandate that teachers must tell their students.

Conclusion

The gender gap is real in STEM careers. This study explores why some women succeed as science majors by peering into the lived experiences of women going through both formal and informal science learning experiences, looking at events and circumstances that made them decide to major in science. The importance of understanding how a curriculum designed by men may affect how women learn science and the social and communal opportunities that a science career may offer can help attract and retain more women in STEM. A focus on both informal and formal science learning opportunities and experiences needs to address gaps in gender equity. The "old boys' club" still exists in certain science departments and careers and this needs to come to an end. Women should feel welcome and safe at school and on the job. This study attempts to compliment, reinforce, and extend the work done by the AAUW, NSF and the other countless authors and researchers dedicating their careers to promoting gender equity in science with the hope of women having a greater representation in the STEM work force. In order to accomplish this goal, the lived experiences of women in both STEM careers and STEM majors are important resources that need to be explored, evaluated, and replicated. Interest in science starts at a young age, and more resources need to be made available to support and cultivate that desire.

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APPENDIX A

Gender Equity in Science Questionnaire

and

Science Motivation Questionnaire II

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000
www.tc.edu

Recruitment Materials for Student's Motivation to participate in Science

IRB Protocol # XX

My name is Philip Adornato and I am a doctoral student at Teachers College. My research involves the lived experiences of women majoring in science, technology, engineering and mathematics (STEM). I am attempting to gain further insight on the factors from both within and outside of formal education that motivate, sculpt and inspire women to major in STEM majors. This research involves women STEM majors taking a five to ten-minute survey with the possibility of a 45-minute interview, depending on your responses to the survey. Those who partake in the survey will be entered into a raffle to win a $25 Amazon gift card. My goal is to shed additional light on reasons why women major in STEM with the hope of inspiring more women to major in STEM as well as enter into careers in STEM. All the names of students and the University will be changed and your identity will remain anonymous.

About me: I have been teaching high school biology and chemistry for fifteen years, and I worked in a biotech research lab for two years prior to teaching. I received a masters' degree from Rutgers University in molecular and microbiology. I have been working on my doctorate at Teachers College, Columbia University for the last five years, focusing on gender equity in science education. My goals are to further understand why women choose to major in STEM and their lived experienced that led them to their current position with the hope of increasing greater female participation in STEM, and to create an environment that allows men and women to work together comfortably and happily in a STEM career. More women in STEM careers can lead to greater advancements in science (because we would have more intelligent people doing research, instead of only half the population), better paying jobs, and a more equitable workforce.

This study has been approved by Teachers College, Columbia University Institutional Review Board. If you have any questions, feel free to contact me, Philip Adornato at pa2290@tc.columbia.edu. My dissertation sponsor is Dr. Felicia Moore Mensah at fm2140@tc.columbia.edu.

Women In STEM Majors Survey

Q1 Please list your age.
Less than 17 (1)
17 (2)
18 (3)
19 (4)
20 (5)
21 (6)
22+ (7)

Q2 What is your major?
Biology / Micro or Molecular biology / Biotechnology / Genetics (1)
Chemistry / Biochemistry (2)
Engineering (all types) (3)
Computer Science (4)
Physics / Astrophysics (5)
Math (6)
Other (7)

Q13 Currently, what year are you in?
Freshman (1)
Sophmore (2)
Junior (3)
Senior (4)

Q3 I am majoring in science because:

Q4 My Minor is:

Q5 The first set of questions are about your prior experiences in science during middle and high school. Please answer to the best of your knowledge.

	Never (1)	Rarely (2)	Sometimes (3)	Usually (4)	Always (5)
You knew from middle school you wanted to major in science. (1)	❍	❍	❍	❍	❍
You knew from high school you wanted to major in science. (2)	❍	❍	❍	❍	❍
You plan on pursuing a career in science upon graduation. (3)	❍	❍	❍	❍	❍
You feel like you had an equal opportunity in high school to participate in science. (4)	❍	❍	❍	❍	❍
You feel like men and women were treated equally in a science classroom. (5)	❍	❍	❍	❍	❍
Your science teachers were very supportive of your interests in science. (6)	❍	❍	❍	❍	❍
Your family was supportive of your interests in science. (7)	❍	❍	❍	❍	❍
Your high school teacher / teachers inspired you to major in science. (8)	❍	❍	❍	❍	❍
Your male friends supported your interests in science. (9)	❍	❍	❍	❍	❍
Your female friends supported your interests in science. (10)	❍	❍	❍	❍	❍

Science teachers in high school treated men and women equally. (11)	❍	❍	❍	❍	❍

Q6 Comments: You may respond to any of the questions above that you feel need further clarification or an explanation.

Q7 Your college experiences as a STEM major.

	Never (1)	Rarely (2)	Sometimes (3)	Usually (4)	Always (5)
You feel like women and men have equal opportunities for careers in science. (1)	❍	❍	❍	❍	❍
You feel women have to work harder to succeed in science or STEM fields. (2)	❍	❍	❍	❍	❍
You feel women are discouraged from entering careers in science or STEM fields. (3)	❍	❍	❍	❍	❍
Your male professors treat men and women equally. (4)	❍	❍	❍	❍	❍
Your female professors treat men and women equally. (5)	❍	❍	❍	❍	❍
Female science majors encounter greater hardships than males science majors. (6)	❍	❍	❍	❍	❍
You lack support from your female friends with your choice of a science major. (7)	❍	❍	❍	❍	❍

You lack support from your male friends with your choice of a science major. (8)	❍	❍	❍	❍	❍
You lack adequate time to socialize with your friends. (9)	❍	❍	❍	❍	❍

Q10 Comments: You may respond to any of the questions above that you feel need further clarification or an explanation.

Q12 In order to better understand what you think and how you feel about your college science courses, please respond to each of the following statements from the perspective of ''When I am in a college science course. . .''

	Never (1)	Rarely (2)	Sometimes (3)	Usually (4)	Always (5)
The science I learn is relevant to my life (1)	❍	❍	❍	❍	❍
I like to do better than other students on science tests (2)	❍	❍	❍	❍	❍
Learning science is interesting (3)	❍	❍	❍	❍	❍
Getting a good science grade is important to me (4)	❍	❍	❍	❍	❍
I put enough effort into learning science (5)	❍	❍	❍	❍	❍
I use strategies to learn science well (6)	❍	❍	❍	❍	❍
Learning science will help me get a good job (7)	❍	❍	❍	❍	❍
It is important that I get an ''A'' in science (8)	❍	❍	❍	❍	❍
I am confident I will do well on science tests (9)	❍	❍	❍	❍	❍
Knowing science will give	❍	❍	❍	❍	❍

me a career advantage (10)					
I spend a lot of time learning science (11)	❍	❍	❍	❍	❍
Learning science makes my life more meaningful (12)	❍	❍	❍	❍	❍
Understanding science will benefit me in my career (13)	❍	❍	❍	❍	❍
I am confident I will do well on science labs and projects (14)	❍	❍	❍	❍	❍
I believe I can master science knowledge and skills (15)	❍	❍	❍	❍	❍
I prepare well for science tests and labs (16)	❍	❍	❍	❍	❍
I am curious about discoveries in science (17)	❍	❍	❍	❍	❍
I believe I can earn a grade of ‘‘A’’ in science (18)	❍	❍	❍	❍	❍
I enjoy learning science (19)	❍	❍	❍	❍	❍
I think about the grade I will get in science (20)	❍	❍	❍	❍	❍
I am sure I can understand science (21)	❍	❍	❍	❍	❍
I study hard to learn science (22)	❍	❍	❍	❍	❍
My career will involve science (23)	❍	❍	❍	❍	❍
Scoring high on science tests and labs matters to me (24)	❍	❍	❍	❍	❍

I will use science problem-solving skills in my career (25)	❍	❍	❍	❍	❍

Q12 If you are willing to answer some follow up questions regarding your response, please leave your email address. Your name and email address will be anonymous in my dissertation and nothing will be traced back to you. Also by entering your email address, you will be entered into a drawing for a $25 Amazon gift card.

APPENDIX B

Interview Protocol

Interview Protocol:

Time of interview: 12pm EST

Date: 3/30/2016

Place: Google hangouts (between England and USA)

Interviewer: Philip Adornato

Interviewee: Erin Flowers

Position of the interviewee: Student

Brief Description of the Project: I am looking at reasons why women major in STEM to see if we can come up with more ways of getting women to major in STEM and enter STEM careers because there are very few women in STEM. I've been an active propionate of equity, doing my best to push for it and challenge the status quo. Never accepting "that's the way it always has been" type attitude and response.

Interview Questions:

Intro: basic background to build a rapport with the interviewee

1. Could you please tell me your full name?
2. Tell me about yourself?
    a. Where did you grow up?
    b. Do you have siblings?
    c. What do you do for fun or relaxation?
    d. Currently, what do you do outside of school that relates to science?

Body: slowly easing into the tougher questions

3. Have you always enjoyed science? Why?
4. What is it about science that sparks your interests?

a. Any specific moment that you can recall?

5. When did you realize that you wanted to major in science?
6. Were there things outside of school that you did that were science related?
7. How did your family influence your science education early on?
8. Can you recall any moments during your schooling that stood out in regards to science?
   a. What was science like for you during elementary, middle, and/or high school?
9. Could you tell me of certain time during high school that you felt like it was harder for you as a woman to be interested in science? Any obstacle or specific events?
10. What about now, during college?
11. Do you have any examples of your friends disapproving or making fun of your love of science?
    a. Was this from both boys and girls or more of one than the other?
    b. Why do you think this was the case?
12. Do you feel it is / was more challenging for a female to get involved and major in science?
13. Has your science program been supportive of you as a science major? In what ways, yes or no?
14. Do you think majoring in science has affected your social life? In what ways, yes or no?
15. What are your future goals as a science major/ or career in science?
16. Is there something that you would like to add or ask me?

Follow up Interview Questions:

1. Could you go into any of your research experiences during college? Did anything stand out? Were there any gender dynamics in the lab? Did you have and research advisors that stood out or acted as role models? Was it easy or hard to get into research at college?
2. Did any of your professors or research advisors act as a mentor or role model for you?
3. Has having a family or becoming a mother influenced your future career in STEM?
4. Do you identified as cis-females (born genetically female) or trans-female (born genetically male and now identify as female)? If you feel uncomfortable or rather not share, please let me know. You do not have to answer this question.
5. If it's not too much trouble, could you please let me know how your race / ethnicity? If you feel uncomfortable or rather not share, please let me know. You do not have to answer this question.

APPENDEX C

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000
www.tc.edu

INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: The goal of this project is to look at the factors that led women to major in science, technology, engineering and mathematics (STEM) and the lived experiences they had going through both formal and informal education.

The amount of men majoring in science, technology, engineering, and math (STEM) is almost double that of women majoring in STEM (National Science Foundation, 2009). Since women make up approximately half the population in The United States, more of them should be encouraged to enter a career in STEM. Women can also provide new insight and differing perspectives, which can accelerate innovations; "When women are not well represented in these fields, everyone misses out on the novel solutions that diverse participation brings" (Hill & Corbett, 2015, p. 10). This study may help understand why women enter the science fields, and can provide educators with insight that can inspire more young women to consider science as a major, a profession, and a career.

Students will be given a survey of thirty questions about their formal and informal education in science, their support or lack for their interest in science from their parents, teachers and peers. From the surveys, students may be called on for an in depth 30-40 minute interviews. Not all students that take the survey will be asked to interview, and only students 18 and over will be allowed to participate in the survey and interview. Only 8 of the students will be asked to interview based on their responses to the survey. Interviews will also be recorded and given from a selection of eight students from the survey. Participants will be asked more in depth questions about their childhood in regards to what influenced them into majoring in science, their struggles and obstacles they may have encountered on their way into becoming a STEM major in college as well as any struggles or challenges they continue to face during college. All recordings will be will be locked in a secure drawer in the investigator's home, and after seven years they will be destroyed after the completion of the study and participants names will be changed as well as the name of the university they attend. Philip Adornato will be conducting the research for his Ph.D. dissertation at Teachers College, Columbia University under the Science and Education department.

The interviews conducted provide a voice for women within the science, technology, engineer and math. It gives researchers a lens into how these programs affect students' and their lives. There will be eight semi-structured one-on-one interviews. Each one will last between 30-45 minutes. Students will also be asked if they can be contacted in the future for clarifications and possible follow-up questions. The interviews will be face-to-face in a natural setting in a quiet room in the library at the university. The interviews focus on themes and experiences: (a) the experiences these women has as children growing up that influenced them into majors in STEM, (b) the informal science learning these women had growing up though their current state, (c) the support they had from family members, teachers, and friends about their interests in STEM, (d) the opportunities and equity they may not have had, and (e) the resistance and isolation they may have felt by liking science because they are women. See Appendix 3.1 for the Interview Protocol.

The surveys used in the proposal are part of a Likert scale that fit into the categories of both position or stance and sentiment and attitude (Anderson, 2011). The Likert scale follows the three main guidelines presented by Anderson: (1) Each scale should be based on a conceptually defined dimension that you want to assess and should be related to your research question and specifies the focus or theme of the items in the Likert scale, (2) The number of options provided on the Likert scale should be considered in light of the respondents' attention capacity and the appropriate number to quantify the results, (3) Careful attention should be given to the wording of each option to ensure that it is clear to the respondent depending on the age, experience, etc. and that the options are consistent with respect to emotional or cognitive focus of the dimension that is being assessed. After data is collected, relationships and patterns will be established, while calculating the mean and standard deviation.

The survey is divided up into three main parts: (1) questions about prior experiences in science during middle and high school, (2) questions about women in STEM majors, (3) questions from the Science Motivation II survey. Some examples of the questions included asking students about their informal experiences with science growing up, to see if they felt and were treated differently as a female student interested in science by their friends, family and peers. An introduction section asks the students what their age is, their major, minor and why they chose to major in STEM. A comment section was added after each of the three sections of the survey, allowing students to expand on any of their responses. When students complete their survey, they will be asked to include their email and phone contact information for possible follow-up questions and if they would be interested in a one-on-one interview.

The data collection will take place within a female STEM program at a large public university in the Northeast United States.

<u>RISKS AND BENEFITS</u>: The risks with this study are small and there will be no physical interactions that can cause harm, however certain emotions and feelings about sexual discrimination in science education may cause distress. There are no direct benefits for the participants in this study.

<u>PAYMENTS</u>: Each interviewee will receive a twenty dollar Amazon® gift card and the survey participants will enter a raffle for a chance to win one twenty dollar gift card from Amazon®

<u>DATA STORAGE TO PROTECT CONFIDENTIALITY</u>: All data will be coded and stored on a secure password protected hard drive locked in the interview's desk at his home. The data will only be used for the purpose of this dissertation and destroyed after 7 years.

TIME INVOLVEMENT: 8 Students will be Interviewed and will spend two 45 min sessions each, while the people taking the survey will take between 10-20 minutes.

HOW WILL RESULTS BE USED:

The results of the study will be used for my dissertation. They will also be used in either a publication or presented at a professional meeting.

Teachers College, Columbia University
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PARTICIPANT'S RIGHTS

Principal Investigator: Philip Adornato

Research Title: "UNCOVERING THE LIVED EXPERIENCES OF JUNIOR AND SENIOR UNDERGRADUATE FEMALE SCIENCE MAJORS".

- I have read and discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at his/her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's phone number is (732)322-0937
- If at any time I have comments, or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.
- I should receive a copy of the Research Description and this Participant's Rights document.
- If video and/or audio taping is part of this research, consent is required. I ( ) consent to be audio/video taped. I ( ) do NOT consent to being video/audio taped and will not participate in the interview process of this study. Only the principal investigator and members of the research team will view the written, video and/or audio taped materials.
- Written, video and/or audio taped materials ( ) may be viewed in an educational setting outside the research

( ) may NOT be viewed in an educational setting outside the research.

- My signature means that I agree to participate in this study.

Participant's signature: ________________________________ Date:____/____/____

Name: ________________________________

If necessary:

Guardian's Signature/consent: ____________________________________
Date:____/____/____

Name: ____________________________________

Investigator's Verification of Explanation

I certify that I have carefully explained the purpose and nature of this research to __________________________________ (participant's name) in age-appropriate language. He/She has had the opportunity to discuss it with me in detail. I have answered all his/her questions and he/she provided the affirmative agreement (i.e. assent) to participate in this research.

Investigator's Signature: ____

Date: ______________________

APPENDIX D

Likert Surveys' Raw Score from Surveys

Survey without freshman

Last Modified: 01/26/2016
Filter By: Report Subgroup

1. Please list your age.

#	Answer	Bar	Response	%
1	Less than 17		0	0%
2	17		0	0%
3	18		0	0%
4	19		2	6%
5	20		9	28%
6	21		13	41%
7	22+		8	25%
	Total		32	

Statistic	Value
Min Value	4
Max Value	7
Mean	5.84
Variance	0.78
Standard Deviation	0.88
Total Responses	32

2. What is your major?

#	Answer	Bar	Response	%
1	Biology / Micro or Molecular biology / Biotechnology / Genetics		3	9%
2	Chemistry / Biochemistry		8	25%
3	Engineering (all types)		3	9%
4	Computer Science		9	28%
5	Physics / Astrophysics		3	9%
6	Math		3	9%
7	Other		3	9%
	Total		32	

Statistic	Value
Min Value	1
Max Value	7
Mean	3.69
Variance	3.25
Standard Deviation	1.80
Total Responses	32

3. I am majoring in science because:

Text Response
I've wanted to pursue career in chemistry since 8th grade when I learned about chemistry mots toy because of the great teachers and professors I met along the way.
I decided I wanted to study chemistry after taking classes.
I have always been interested in science and I want to become a research scientist
I was diagnosed with MS and I realized I know nothing about how the body works.
science is super cool.
I love chemistry and I want to contribute to the future in science discoveries and improvements.
I find my field interesting and suited for my personality. A science major also gives me more flexibility in career choice.
I want to go to medical school and be a doctor. I've also always had an interest in science since I was very young.
I'm deeply fascinated by the processes which define our existence. The field of astrophysics particularly is unique in that its potential for new knowledge is endless. There will always be something new to be discovered, and this concept excites me. It brings me joy to learn about planets beyond our solar system, super massive black holes, and the countless other phenomena and mysteries of our universe.
I enjoy the subject and the accompanying thought process.
Astrophysics is the fire that fuels my soul. I find fewer things are beautiful as our existence due to, and partly in spite of, the evolution of this universal reality. I studying this because I find no other path as elucidating as this to understand our perception as a function of the symbolic logic we apply to the physical world around us. Physics, however, does not represent the totality of what humanity is capable of and I believe that our conceptions of the world arising from simply consciousness played a key role in grounding ourselves within the system and the art we create is an important representation of our understandings of this universe as well.
I think it's really cool and useful, and it helps me better understand how the world works.
I am majoring in Neuroscience & Behavior because I find the complexity of the human mind utterly fascinating. We also know so very little about it. I am specifically focusing my studies on psychiatric disorders, and hope to obtain my PhD in neuroscience studying these mental illnesses, as progress in the field has been at a stalemate. Many psychiatric disorders such as major depressive disorder (MDD) and post-traumatic stress disorder (PTSD) are leading burdens of disease worldwide. I hope to devote my research to understanding it more clearly, and developing more effective therapeutics.
I want to be a doctor
I am fascinated with biology!
I am majoring in cellular neuroscience because I am interested in participating in the emerging field studying how the brain works. I am also interested in going to medical school, and having a science background will be helpful.
Bio is cool
it excites me intellectually.
I enjoy problem solving, which is exactly what computer science is. I like subjects, such as math and science, that have definitive solutions to problems, unlike more humanity-based majors that can have more subjective results.
I have always loved understanding the world around me and nature has always been fascinating to me. Being able to learn how life works like it does is really cool. I was also in a program at the Museum of Natural History that further enticed me and prepared me to study science.
like mathematical reasoning
I've always been analytically minded. I never really imagined myself in any other career field.
I find problem solving interesting
I like it
I enjoy it and want to work in tech.
I like to learn how the world around us works. I enjoy learning about the rules and laws that make simple things possible in our daily life.
I enjoy it a lot! I was originally neuroscience, but I liked the programming aspect of everything more than the major itself so I switched to computer science.
I have never seen myself doing anything else
There is a lot of money is cs and my family doesn't have a lot. I have also managed to convince myself that cs is flexible. I can work in finance or a health startup with the same degree.
I am a curious person that loves solving problems.
I love it! I also can't stand writing papers.
I like to program.

Statistic	Value
Total Responses	32

4. My Minor is:

Text Response
N/A
N/A
none
NA
Political Science
N/A
none
n/a
Mathematics
Computer Science
English
sociology
computer science
Computer Science
Statistics
None
Mathematics
Double-major in philosophy.
Psychology
(don't have minors in Brazil)
Psychology
Computer Science
Statistics

Statistic	Value
Total Responses	23

5. The first set of questions are about your prior experiences in science during middle and high school. Please answer to the best of your knowledge.

#	Question	Never	Rarely	Sometimes	Usually	Always	Total Responses	Mean
1	You knew from middle school you wanted to major in science.	5	5	5	5	12	32	3.44
2	You knew from high school you wanted to major in science.	2	1	7	5	16	31	4.03
3	You plan on pursuing a career in science upon graduation.	1	0	5	5	21	32	4.41
4	You feel like you had an equal opportunity in high school to participate in science.	1	5	4	12	10	32	3.78
5	You feel like men and women were treated equally in a science classroom.	1	4	3	17	7	32	3.78
6	Your science teachers were very supportive of your interests in science.	0	0	8	9	15	32	4.22
7	Your family was supportive of your interests in science.	0	2	3	4	23	32	4.50
8	Your high school teacher / teachers inspired you to major in science.	4	3	10	5	10	32	3.44
9	Your male friends supported your interests in science.	1	2	10	9	10	32	3.78
10	Your female friends supported your interests in science.	1	1	6	12	12	32	4.03
11	Science teachers in high school treated men and women equally.	0	1	8	14	9	32	3.97

Statistic	You knew from middle school you wanted to major in science.	You knew from high school you wanted to major in science.	You plan on pursuing a career in science upon graduation.	You feel like you had an equal opportunity in high school to participate in science.	You feel like men and women were treated equally in a science classroom.	Your science teachers were very supportive of your interests in science.	Your family was supportive of your interests in science.	Your high school teacher / teachers inspired you to major in science.	Your male friends supported your interests in science.	Your female friends supported your interests in science.	Science teachers in high school treated men and women equally.
Min Value	1	1	1	1	1	3	2	1	1	1	2
Max Value	5	5	5	5	5	5	5	5	5	5	5
Mean	3.44	4.03	4.41	3.78	3.78	4.22	4.50	3.44	3.78	4.03	3.97
Variance	2.32	1.50	0.96	1.34	1.08	0.69	0.84	1.87	1.14	1.00	0.68
Standard Deviation	1.52	1.22	0.98	1.16	1.04	0.83	0.92	1.37	1.07	1.00	0.82
Total Responses	32	31	32	32	32	32	32	32	32	32	32

6. Comments: You may respond to any of the questions above that you feel need further clarification or an explanation.

Text Response
I think it is important to note that I did not go to high school in the US. I did attend community college here where all science professors were being very encouraging and supportive of my desire to major in sciences.
My chemistry / AP chemistry/ AP physics/ Solar Boat teacher was supportive of my efforts however i noticed that when he split people up for the teams on Solar Boat, I was the only girl on mechanical and I actually very rarely had anything to do with it since i got pushed into the secretarial/ managerial position over finances, reports etc. and kind of got edged out with what felt like the teachers support.
I did excellent in my science classes in high school. However, I pursued a career in Economics when I came out of high school. After almost 2 years in college doing Economics I realized that it was not what I was interested for my future anymore and changed my degree to Chemistry.
I had a very supportive science teacher in 8th grade who encouraged me to pursue science. He would share books and scientific articles with me and I ended up helping him design an advanced-level science course that piloted the following year and that he still teaches. He also advocated on my behalf to the school to get me into a different science class so that I could avoid another teacher who was apathetic about teaching the science material. My 8th grade science teacher was the one who made me think I could study science and become a research scientist if I wanted to. On the other hand, I had a terrible science teacher for 9th grade, who I think turned many people off of science. In my experience with her, she graded my assignments differently than my peers and became angry at me if I tried to participate. I do not know why she behaved this way, but I think if I did not have such strong encouragement the year before, I may have abandoned science. Instead, I took more more than twice the math and science courses than I was required to in high school. In terms of support from my family, my parents were very supportive and continue to support my interests in science. I am the first one in both my immediate and extended family to study a STEM field, so my family doesn't really understand what I am studying at school or what my research is about and cannot offer school or career guidance. However, they have been very supportive, from giving me a subscription to Scientific American for my 13th birthday to supporting my decision to go to Columbia and study in a STEM field.
As I've grown older, I've come to realize the sexism in science. Most PIs are male, most chairs and leaders in medicine are male, etc. However, this hasn't stopped me from wanting to pursue medicine.
I was lucky in that I grew up in a district where the public schools are some of the best in the country. My science teachers particularly were phenomenal - they were always supportive and engaging, making the learning process enjoyable. Although I've always been interested in science, the teachers I've had in my life have enforced that interest.
To clarify, throughout middle school and high school I was interested in pursuing a math degree. It wasn't until college that I altered this and went into Computer Engineering.
In high school, I don't believe I received proper scientific education. It was partly because of the cohort of students I was among; the top students were a group of men who were obnoxious. The top student of the class was a women, but everyone seemed to perceive her as an anomaly.
I attended a performing arts high school that did not have a very good science program. Science classes were a "check in the box."
Up until about a year ago, I'd planned to major in some kind of biological science and become a doctor. My father is a doctor, and so was his father, and so was his father. There seemed to be a lot more women in that field than in computer science. I only just realized how much I loved computer science because there weren't really any opportunities for me to try it until I came to college, and I didn't know of any women that were in the field that I could use as a role model.
I encountered two types of science teachers that treated girls unequally (the majority treated us equally though, which is great) : The first type that validates male students' class contributions more than female students' contributions. The logic is : what comes out of a girl's mouth doesn't make as much sense as what a boy says, even though they have the same content in essence. The second type actually is biased towards girls. Girls got better participation grades and were graded more leniently. Both were male teachers.
DOuble major Major in: Math-computer science and physics
Often the all-male clubs in high school were intimidating (like robotics club, physics club, math club, etc.), but there were never any actual problems with people not treating me equally.

Statistic	Value
Total Responses	13

7. Your college experiences as a STEM major.

#	Question	Never	Rarely	Sometimes	Usually	Always	Total Responses	Mean
1	You feel like women and men have equal opportunities for careers in science.	0	2	11	15	4	32	3.66
2	You feel women have to work harder to succeed in science or STEM fields.	0	4	9	13	6	32	3.66
3	You feel women are discouraged from entering careers in science or STEM fields.	0	9	18	4	1	32	2.91
4	Your male professors treat men and women equally.	0	0	6	18	8	32	4.06
5	Your female professors treat men and women equally.	0	1	1	20	9	31	4.19
6	Female science majors encounter greater hardships than males science majors.	0	8	8	9	7	32	3.47
7	You lack support from your female friends with your choice of a science major.	17	11	4	0	0	32	1.59
8	You lack support from your male friends with your choice of a science major.	17	9	4	0	1	31	1.68
9	You lack adequate time to socialize with your friends.	0	3	14	7	8	32	3.63

Statistic	You feel like women and men have equal opportunities for careers in science.	You feel women have to work harder to succeed in science or STEM fields.	You feel women are discouraged from entering careers in science or STEM fields.	Your male professors treat men and women equally.	Your female professors treat men and women equally.	Female science majors encounter greater hardships than males science majors.	You lack support from your female friends with your choice of a science major.	You lack support from your male friends with your choice of a science major.	You lack adequate time to socialize with your friends.
Min Value	2	2	2	3	2	2	1	1	2
Max Value	5	5	5	5	5	5	3	5	5
Mean	3.66	3.66	2.91	4.06	4.19	3.47	1.59	1.68	3.63
Variance	0.62	0.88	0.54	0.45	0.43	1.22	0.51	0.89	0.95
Standard Deviation	0.79	0.94	0.73	0.67	0.65	1.11	0.71	0.94	0.98
Total Responses	32	32	32	32	31	32	32	31	32

8. Comments: You may respond to any of the questions above that you feel need further clarification or an explanation.

Text Response
1. I feel like in general women have more opportunities in sciences than men because they are so "underpopulated", meaning there is a very small percentage of women who decides to pursue serious science career.
I find it inevitable that females have a harder time pursuing any type of graduate degree/further education simply because we have the burden and joy of having to bear children. One thing I've always struggled with is what kind of degree I want that will allow me to have children.
The physics department at Columbia particularly is a "boys club." All of my physics professors have been older (white) men, who generally favor other male students. Although my experience hasn't been horrible by any means, I do feel as if there is more pressure for me to succeed in the physics department. In contrast, the astronomy/astrophysics department is much more inclusive. I've had both men and women as professors and mentors, and the general atmosphere is so much more inclusive and supportive. The relationship I have with the Astro department is much better than the one I have with the physics department I believe.
My answers about being treated differently from males in college is skewed because I attend an all female school. I haven't really had very many co-ed science classes.
I don't really ever feel directly disrespected, but there are times that it feels like men's voices are always heard and mine isn't. Men are generally more willing to speak up and are confident in their answers even when they're guessing , whereas I (and a lot of girls I know) am more hesitant unless I am 100% sure that I have the solution. I've also heard some stories about female TAs being ignored or doubted by male students because they're pretty/don't "seem like they know what they're doing".
I would enjoy computer science so much more if it wouldn't eat up my social life. It really is fun to build things, but I want to step away from it all once in a while. It really makes me doubt my major, but I'm too far in now.

Statistic	Value
Total Responses	6

9. Currently, what year are you in?

#	Answer	Bar	Response	%
1	Freshman		0	0%
2	Sophmore		0	0%
3	Junior		17	61%
4	Senior		11	39%
	Total		28	

Statistic	Value
Min Value	3
Max Value	4
Mean	3.39
Variance	0.25
Standard Deviation	0.50
Total Responses	28

10. In order to better understand what you think and how you feel about your college science courses, please respond to each of the following statements from the perspective of "When I am in a college science course. . ."

#	Question	Never	Rarely	Sometimes	Usually	Always	Total Responses	Mean
1	The science I learn is relevant to my life	0	2	11	15	4	32	3.66
2	I like to do better than other students on science tests	0	2	4	13	13	32	4.16
3	Learning science is interesting	0	0	1	18	13	32	4.38
4	Getting a good science grade is important to me	0	3	4	14	11	32	4.03
5	I put enough effort into learning science	0	0	6	15	11	32	4.16
6	I use strategies to learn science well	0	3	8	14	7	32	3.78
7	Learning science will help me get a good job	0	2	6	12	12	32	4.06
8	It is important that I get an "A" in science	1	5	10	8	8	32	3.53
9	I am confident I will do well on science tests	0	7	15	10	0	32	3.09
10	Knowing science will give me a career advantage	0	1	9	13	9	32	3.94
11	I spend a lot of time learning science	0	0	4	15	13	32	4.28
12	Learning science makes my life more meaningful	0	1	5	12	14	32	4.22
13	Understanding science will benefit me in my career	0	0	4	15	13	32	4.28
14	I am confident I will do well on science labs and projects	0	5	11	11	5	32	3.50
15	I believe I can master science knowledge and skills	0	2	7	16	6	31	3.84
16	I prepare well for science tests and labs	0	1	12	15	4	32	3.69
17	I am curious about discoveries in science	0	1	7	7	17	32	4.25
18	I believe I can earn a grade of "A" in science	1	3	7	16	5	32	3.66
19	I enjoy learning science	0	0	2	15	15	32	4.41
20	I think about the grade I will get in science	0	4	10	9	9	32	3.72
21	I am sure I can understand science	0	1	6	20	5	32	3.91
22	I study hard to learn science	1	0	5	13	13	32	4.16
23	My career will involve science	0	0	3	10	19	32	4.50
24	Scoring high on science tests and labs matters to me	1	3	7	11	9	31	3.77
25	I will use science problem-solving skills in my career	1	1	1	10	19	32	4.41

Statistic	The science I learn is relevant to my life	I like to do better than other students on science tests	Learning science is interesting	Getting a good science grade is important to me	I put enough effort into learning science	I use strategies to learn science well	Learning science will help me get a good job	It is important that I get an "A" in science	I am confident I will do well on science tests	Knowing science will give me a career advantage	I spend a lot of time learning science	Learning science makes my life more meaningful
Min Value	2	2	3	2	3	2	2	1	2	2	3	2
Max Value	5	5	5	5	5	5	5	5	4	5	5	5
Mean	3.66	4.16	4.38	4.03	4.16	3.78	4.06	3.53	3.09	3.94	4.28	4.22
Variance	0.62	0.78	0.31	0.87	0.52	0.82	0.83	1.29	0.54	0.71	0.47	0.69
Standard Deviation	0.79	0.88	0.55	0.93	0.72	0.91	0.91	1.14	0.73	0.84	0.68	0.83
Total Responses	32	32	32	32	32	32	32	32	32	32	32	32

Statistic	Understanding science will benefit me in my career	I am confident I will do well on science labs and projects	I believe I can master science knowledge and skills	I prepare well for science tests and labs	I am curious about discoveries in science	I believe I can earn a grade of "A" in science	I enjoy learning science	I think about the grade I will get in science	I am sure I can understand science	I study hard to learn science	My career will involve science	Scoring high on science tests and labs matters to me	I will use science problem-solving skills in my career
Min Value	3	2	2	2	2	1	3	2	2	1	3	1	1
Max Value	5	5	5	5	5	5	5	5	5	5	5	5	5
Mean	4.28	3.50	3.84	3.69	4.25	3.66	4.41	3.72	3.91	4.16	4.50	3.77	4.41
Variance	0.47	0.90	0.67	0.54	0.84	0.94	0.38	1.05	0.47	0.85	0.45	1.18	0.89
Standard Deviation	0.68	0.95	0.82	0.74	0.92	0.97	0.61	1.02	0.69	0.92	0.67	1.09	0.95
Total Responses	32	32	31	32	32	32	32	32	32	32	32	31	32