3-30-2015

Examining the underlying currents of high school girls' perceived STEM self-efficacy and science course options: a mixed methods study

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EXAMINING THE UNDERLYING CURRENTS OF HIGH SCHOOL GIRLS' PERCEIVED STEM SELF-EFFICACY AND SCIENCE COURSE OPTIONS: A MIXED METHODS STUDY

by
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A Dissertation

Submitted to the
Department of Educational Leadership
College of Education
In partial fulfillment of the requirement
For the degree of
Doctor of Education
at
Rowan University
March 13, 2015

Dissertation Chair: Ane Turner Johnson, Ph.D.

Dedication

I dedicate this dissertation to my husband, Brian, whose love reminds me every day that dreams can come true.

Acknowledgements

Writing a dissertation is no solitary effort, more of a journey that you take with other people. This dissertation is a culminating product of the commitment and collaborative efforts of so many talented and inspirational people. I would like to acknowledge them in this section.

First, I would like to acknowledge my dissertation chairperson, Dr. Johnson, for her unwavering support and encouragement. I wanted to work with Dr. Johnson from the moment I met her, knowing that her critical feedback and expertise would push me to my limits. She has opened my eyes to a much broader view of research and the impact that we may all strive to have in our local contexts and the larger world around us. I hope, through what I have learned from her the past few years and through what I will learn through our continued collaboration, that I may, like her, help to illuminate injustices, take action, and inspire others to do the same to make the world a better place.

I would also like to acknowledge my dissertation committee members, Dr. Abi-El-Mona and Dr. Robinson. It was a little over a year ago from the completion of this dissertation that I contacted each of them to ask if I could meet them and see if they would be interested in joining me throughout this dissertation process. I was immediately struck by their ideas and insightful perspectives on this dissertation's topic and I knew they would be amazing, valuable team members. I am thankful and humbled by the amount of time each of them gave to me, the depth of their feedback, and their overall support. To all those who read this dissertation, check out their work. They are true examples of those who have successfully translated their research efforts to action, supporting efforts to reduce inequalities in STEM participation and achievement.

I would also like to thank everyone who I have met through the NJPSA cohort and Sunday advisee meetings for being a part of this journey with me. I have learned so much from all of you and am so thankful for the support, feedback, friendship, and, of course, the stories over "vittles".

I would like to thank Mr. Moore for giving me a starting point to conceptualize this study and his continual encouragement. In addition, I would like to thank all of the teachers and students who have helped me with this study. While I may not thank you by name due to the study's confidentiality and anonymity provisions, please know that, without your help, patience, and insight, this dissertation would be nonexistent. I would also like to thank my dearest friend, Lauren, for her friendship and unwavering belief in me. She inspired me to never give up, be proud of who I am, and reach for the stars as our futures are limited only by our imaginations.

I would like to thank my husband, Brian, for, well, everything. Whether it was "journicles" or hours-long talks and walks, he was my rock, my inspiration. He always provided the "perspective" when I seemed to be "fresh out", suggesting a nice wine to go with it. The love he has shown throughout this process is unparalleled and, no doubt, helped me persevere. Time to be like Elsa, and let it go – On to our next journey together!

And, finally, I would like to thank my parents. From a family heritage point of view, I am proud to be the first member of our family to complete a dissertation. Throughout my life, I was blessed to have such loving parents. My parents have been there to share in all of my life's milestones. I am thankful that they were so supportive (of Brian and me) throughout this process, and, moreover, thankful that they raised me to be the woman I am today.

Abstract

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2015
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Doctorate in Educational Leadership

Increased demands for a STEM-literate workforce have emerged in response to sustainability issues that threaten human welfare. A workforce capable of addressing such issues would need to be competent, have an understanding of Earth as a system and related physical science principles, and available, be willing to pursue such fields. Workforce concerns about contributors' competency and availability are further fueled by students' persisting underachievement in science and women's underrepresentation in STEM degrees and careers. While New Jersey students, in comparison to other states, are achieving in science, girls remain underrepresented in physical sciences. From a feminist lens of social cognitive theory, this study sought to examine how gender and earth science resources inform high school girls' efficacy-activated processes related to their perceptions of potential science course pursuits. This mixed methods study followed a sequential, explanatory design, collecting data from surveys, open-ended task surveys, focus groups, and interviews. Findings illuminated the influence of gender role socialization on girls' perceptions of potential science course pursuits. Persisting gender constructs regarding appropriate science domains and careers, notions of math talent and intelligence, and competitive norms all threaten girls' participation in physical sciences. Implications for policy, research, and practice are discussed.

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Chapter 1

Introduction

With the world's population reaching seven billion and growing (U.S. Census Bureau, 2012), the delicate balance between natural and social systems is being disrupted. The persistence of global sustainability issues has serious implications for human welfare, the global economy, and social justice. Numerous global issues have arisen "as a result of significant concerns about the unintended social, environmental, and economic consequences of rapid population growth, economic growth, and consumption of our natural resources" (United States [U.S.] Environmental Protection Agency, n.d., What is EPA doing? section, para. 1). Mora et al. (2013) described the resulting consequences as:

> Human welfare, through changes in the supply of food and water; human health, through wider spread of infectious vector-borne diseases, through heat stress and through mental illness; the economy, through changes in goods and services; and national security as a result of population shifts, heightened competition for natural resources, violent conflict and geopolitical instability. (p. 183)

More specifically, these global issues include, but are not limited to, soil erosion, oceanic dead zones, depletion of natural resources, deforestation, species' extinction, territorial disputes, inequitable access to fresh water, and global climate change (Chapman & Khanna, 2006; Diaz & Rosenberg, 2008; Mora et al., 2013; O'Green, 2006; Shukla, Noble, & Sellers, 1990; Singing-Larsen & Wellmer, 2012). While ecological and social systems allow for a certain extent of variability, a recent study's projections of climate shifts in the coming years suggest that major changes may occur sooner than expected

(Mora et al., 2013). All of these consequences seriously threaten the sustainability of our global economy and would have a dramatic impact on the welfare of current and future inhabitants.

The urgency to address sustainability issues has informed social and economic demands worldwide. Most evident of this influence is the increased demand for a STEM-literate society from which to draw a workforce. The success of such a workforce in addressing complex sustainability issues would be dependent on the competency and availability of potential contributors. Worldwide, countries made a commitment to United Nations Educational, Scientific and Cultural Organization’s [UNESCO] Education for All vision, adopted in 1990 and readopted in 2000. This commitment led to the enactment of educational policies with the following underlying beliefs:

> Education is a fundamental human right. It is the key to sustainable development and peace and stability within and among countries, and thus an indispensable means for effective participation in the societies and economies of the twenty-first century, which are affected by rapid globalization. Achieving EFA [Education for All] goals should be postponed no longer. The basic learning needs of all can and must be met as a matter of urgency. (UNESCO, 2000, p. 8)

Thus, worldwide, attention was turned to the role of equal access to quality education in preparing a competent and available workforce to address sustainability demands.

Despite efforts, concerns regarding the sufficiency of these policies have emerged in light of persisting sustainability issues (UNESCO, 2013). Concerns about availability and gender equality emerged as well as women and girls worldwide continue to be "excluded from participation in science and technology activities by poverty and lack of education (at all levels) or by aspects of their legal, institutional, political and cultural environments" (UNESCO, 2007, p. 7). Worldwide, countries' enactment of policies to reduce the gender gap resulted in some strides in promoting gender equality in educational and career participation. From 2006 to 2013, the gender gap in educational attainment was closed by 96%. This improvement notwithstanding, the economic participation gap only closed by 60% (World Economic Forum, 2013). As women make up more than half of the world's population, these issues present social injustices and a serious deficit to the pool of potential contributors to addressing these sustainability challenges.

More recently, in response to these concerns, countries worldwide have expressed their commitment to Global Action Programme on Education for Sustainable Development that has the following goals:

> (a) to reorient education and learning so that everyone has the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to sustainable development; and
>
> (b) to strengthen education and learning in all agendas, programmes and activities that promote sustainable development. (UNESCO, 2013, Background section, para. 6)

This has led to a renewed sense of urgency to promote equal access to educational opportunities that specifically support the knowledge and skills needed to address sustainability issues. However, persisting gender inequality trends may also suggest a misalignment between workforce demands and educational preparation and persistence of other transitional barriers. Left unaddressed, the achievement of these goals is threatened.

The United States (U.S.) also faces similar concerns with respect to the competency and availability of a workforce capable of addressing sustainability issues. In recognition of the role of equal access to quality education to address sustainability issues, federal policy continues to prioritize Science, Technology, Engineering, and Mathematics (STEM) education with the goals of better meeting workforce demands and increasing participation of those from traditionally underrepresented groups in the STEM domains (National Science and Technology Council, 2013).

Despite efforts, competency and availability concerns continue to emerge. Businesses express concerns about the upcoming workforce's competency, particularly with respect to STEM literacy (U.S. Department of Commerce, 2011). U.S. youth's low achievement scores in science and math (Fleischman, Hopstock, & Pelczar, 2010; Gonzales et al., 2008; Martin, Mullis, Foy, & Stanco, 2012; National Center for Education Statistics, 2012) and businesses' need to provide remediation in skills related to STEM literacy are further used to justify their concerns (Atkinson, 2012; Feinstein, Allen, & Jenkins, 2013). Availability of contributors is further compromised as gender inequalities in STEM educational and career paths persist. While more women pursued science and engineering degrees from 2002 to 2012, a 41% increase (National Science Foundation [NSF], 2013), the economic gender participation gap remains wide as women represent only 28% of the STEM workforce (NSF, 2014). To account for these persisting gender inequalities, literature widely recognized that women, despite the civil rights movement and related laws and regulations, have lower salaries and fewer promotions or opportunities in general (Sonnert & Holton, 1995; Valian, 1999). However, these external factors fail to account for the internal factors that inform decisions to act (Sonnert & Holton, 1995). These persisting gender gaps, then, may also suggest the failure of K-12 science educational preparation to sufficiently develop girls' needed agency beliefs for actual pursuance of STEM-related educational and career paths.

Theoretically, efficacy, or agency, beliefs are associated with increased academic achievement, persistence, and pursuance of future opportunities (Bandura, 1977). Mastery experiences, the valuation that an individual places on past experiences in relation to his or her perceptions of the likelihood of success in related future experiences, strongly inform efficacy beliefs (Bandura, 1995). As efficacy beliefs tend to be domain-specific (Usher & Parajes, 2008), girls' experiences, then, with STEM educational opportunities may play a contributing role in informing the strength of their STEM efficacy beliefs that, in turn, will either expand or narrow their perceptions of potential future related course, and, later, career paths.

However, many high school students are denied access or fail to take advantage of opportunities to develop sustainability-related STEM literacy and knowledge of or interest in related fields. These skills are most often taught in earth sciences and other physical science courses. Upon examination of high school graduation requirements, only one state in the U.S. required a full year of earth sciences and only 27 states required a full year of physical sciences (American Geosciences Institute, 2013). In addition, there are currently no Advanced Placement (AP) courses offered in earth sciences. Moreover, girls seemed to be more vulnerable to these trends as they were persistently underrepresented in physical science related courses and degrees (College Board, 2014;

NSF, 2013). As domain-specific course participation is highly associated with future pursuance of more advanced courses and related careers (Hackett, 1995), girls' underrepresentation in physical sciences and lack of exposure to earth sciences, may fail to provide them with the mastery experiences needed to bolster their efficacy beliefs in specific STEM domains. In turn, the resulting agency beliefs may not be sufficient for action. Consequently, this context may prematurely narrow their perceptions of potential career paths (Bandura, 1995; Bussey & Bandura, 1999; Hackett, 1995), perpetuating their limited participation in STEM-related fields.

Equal access to quality K-12 science educational opportunities have long been recognized as imperative to build the "capacity of the people to address environment and development issues" (UNESCO, 1978, Section 36.3). To increase gender equality in STEM course, degree, and career pursuits, science educational opportunities need to not only support the development of STEM literacy, particularly as it relates to the earth as a system and physical science principles, but also the needed agency beliefs for actual pursuance of such opportunities (Bandura, 1977; Hackett, 1995; Zimmerman, 1995). To those points, this chapter situates this study in the larger context of welfare concerns resulting from sustainability issues. While educational systems espouse to prepare students for workforce demands (National Science and Technology Council, 2013; U.S. Department of Education, 2010), this chapter highlights how the current deficiencies and gender inequalities in U.S. students' science educational outcomes limit the workforce's potential to address sustainability issues. It continues with a description of the current state of New Jersey's (N.J.) science education in relation to national and international trends with a focus on key characteristics of persisting gender inequalities in N.J.

students' achievement and course participation. Considering the research problems that underpin the practical problems of these persisting gender inequalities, this chapter presents this study's purpose, research questions, and significance from a social cognitive theoretical framework with an embedded feminist lens. It concludes with a brief discussion of the study's limitations and delimitations to promote ethical use of its findings.

STEM and the Economy

The earth is "a complex set of interacting natural systems (the geosphere, atmosphere, hydrosphere, and biosphere) and social systems (e.g., agricultural, economical, legal, communications, transportation, moral, political, and cultural)" (Finley, Nam, & Oughton, 2011, p. 1073). A change in any part of one system will have far reaching consequences in the other system and vice versa. The earth, then, is in a continual balancing act, negotiating the natural and social systems. Sustainability issues arise as a result of changes that subsequently affected both ecological and social systems in a suboptimal way (Mora et al., 2013).

America's ability to innovate and create through its workforce related to sustainability fields is imperative to our nation's future safety and prosperity in a global society (American Competitiveness Initiative, 2006; National Science and Technology Council, 2013). A STEM-literate workforce capable of addressing sustainability issues would need to be both competent, have an understanding of the earth as a system and related physical science principles, and available, willing to pursue fields related to sustainability. Such a workforce may aid in the discovery of alternative natural, renewable resources, the increased use of recyclable resources, and the emergence of human innovation, all needed components to sustain the demands placed upon our society by the global economy and increasing population (Singing-Larsen & Wellmer, 2012).

Demands, then, for a STEM workforce have become a major part of national policy efforts to promote the nation's safety and prosperity through improving its workforce (American Competitiveness Initiative, 2006; National Science and Technology Council, 2013). STEM-related jobs, for example, increased dramatically from 1950 to 2007, offering about 5.5 million jobs (National Science Foundation [NSF], 2010). Three years later there were 7.6 million STEM workers in the U.S., a 38% increase (U.S. Department of Commerce, 2011). Projections of STEM job growth suggest that STEM-related jobs will continue to increase and increase more than other types of jobs in the coming years (NSF, 2010; U.S. Department of Commerce, 2011). In light of these increased workforce demands, more than ever, potential contributors need to be STEM-literate, particularly as it relates to addressing complex, sustainability problems.

Federal Policy, Workforce Demands, and STEM

Sustainability jobs are not limited to STEM fields. Oftentimes overlooked, as evidenced in the public's low placement of environmental issues among policy issues (Harms, 2013), is the understanding that the economy is highly related to the environment with respect to jobs, resources' supply and demand, agriculture, land use, and energy (Singing-Larsen & Wellmer, 2012). Federal policies regarding sustainability such as Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management and Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance, have led to the creation of sustainability jobs across career fields related to ensuring compliance and safety. Such positions focus on changes that better promote environmentally-sound practices while also increasing profitability. Findings from the Bureau of Labor Statistics (Bureau of Labor Statistics [BLS], 2013) via the Green Technologies and Practices survey of approximately 350,000 businesses at the local, state, and federal levels reported that three-quarters of U.S. businesses use green technology and practices, corresponding to about 854,700 jobs. Green technology and practices are defined as either jobs "that produce goods or provide services that benefit the environment or conserve natural resources" or "in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources" (BLS, 2013, The BLS Green Jobs Definition section, para. 1). Related sustainability jobs include managers (general, operation, industrial production, transportation, storage, and distribution), chemists, microbiologists, environmental scientists (atmospheric, conservation, soil, and plant), engineers (chemical, civil, industrial, and environmental), accountants, compliance officers, cost estimators, and occupational health and safety specialists (Hamilton, 2012). Sustainability-related careers, then, traverse multiple disciplines in both traditional STEM and non-STEM fields.

While it remains unclear if those who dismiss traditional STEM jobs also dismiss non-STEM jobs related to sustainability as potential career options, it is clear that both STEM and non-STEM paths require STEM-literate and willing, available contributors. The current state of the workforce, nonetheless, raises questions about the readiness and availability of such a workforce.

Problems with the Current Workforce

The outcomes of such job growth in sustainability careers are dependent on the quality and availability of the workers. Despite higher salaries and job demand, businesses in the United States (U.S.) persistently express concern about the preparation and availability of the future workforce (Feinstein, Allen, & Jenkins, 2013; U.S. Department of Commerce, 2011). Many businesses lamented that they had to spend time providing remediation training in STEM literacy, in response to workers' deficient problem-solving skills, inability to find and evaluate scientific sources, and unfamiliarity with engagement in inquiry (Feinstein et al., 2013). In addition, professional organizations even showed concern that the demand for STEM-related jobs may surpass the supply (National Science and Technology Council, 2013). A lack of a sufficient workforce would be of little use to addressing sustainability issues and would have detrimental effects on America's prosperity and position in the global economy.

With a focus on participation, women continue to be underrepresented in STEM fields. From 2002 to 2012, the percentage of women who earned STEM degrees at either the associate's or bachelor's levels increased by 41% and, at the graduate level, master's degree attainments in STEM fields increased 68% (National Science Foundation [NSF], 2013). Despite increases in degree attainment, women remained underrepresented in physical sciences, representing approximately 41% of undergraduate and 36% of graduate degrees in awarded in 2012 in those fields (NSF, 2013). National data regarding degree enrollments also indicated an overrepresentation of women in biological, psychology, and social sciences (NSF, 2013). Even more troubling was that women's STEM degree attainment, regardless of the field, was not strongly associated with economic participation after college as women represented only 28% of the STEM workforce (NSF, 2014). These STEM degree attainment trends and their lack of association with economic participation, then, suggest the existence of transitional barriers between higher education and STEM career paths.

The underrepresentation of women in STEM domains is problematic for two key reasons. First, it is a threat to basic social justice. While the role or existence of biological differences that could account, in part, for gender differences in STEM participation are debated, the majority of literature tends to support that gender differences in STEM participation are more a result of environmental factors and situational factors like the and lack of experience or exposure to STEM fields (Hill, Corbett, & St. Rose, 2010; Wai, Lubinski, & Benbow, 2009). Implicit biases, then, may be influencing career choices as science has traditionally been a male-dominated field (Sonnert & Holton, 1995). While many men and women are challenging traditional gender roles, the economic, organizational, and institutional structures may be serving to sustain traditional gender role expectations, thus, perpetuating gender inequalities (Hill, Corbett, & St. Rose, 2010; Sonnert & Holton, 1995), particularly in physical sciences, a traditionally male-gendered science in comparison to biology (Cervoni & Ivinson, 2011; Jones, Howe, & Rua, 2000).

Second, this underrepresentation denies the STEM field of potential contributors to the workforce. These problems starkly contrast with the U.S. Department of Education's (2010) espoused goal "to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access" (What We Do section, para. 1). All of these issues indicate inhibiting factors that present barriers for women's and girls' STEM educational opportunities and subsequent transition from related educational preparation to economic participation.

STEM and Science Education

From as early as the late 1800s, science education has espoused its role in preparing students to meet societal and economic needs through the learning of scientific knowledge and skills (DeBoer, 1991). In his widely cited book, *A History of Ideas in Science Education: Implications for Practice*, DeBoer (1991) provided a detailed account of how science education has evolved over time in response to competing demands. More recently, the demands that sustainability issues have placed upon workforce needs have raised concerns of science education's ability to meet three key needs. First, there is an increased demand for a STEM-literate society from which to draw a capable and available workforce. Second, there is an increased demand for an available workforce through increased gender equality and equitable STEM educational opportunities. Third, STEM literacy, specifically as it relates to addressing sustainability issues, demands an increased understanding of earth sciences and physical science principles (Achieve, 2013; National Research Council [NRC], 2011; Wysession, 2013).

The concept of STEM literacy, however, is ambiguous. It is currently defined in many ways, oftentimes modified to relate to the definer's purpose or goals (Gerlach, 2012). An examination of various definitions of how science education prepares students for civic and economic needs, suggests that current notions of STEM literacy may have evolved from previous conceptualizations of scientific-literacy. Since the early 1900s, science education advocates have engaged in defining the concept of scientific-literacy. While these notions consistently had both civic and economic goals, what those notions meant for teaching and learning fluctuated along the continuum between rigor, content, and relevance, real-life application (DeBoer, 1991).

While college demands in the 1920s led to more specialized courses in biology, chemistry, and physics with the assumption that rigorous, content-based courses were more appropriate for those going to college and relevant, application-based courses were more appropriate for those not going to college, the priority today is that *all* students need quality an equitable science educational opportunities (American Association for the Advancement of Science, 1990; NRC, 2011). In 1996, the NRC's publication of the *National Science Education Standards* focused on the need to develop scientific-literacy, defined as "the knowledge and understanding of science required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 2). In 2011, the NRC published *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, a framework that further supported the previous 1996 standards' vision. The framework, however, more specifically placed emphasis on the outcomes of scientific-literacy preparation:

> *All* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (Summary section, para. 2)

This framework, in turn, informed the development of the Next Generation Science Standards (NGSS), the most recent standards-based attempt to define the content, goals, and outcomes of student learning and teacher practice in science education.

This most recent framework expands the previous vision of scientific-literacy to a broader concept of STEM literacy, more intentionally and strongly acknowledging that science concepts and practices do not operate in isolation of each other.

> Engineering and technology are featured alongside the physical sciences, life sciences, and earth and space sciences for two critical reasons: to reflect the importance of understanding the human-built world and to recognize the value of better integrating the teaching and learning of science, engineering, and technology. (NRC, 2011, A New Conceptual Framework section, para. 1)

As evidenced in the resulting standards document, concepts and practices are further merged through the NGSS' identification of crosscutting concepts that serve as transferrable skills among the science, technology, engineering, and mathematics fields. It is through these crosscutting concepts that the domains of science, technology, engineering, and mathematics may be integrated in a meaningful way to further support conceptual change and application of the concepts to real world situations. In emphasizing the triadic reciprocal relationship among core disciplinary concepts, practices, and crosscutting concepts, the NGSS challenge educators to once again consider the potential of the integrative nature of STEM literacy to better prepare students to meet workforce and, more broadly, sustainability demands.

Drawing from the underlying assumptions of the NGSS and various descriptions of STEM literacy (Gonzalez & Kuenzi, 2012; Moon & Singer, 2012; National Governors

Association Center for Best Practices, 2007), this study operationalizes STEM literacy as the ability to engage in problem-solving, inquiry, and innovation through the meaningful integration of science, technology, engineering, and mathematics to address real world issues via personal, community, and professional actions. In alignment to the U.S. Department of Education (DOE)'s You for Youth's definition of STEM literacy, this study also assumes that literacy in each of these domains has a cumulative effect on overall STEM literacy. This section continues with an examination of how federal and state policies have integrated the concept of STEM literacy. It, then, identifies current issues with science educational outcomes that may inhibit those policies' goals from coming to fruition.

Federal Educational Policy and STEM Literacy

As workforce demands have the potential to inform national policy issues, it is not uncommon for the federal government to increase its involvement in education through its identification of goals, financial support through grants, and other policy enactments. For example, concerns about the extent to which science education was preparing students were also raised when deficiencies in our nation's pool of scientists and professors became evident during and after World War II (DeBoer, 1991). In response to those concerns, federal involvement in science education increased through the founding of the National Science Foundation, provision of grants, and oversight of curricula development in the 1950s. Around the same time, science became more recognized as a key component of our nation's prosperity and safety, sentiments that continue today in policies related to STEM education (American Competitiveness Initiative, 2006; National Science and Technology Council, 2013). Similarly, the launch of *Sputnik* in 1957, again increased the sense of urgency to improve science education with the assumption that science played a key role in protecting our nation's prosperity and safety (DeBoer, 1991). Federal policies like the National Defense Education Act provided financial support for math and science programs as well as financial aid and loans for students to continue their studies through higher education. Concerns surged once again after the 1983 publication of *A Nation at Risk*, a landmark report from the National Commission on Excellence in Education that identified troubling deficiencies in students' science and math achievement. The report's findings informed federal policies that focused on accountability and academic standards such as the No Child Left Behind Act of 1990. All of these calls for reform were based on the assumption that the "U.S. had not responded as quickly as other countries in preparing its young people for a world in which science and technology play such a large part, and now the U.S. needed to catch up" (DeBoer, 2000, p. 589).

Today, federal educational policies prioritize both the need to prepare a STEM-literate society and to increase gender equality in STEM fields. STEM education has the goal of "reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation which is essential to meeting the challenges of this century" (Obama, 2009). The America COMPETES Reauthorization Act of 2010 necessitated the creation of the Committee on STEM Education, part of the National Science and Technology Council. This committee's responsibilities included reviewing STEM education programs and creating a federal strategic plan that focused on both STEM literacy and increasing participation of traditionally underrepresented groups in STEM fields.

Current federally funded STEM educational programs encompass a wide variety of objectives related to increasing both competency and availability of a STEM-literate workforce. According to the National Science and Technology Council’s Committee on STEM Education 2013 report, these objectives included developing students’ STEM skills, increasing interest in STEM fields, providing professional development to teachers, supporting STEM degree and career pursuits, establishing partnerships, and promoting research opportunities on STEM best practices. The report found that approximately 59% of the programs focused on increasing the number of STEM degree and career pursuits. The majority also had increasing interest in STEM fields and institutional capacity to implement STEM programs as secondary goals (National Science and Technology Council, 2013). The report, however, warned of overlaps and lack of coordination among programs. Such factors may be diffusing the potential impact of these investments, resulting in the persistence of currently observed deficiencies and gender inequality trends in STEM educational outcomes and career participation.

With respect to participation, The Committee on STEM Education’s five year plan also included goals to “increase the number of students from groups that have been underrepresented in STEM fields that graduate with STEM degrees in the next 10 years and improve women’s participation in areas of STEM where they are significantly underrepresented" (National Science and Technology Council, 2013, Choosing National Goals section, para. 1). According to the plan, the federal government will continue to prioritize STEM education through policies such as Race to the Top and the Department of Education's Invest in Innovation and Supporting Effective Educator Development programs. These policies primarily focus on increasing gender equality in achievement and participation through increased accountability for standards, assessment, and teacher effectiveness. In science education, these policies primarily focus on science standards revision with a STEM approach. It is unclear how such measures will also foster the needed agency beliefs for pursuance of continued STEM educational and career options.

Federal involvement in education has led to a complex web, as Epstein (2004) described it, of governance with related power tensions that exist among levels of education as a result of spending power and constitutional status. While states, for example, have the authority to maintain control of educational policy, federal funding has imposed requirements that ultimately affect educational policy. Similarly, districts find themselves in a similar position regarding state funding. These power imbalances are difficult to remediate as a result of political, social, and/or economic pressures and, as Ryan (2004) noted, those at the closest proximity to students tend to have the least authority to make decisions about educational policies. Due to competing tensions, the investment in education at the federal level may not achieve its intended outcomes as it largely ignores the many of the contextual factors that influence girls' achievement, efficacy beliefs, and future pursuance of STEM-related courses, degrees, or careers.

State Educational Policies and STEM Literacy

While these federal policies inform states' educational policy decisions, states retain the power to make decisions about which educational policies to adopt to best address the current problems evident in their student population's achievement and participation outcomes. In response to federal demands for rigorous standards, eleven states and the District of Colombia, as of July 2014, adopted the Next Generation Science Standards (NGSS). States' adoption of the NGSS plays a vital role in subsequent decisions at the local school level particularly with respect to content, learning outcome expectations, and course offerings.

With respect to competency and availability, the framework that informed the development of the NGSS stressed the need to provide a broader scope of courses and opportunities to achieve the goals of increasing STEM literacy and participation in STEM-related educational and professional paths:

> Course options, including Advanced Placement (AP) or honors courses, should be provided that allow for greater breadth or depth in the science topics that students pursue… It is the committee's conviction that such an education, done well, will excite many more young people about science-related subjects and generate a desire to pursue science- or engineering-based careers. (National Research Council [NRC], 2011, A Vision for K-12 Education in the Sciences and Engineering, para. 4)

In addition, the NGSS broadened the goals of science education to the development of STEM literacy, particularly as it relates to sustainability issues. The NGSS further recognized that a STEM-literate workforce will need to have an understanding of geosciences and related physical science principles. Therefore, the NGSS prioritized understandings of how humans impact the earth's systems by increasing the expectations for earth sciences at both the middle and high school levels. The new standards increased expectations for earth sciences by placing equal priority to earth, life, and physical sciences at the middle school level and raising expectations of ESS to equal those of chemistry and physics combined at the high school level (Wysession, 2013). The increased expectations were possible as many of the concepts of physics, biology, and chemistry may be taught through earth sciences, and vice versa, in a more concrete and visual manner through the NGSS' identification of crosscutting concepts (Wilson, 2014; Wysession, 2013).

The increased expectations, then, for earth sciences and a broader scope of curricular offerings will have implications for practice and course offerings. Currently, earth sciences are taught in variety of ways, varying from school to school, and state to state, and will continue to evolve (Ireton, n.d.). Traditionally, Earth sciences were introduced as fragmented courses in middle and high school focusing on geology, meteorology, astronomy, and oceanography. At the high school level, in particular, they were never quite elevated to the same priority levels associated with more traditional science courses such as biology, chemistry, and physics (Finley, Nam, & Oughton, 2011). This may have resulted from earlier assumptions about college admissions requiring and prioritizing biology, chemistry, and physics (American Geosciences Institute, 2013). This has changed over time and, today, approximately 77% of colleges and universities accept earth sciences as an admissions requirement (Wilson, 2014). As it has yet to be determined how school curricular programs may change as a result of updated admissions requirements and the NGSS, educators, in the meantime, may integrate earth sciences into their existing curricula using the NGSS' crosscutting concepts (Wilson, 2014). In doing so, learning opportunities provide exposure to topics related to sustainability issues as well as foundational skills in physical sciences that are needed to pursue more advanced STEM courses (American Physical Society, 2014; Cornell University Physics Teacher Education Coalition, 2011).

With respect to access and participation, the actual standards document also underwent a series of reviews to decrease potential bias in hopes of increasing representation of traditionally underrepresented populations in STEM-related educational and career paths (Lee, Miller, & Januszyk, 2014).

> We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change. In addition, although not all students will choose to pursue careers in science, engineering, or technology, we hope that a science education based on the framework will motivate and inspire a greater number of people—and a better representation of the broad diversity of the American population—to follow these paths than is the case today. (NRC, 2011, A Vision for K-12 Education in the Sciences and Engineering section, para. 3)

Underlying problems in science education, if left unaddressed, may threaten the realization of these standards-based goals.

Problems in Science Education

The majority of data used to critique our country's science educational program's ability to prepare a workforce capable of competing in a global economy is quantitative, achievement data. Internationally, student scores on the Trends in International Mathematics and Science Study (TIMSS) did not significantly increase from 1995 to

2007 (Gonzales et al., 2008). Data from the 2011 TIMSS indicated that of the 53 participating counties, United States (U.S.) fourth grade students scored on average below six countries and of 45 participating countries, U.S. eighth grade students scored below nine countries in science (Martin, Mullis, Foy, & Stanco, 2012). The Program for International Student Assessment (PISA) data indicated a more dismal state of science education in its 2009 study. It found that of the 34 member countries of the Organization for Economic Cooperation and Development (OECD), U.S. fifteen-year-old students scored below 18 countries and above only nine countries with statistical significance (Fleischman, Hopstock, Pelczar, & Shelley, 2010). In 2012, similar trends were noted as U.S. students scored below 19 of the 34 OECD member countries (OECD, 2013).

TIMSS data further indicated sex differences in scores. Grade four assessments assessed knowledge and skills in life sciences, physical sciences, and earth sciences. Females scored lower than males in all three components, differences being statistically significant. With respect to cognitive skills assessed, females scored lower than males in knowledge and applying. Grade eight assessments assessed the knowledge and skills in biology, chemistry, physics, and earth sciences. Females scored lower in all four components, with statistically significant differences in all of the components with the exception of biology. With respect to cognitive skills assessed, females scored lower in all domains (Martin et al., 2012). Even more troubling is that longitudinal trend data from the TIMSS indicated that males persistently earned higher scores than females. PISA assessment data from 2006 to 2012, however, did not indicate statistically significant gender differences in scores (OECD, 2013).

National assessment data mirror findings of the TIMSS and PISA assessments, further indicating that U.S. students are underperforming in science. Like the TIMSS data, national testing data from the National Center for Educational Statistics (NCES) indicated similar sex differences in science achievement scores. Data from the 2009 National Assessment of Education Progress fourth grade science assessment indicated that 35% of males and 32% of females and, in eighth grade, the gaps widened to 34% of males and 27% of females scoring proficient or above (NCES, 2010). Similar gaps were also evident in the 2011 data. Data from the 2011 National Assessment of Education Progress eighth grade science assessment, for example, found that 34% of males and 27% females scored proficient or above (NCES, 2012). While increasing students' proficiency levels is outside the scope of this study, the context is worth noting because these persisting deficiency trends may also negatively inform students' perceptions of their abilities in science and limit the types of courses they choose to take in high school (Zimmerman, 1995).

This is problematic as taking an increased number of challenging, advanced level science courses has been highly associated with the likelihood of increasing proficiency in STEM-related subjects (NCES, 1997). High school science course participation trends already suggest that many students do not have access to or fail to take advantage of such courses. For example, in 2011, only 36% of high school graduates nationwide took physics and 28% took earth sciences, in comparison to much higher participation percentages in biology and chemistry, at 77% and 70% respectively (NCES, 2012). Furthermore, participation in Advanced Placement (AP) courses indicated differences. While 22% of students nationwide participated in AP biology courses, only 6% took AP chemistry and 6% took AP physics (NCES, 2012). Nationwide, even fewer students participated in AP Environmental and, currently, there is no AP course offered in earth sciences (College Board, 2014). Girls may be even more vulnerable to the influence of persisting gender gaps in achievement trends, using them to validate gender constructs and stereotypes that associate males with science and females with humanities (Lane, Goh, & Driver-Linn, 2012; Nosek, Banaji, & Greenwald, 2003), limiting their perceptions of possible educational and career paths (Sonnert & Holton, 1995).

Girls' science course participation trends may also suggest that such an influence is already affecting how they act upon these trends. For example, female students are increasingly participating in biology majors (National Science Foundation [NSF], 2013). As AP course participation is highly associated with pursuance of related fields, it is not surprising that more females took the AP Biology examination nationwide in comparison to male students (College Board, 2014). In physical science majors, however, female students, remain underrepresented (NSF, 2013), perhaps foreshadowed by their low participation rates in AP physical science courses. In 2013, female students constituted 47% of the students who took the AP Chemistry examination and only 36% of those who took the AP Physics (College Board, 2014). More specifically, the low participation rates in physics is problematic as physics is a prerequisite for almost all science and engineering fields, including those in earth sciences (Cornell University Physics Teacher Education Coalition, 2011) as it, fundamentally, provides a strong foundation for continued growth in a variety of careers (American Physical Society, 2014).

These declining participation rates from biology to chemistry, and then further decline from chemistry to physics, further suggest the persisting influence of gender constructs and gender role socialization. The overrepresentation of girls in biology, for example, may be a result of biology being considered more feminine than physical sciences (Cervoni & Ivinson, 2011; Jones, Howe, & Rua, 2000). Furthermore, girls may be given guidance to pursue courses and careers that align to these gender constructs (Burger & Sandy, 2002; Hackett, 1995). An understanding of state and local contextual factors, however, is needed to further examine how girls, as a function of gender, are interpreting and acting upon these persisting trends and their own science educational experiences.

New Jersey Science Education and STEM

New Jersey (N.J.), in comparison to other states in the nation, has more promising data regarding students' science achievement outcomes. Science assessment data indicate that N.J. students, on average, are achieving in science. Using data from the TIMSS scores to measure science achievement, N.J. is one of the top ten states in the nation (National Center of Educational Statistics [NCES], 2013). When compared internationally, N.J.'s students' average scores ranked below only five of the other countries on the TIMSS (NCES, 2013). Nationally, N.J.'s average scores on the NAEP science assessment were among the highest fifteen states (NCES, 2012). This achievement was also indicated on state assessments. As of 2014, science was assessed in grades four and eight through the New Jersey Assessment of Skills and Knowledge (NJ ASK) based on the 2009 Science Core Content Curriculum Standards. Data from these assessments indicated that the vast majority of N.J. students were proficient in science (N.J. Department of Education [DOE], 2012). In addition, N.J. is currently ranked among the top ten states with the most students succeeding on Advanced Placement (AP) examinations and participation in AP courses increased approximately 80% from 2003 to 2013 (College Board, 2014). Of its 34 different AP examinations taken in 2013, the science concentrations accounted for approximately 40% of all tests taken (College Board, 2014).

While these scores and data analyses are promising, workforce and educational trends nationally cannot be ignored and educational systems need to continue to strive for improvement to meet sustainability issues and related social, political, and economic demands. The N.J. DOE, for example, continues to espouse its vision of increased achievement in STEM education. Chris Cerf (2011), former N.J. Commissioner of Education, stated that N.J. "will work collaboratively to define the content and practices that students will need to learn from kindergarten through high school graduation, to ensure all students graduate from high school ready for college and career... and to continue to ensure that New Jersey is a national leader in STEM education" (para. 2). As evidence of its continued commitment to increasing student achievement and participation in science, N.J. joined 19 other states as Lead State Partners in the Next Generation Science Standards (NGSS) initiative in 2011 and later adopted the NGSS in July 2014.

State Policy, Standards, and STEM

The adoption of the Next Generation Science Standards (NGSS) will play a vital role in shaping the state's future educational policies, practices, assessment, and accountability measures. Achieve, Inc. (2011), the sponsor of the standards, stated that "the inclusion of science practices in N.J.'s 2009 science standards has the potential to serve as a bridge between N.J.'s 2004 standards and the anticipated structure of the

NGSS, therefore the state would be well positioned for adoption" (Commitment section, para. 1). The 2009 Science Core Curricular Content Standards (CCSS) had the goal of preparing students for college and careers through their development of "knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity" (N.J. Department of Education [DOE], 2009, p. 1). Like national science education standards, these standards emphasized students' ability to transfer these skills so that they may make responsible decisions, advocate for issues related to science and technology, and contribute to the workforce. Implementation of the NGSS will continue to support these goals with an increased emphasis on the interdisciplinary nature of STEM literacy development. The standards' increased demands for earth sciences and a broader scope of curricular programs (Achieve, 2013; National Research Council, 2011) will, no doubt, have implications for practice. While it seems that N.J. has built a foundation from which to build a stronger science educational program, underlying issues, gleaned from closer examination of NJ Assessment of Skills and Knowledge scores and Advanced Placement science course participation, may threaten the achievement of those goals. If left unresolved, N.J. girls may continue to be marginalized in science.

Problems in New Jersey Science Education

With respect to achievement, the fourth grade 2012 NJ Assessment of Skills and Knowledge data indicated that approximately the same percentage of male and female students scored proficient or advanced proficient in science, 91.8% females and 90.8% males. Upon closer examination of the advanced proficient scores on state assessments, males scored higher than females, 46.1% and 43.1% respectively. Similar trends were noted in eighth grade, but the difference in advanced proficient scores widened to 35.3% males and 29.5% females (N.J. DOE, 2012). Sex achievement gaps at the advanced levels, then, are widening with respect to increasing grade levels. These proficiency score differences suggest the need to examine such trends as a function of gender.

With respect to participation, fewer N.J. female high school students than male students pursue advanced physical science courses, regardless of previous achievement levels. N.J. Advanced Placement (AP) examination data mirrored national data regarding gender participation inequalities. More female students than male students participated in the AP Biology examination, 59% and 41% respectively. In physical sciences, male students participated more than females, 53% and 47% respectively in AP Chemistry and 64% and 36% respectively in AP Physics (College Board, 2014). The sex gaps in participation may further suggest the influence of gender related implicit biases regarding girls' perceptions of potential science course paths. Without exposure to advanced physical sciences, girls lack the opportunities needed to develop competency and interest in the subjects, denying them the foundation to pursue more advanced STEM courses (American Physical Society, 2014; Cornell University Physics Teacher Education Coalition, 2011)

Furthermore, girls' limited access and exposure to physical sciences, may hinder their development of efficacy beliefs needed to consider related degrees and careers as potential options (Bandura, 1977), thus, perpetuating the gender inequalities evident in current course, degree, and career trends. The recent adoption of the NGSS is an opportunity for change. Reexamination of curricula, instructional practices, recruitment, and advisement procedures for girls with respect to advanced physical science course enrollments is needed (Burger & Sandy, 2002; Hackett, 1995) to inform how the NGSS' implementation may help to address both current and emergent issues.

Local Level Science Education and STEM

New Jersey's (N.J.) adoption of the Next Generation Science Standards (NGSS) is an opportunity for school districts and teachers to use the standards' shifts in disciplinary content, skills, and learning outcome expectations as vehicles through which to address current inequalities in girls' achievement and participation trends. While N.J.'s achievement data trends indicated that girls were achieving in science, they persistently achieved at a lower level than boys and were less likely to pursue courses in physical sciences. The implementation of the NGSS is an opportunity to examine how we can use the standards' increased emphasis on earth sciences to reduce barriers to girls' achievement and participation in advanced physical science courses.

The NGSS' increased expectations for earth sciences also has implications for the local school context. Whether school districts choose to integrate earth sciences into existing courses or create new course offerings, teachers will need guidance, support, and collaborative forums to manage these changes (Cooper, 2013; Krajcik, 2013; Lederman & Lederman, 2014). Partnerships with scientific organizations may serve to facilitate the implementation of the NGSS through the provision of resources and expertise (Ejiwale, 2012; Watters & Diezmann, 2013). Federal STEM educational programs, such as Educate to Innovate, also support the development of partnerships between schools and colleges or other private institutions to share expertise, resources, and research opportunities (Obama, 2009).

With respect to gender equality in science participation, several scientific organizations, including the National Science Foundation, the National Oceanic and Atmospheric Administration, and the American Meteorological Society (AMS), have included an educational partnership component in their missions with the goal of increasing participation of traditionally underrepresented student populations in science fields, particularly those related to earth and physical sciences. Many of these programs focus on teacher development and provision of resources that teachers may integrate into the K-12 science courses that they teach. The question remains, how may these resources be integrated to best promote girls' participation in advanced physical science courses?

Partnerships and the DataStreme Project

The DataStreme Project is one element of the American Meteorological Society's (AMS) Education program that seeks to increase gender equality in the workforce. Through further preparing K-12 teachers, the program seeks to affect student outcomes, particularly those of traditionally underserved populations like girls, by supporting their STEM literacy development, increasing their interest in earth sciences, and expanding their career awareness (Brey, 2009). In the 1980s, the National Science Foundation awarded the AMS Education program with a grant to fund the creation of its DataStreme Project. In 1991, the National Oceanic and Atmospheric Administration (NOAA) also awarded the AMS grant money, forming the AMS/NOAA Cooperative Program for earth sciences. This partnership will continue through 2016 to ensure continuation of the DataStreme Project.

The DataStreme Project is a national program that promotes earth science education through courses for K-12 teachers. The resources used in the courses may, then, be used with those teachers' students. The DataStreme Project currently offers three courses for teachers, Atmosphere, Earth's Climate System, and Ocean. These 13-week courses include meetings, text readings, and online investigation activities. The courses focus on the use of real-time information and data and their application across science curricular and instructional practices. Participants document classroom applications of the materials and resources as well as design a plan on how they will exhibit characteristics of a teacher leader. Many of the DataStreme activities themselves are technology-based and include exploratory prompts that require students to use the data from NOAA and other scientific agencies to explore, explain, and make predictions about earth science phenomena.

In New Jersey, AMS offers DataStreme courses in Atmosphere and Ocean. Each year, approximately 80 teachers are enrolled in the courses. The number of new teachers and those completing more than one course is increasing over time, thus, exponentially increasing girls' potential exposure to the program's resources. Program evaluation focuses on teacher outcomes. Findings indicated that the courses positively influenced teachers' pedagogical attitudes and content knowledge. In addition, teachers were interacting and sharing the information and resources with peers (Weinbeck et al., 2006). To date, no data regarding student outcomes or perceptions of the activities have been conducted.

For the partnership between the AMS DataStreme Project and local school districts to reach its goals of integrating earth sciences in high school curricula to increase girls' participation in physical science courses, the integration strategies and girls' perceptions of the resources' relevance and influencing factors that inform their potential science course pursuits need to be considered. First, an understanding of how to integrate these resources into existing curricula is needed. Since there is no uniform way to implement the resources, attention to girls' perceptions of specific task's aspects and resources that are integrated into a lesson or unit may provide a foundation from which to build and study subsequent lessons and units across science domains that incorporate the resources. Second, a deeper understanding of how girls make sense of their potential science course pursuits is needed to design lessons using the resources that are responsive to girls' needs. In doing so, we may better support the realization of the partnership's goal of integrating earth sciences into school curricula in a way that also increases girls' participation in advanced physical science courses.

Problem Statement

Global sustainability issues threaten human welfare worldwide. A STEM-literate society would have the knowledge, skills, and dispositions, particularly as they relate to earth and physical sciences (American Physical Society, 2014; Cornell University Physics Teacher Education Coalition, 2011), to work toward remediating these threats through personal and professional actions. It is from this society, that the workforce draws its potential contributors. The success of such a workforce in addressing sustainability issues is dependent on the competency and availability of its potential contributors.

There are concerns, however, about the competency and availability of a STEM-literate workforce. Competency concerns emerge as businesses express concerns about the workforce and oftentimes need to provide training to remediate deficiencies in preparation (Atkinson, 2012; Feinstein, Allen, & Jenkins, 2013; U.S. Department of

Commerce, 2011). Students' low scores on international, national, and state science assessments fuel competency concerns (Fleischman, Hopstock, & Pelczar, 2010; Gonzales et al., 2008; Martin, Mullis, Foy, & Stanco, 2012; National Center for Education Statistics [NCES], 2012). Scientific organizations also express concern that workforce demands may exceed the supply (National Science and Technology Council, 2013). Availability concerns are compounded as women are persistently underrepresented in STEM fields, representing only 28% of the STEM workforce (National Science Foundation [NSF], 2014). Persisting gender inequalities are a basic infringement to social justice and deny the workforce with a large pool of potential contributors. These concerns suggest a misalignment between educational preparation and workforce needs as well as transitional barriers from educational to workforce settings.

To address these concerns, attention is turned to science education as it is recognized as a key component of preparing students to promote sustainability through participation in a global economy (American Competitiveness Initiative, 2006; National Academy of Sciences, 2005). Nationally, many high school students lack exposure to opportunities to develop sustainability-related STEM literacy and knowledge. Graduation requirements indicate that only one state in the U.S. required a full year of earth sciences and only 27 states required a full year of physical sciences (American Geosciences Institute, 2013). Moreover, girls seemed to be more vulnerable to these trends as they were persistently underrepresented in physical science related courses and degrees (College Board, 2014; NSF, 2013). This is problematic because participation in courses is highly associated with future proficiency and pursuit of related educational and career opportunities (NCES, 1997; College Board, 2014).

To that point, without exposure to advanced earth and physical science courses, girls are denied the opportunities to develop the sufficient agency beliefs to consider and pursue advanced science courses, thus further limiting their future opportunities and potential to contribute to the workforce (Bandura, 1977; Hackett, 1995). The continued observance of gender inequalities in participation may also lead to the premature dismissal of related educational and career paths, regardless of past achievement levels (Sonnert & Holton, 1995). These trends, then, may suggest the influence of gender constructs on girls' perceptions of science course pursuits.

New Jersey (N.J.) girls' participation trends in advanced science courses may provide evidence of these effects. While science achievement data indicate that the majority of female students are proficient in science, far fewer females than males are enrolling and participating in physical science courses (College Board, 2014). A key question is why do high school girls who are achieving in science choose to not take advanced physical science courses. More specifically, how do girls make sense of their perceived STEM self-efficacy and perceptions of potential science course pursuits?

N.J.'s recent adoption of the Next Generation Science Standards' (NGSS) is an opportunity for educators to implement the standards in a way that meets increased expectations for earth sciences and promotes gender equality in physical science course participation. Implementation of the NGSS will have implications for content, student learning expectations, and course offerings. With respect to these changes, educators will need further guidance and support (Cooper, 2013; Krajcik, 2013; Lederman & Lederman, 2014).

Partnerships between scientific organizations and K-12 school settings may help with these changes through sharing of expertise and provision of resources (Ejiwale, 2012; Obama, 2009; Watters & Diezmann, 2013). As such, various scientific organizations' missions now include an educational component with the goal of increasing equality in science participation. The DataStreme Project is one part of the American Meteorological Society's educational program with the goal of encouraging underserved populations, particularly girls, to pursue careers related to earth sciences. The DataStreme Project provides teachers nationwide with weather related materials and access to real time data to integrate into curricula. In N.J. alone, there are approximately 80 new teachers who participate each year and enrollment is increasing, thus, exponentially increasing potential influence on students' learning.

To date, evaluation of the DataStreme Project has focused on teacher outcomes. While these findings are promising (Weinbeck et al., 2006), the voice of girls, those who are interpreting and acting upon these resources, are absent from discussions regarding resource implementation and its influence on their perceptions of potential science educational and career pursuits.

Teachers who seek to integrate the DataStreme course resources into their lessons would benefit from a better understanding of how girls' perceive, interpret, and act upon the use of such resources. Questions such as *if* and *how* the DataStreme Project's resources support high school girls' perceived STEM self-efficacy and enrollment in subsequent physical science courses are key to this inquiry.

The development of STEM literacy is not sufficient to increase gender equality in physical sciences as evidenced in the quantity of N.J. high school girls who are achieving in science, but not pursuing advanced physical science courses. Girls' failure to pursue such courses denies them the needed exposure and opportunities to develop STEM literacy as it relates to earth and physical sciences. As mastery experiences are highly associated with higher efficacy beliefs and potential for future pursuance of related subsequent courses and careers (Bandura, 1977), a deeper understanding of how gender and specific science resources inform girls' STEM-related efficacy-activated processes is needed. In addressing these research problems related to efficacy beliefs, we may better address the practical issue of how, through science educational opportunities, we may reduce barriers to girls' participation in physical science fields.

Purpose of the Study

The purpose of this mixed methods study was to examine how gender and science classroom tasks inform the efficacy-activated processes of high school girls' perceptions of potential science course trajectories. This sequential design first collected quantitative data using a survey to describe the associations between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits. This phase sought to determine the extent to which associations aligned to the underlying efficacy assumptions of social cognitive theory The qualitative phase followed-up with criterion cases using open-ended task surveys, focus groups, and interviews to further explore girls' perceptions of science classroom tasks and factors that influence their science course selections. In addition, field notes and research journal data sources were collected to supplement qualitative data's descriptions and to allow for racketing of potential biases during analyses (Ahern, 1999; Borg, 2001). An embedded feminist lens sought to illuminate possible external and internal factors that served to narrow or expand girls' perceptions of potential science course options. The purpose of collecting both quantitative and qualitative data was to use the qualitative data to explain the quantitative results, invite dialog, and to gain a deeper understanding of the problem than would be obtained by a purely quantitative or qualitative study (Greene, 2012; Johnson & Onwuegbuzie, 2004).

1. What associations, if any, exist between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?
2. What factors do high school girls identify as informing their science course pursuits?
3. How do high school girls negotiate those factors?
4. What aspects of the DataStreme task do high school girls identify as informing their perceived STEM self-efficacy?
5. How do high school girls describe that these aspects achieve such influence?
6. How do high school girl's perceptions of influencing factors and DataStreme task aspects complement and expand our understandings of the associations found between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?

Definition of Terms

The following terms are defined in terms of this study's purpose.

Agency. The term *agency* is used to define a specific set of efficacy-activated processes related to action. Agency "involves not only the deliberate ability to make choices and action plans, but the ability to give shape to appropriate courses of action and to motivate and regulate their execution" (Bandura, 2001).

Gender. The term *gender* is defined as "the roles and responsibilities of men and women that are created in our families, our societies and our cultures…[and] includes the expectations held about the characteristics, aptitudes and likely behaviours of both women and men (femininity and masculinity)" (UNESCO, 2003, para. 1).

Gender construct. The term *gender construct* is defined as a concept that "ascribes different qualities and rights to women and men regardless of individual competence or desires" (Johnsson-Lathem, 2007, p. 17).

Perceived self-efficacy. The term *perceived self-efficacy* is defined as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations. Efficacy beliefs influence how people think, feel, motivate themselves, and act" (Bandura, 1995, p. 2). It is different from confidence in that it is context and domain-specific, grounded in a larger theoretical framework of efficacy-activated processes (Bandura, 1993).

Efficacy-activated processes. The phrase *efficacy-activated processes* are defined as the interpretive processes related perceived self-efficacy. Cognitive, motivational, affective, and selection processes all interplay and influence perceived self-efficacy and may be interpreted differently as a function of gender (Bandura, 1995).

Theoretical Framework

Social cognitive theory, with an embedded feminist lens, informed the identification of the research problem and all subsequent research phase decisions. In light of persisting gender inequality trends, the use of a social cognitive theory framework with an embedded feminist lens recognizes the influence of both external and internal factors as a function of gender on perceptions of potential educational and career options. This framework, however, does not view girls' educational and career paths as deterministic and, as such, assumes that certain factors that limit human agency are playing a vital role in the currently observed STEM educational and career trends. See Figure 1 for this study's theoretical framework.

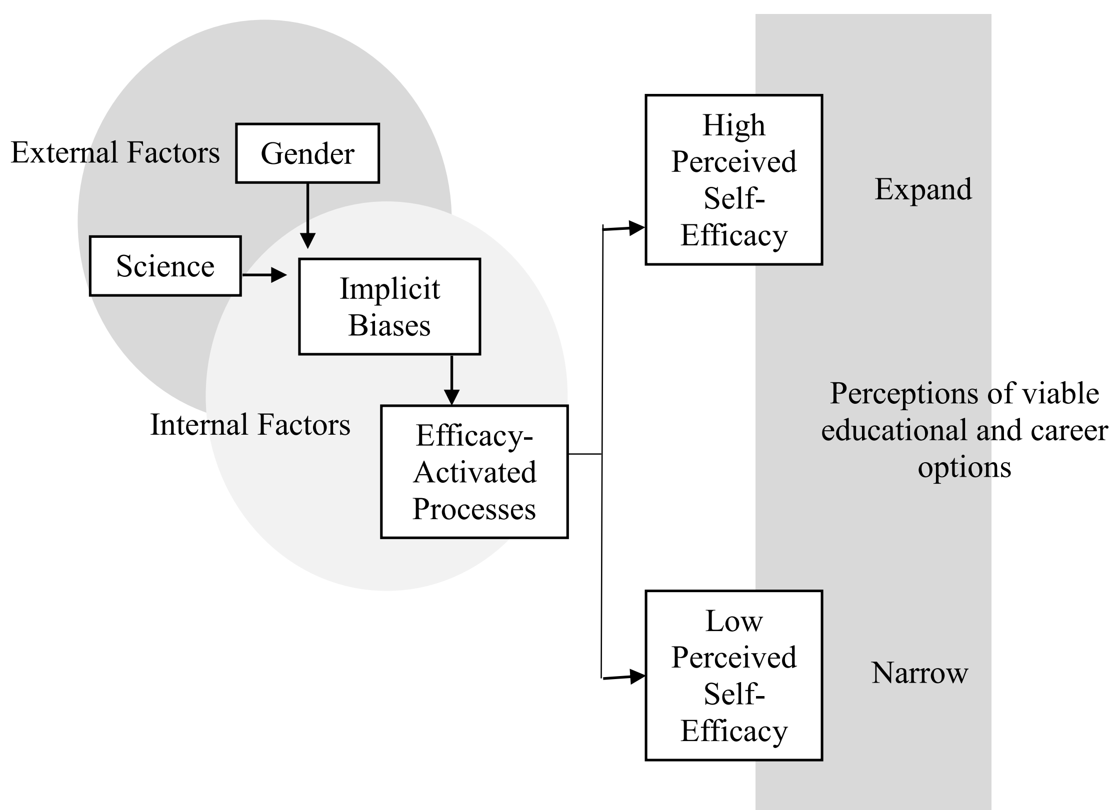

Figure 1. Theoretical framework.

Social cognitive theory deals with agency and posits that people “are producers as well as products of social systems” (Bandura, 2001, p. 1). Self-efficacy is a core concept of social cognitive theory. Self-efficacy levels "determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (Bandura, 1977). High self-efficacy is related to perseverance and success as the individual is more likely to exert effort and experience less frustration when confronted with challenges. Likewise, low self-efficacy does not support perseverance. Multiple underlying cognitive, motivational, affective, and selection processes and related theories influence the development of an individual’s perceived self-efficacy (Bandura, 1995). With respect to this study, these interpretive processes may, then, serve to expand or narrow girls’ perceptions of their STEM educational and career options.

While the role of gender has been identified as a possible influential factor in the application of social cognitive theory (Bussey & Bandura, 1999), how it informs efficacy-activated processes and subsequent agency beliefs is less clear. A feminist lens through the use of practice theory, was embedded into this study’s use of a social cognitive theoretical framework to further explore how gender informs efficacy beliefs. Practice theory posits that social and political power structures may serve to perpetuate injustices and inequalities. It focuses on human agency in the context of a “system” of social and political institutions that has an influence on “*both* the ways in which people think ('the culture') and the ways in which people experience and act upon their environment" (Ortner, 1984, p. 134). As such, this framework further draws attention to both external and internal factors related to gender and science educational experiences to better understand how gender and science course aspects inform the efficacy-activated processes related to perceptions of potential science course pursuits.

Significance

Education plays an integral role in enacting social justice through provision of equitable preparation for students' to enter and be successful in the workforce. Science knowledge and skills, alone, are insufficient to promote gender equality. There is a need to better understand the efficacy-activated processes underlying girls' perceived STEM self-efficacy in relation to their conceptualizations of viable course options. In addition, there is a need to understand how specific aspects of learning tasks narrow, maintain, or expand their conceptualizations of viable course options. In doing so, we may begin to dismantle practices that stifle self-efficacy and perpetuate inequities in learning opportunities. With these goals in mind, this study's findings may be used to inform policy, practice, and research.

Policy

First, the American Meteorological Society's (AMS) DataStreme Project coordinators may use the findings to reflect upon resources and how they promote gender inclusiveness. This evidence may be used to justify needed changes to the program's facilitation and resources regarding alignment to factors that contribute to girls' perceptions of self-efficacy and viable course options. Second, as this study explores girls' perceptions of educational materials that teachers received during the AMS's DataStreme courses, findings may also be used to advocate for policies regarding increased funding, grants, partnership opportunities, and future research opportunities. An increase in such opportunities would further reduce resource inequities that exist among our schools, foster collaboration between schools and scientific organizations, and promote policies responsive to the diverse needs of our student populations. Findings may also be used to inform educational policies regarding the integration of earth science resources to meet the expectations of the Next Generation Science Standards. Understanding how students develop perceptions of the STEM self-efficacy may aid in continued development and implementation of standards that are more gender-inclusive of all students. Similarly, findings may be used to inform educational policies regarding curricula, partnerships, resources, and funding at the school level.

Practice

First, this study's findings may be used to inform educators' decisions about how to use the DataStreme Project resources to foster girls' perceived STEM self-efficacy. Findings of this study are not limited to use of resources solely from the DataStreme Project. As there is no magic bullet in education, educators may be able to relate this study's findings to their own practices, considering the unique traits and characteristics of their planned learning tasks and student population. Second, the findings from this study may inform the development and use of more gender-inclusive pedagogical practices. Third, this study may serve as a model for examining girls' agency beliefs in relation to other lessons, programs, or instructional strategies. Educators may replicate similar procedures in professional learning communities, using their own student data to engage in reflective practice and action research to best meet their students' needs.

Research

First, this study's findings may be built upon to further explore the girls' perceived self-efficacy development in science. This study primarily focused on perceptions of viable educational options, using self-reported measures of self-efficacy. Future studies could be designed to delve further into other cognitive processes related to those self-reported levels of self-efficacy. For example, self-reported levels of self-efficacy could be compared to other sources of self-efficacy such as measured achievement, observed physiological reactions, level of involvement in visualization of tasks, and influence of social persuasion to examine the quality of girls' analytic thinking. Such studies would provide further insight into the role of implicit biases on metacognitive skills in relation to specific interventions in the classroom setting and perceived self-efficacy.

Second, this study's findings may also contribute to the larger academic discussion surrounding conceptual change. Conceptual change is gaining interest in the literature surrounding students' achievement and development in science education. Conceptual change research seeks to better understand "how students' conceptions change under the impact of new ideas and new evidence" (Posner, Strike, Hewson, & Gertzog, 1982, p. 212). Drawing from their review of literature, Pintrich, Marx, and Boyle, (1993) identified major components needed for conceptual change to occur as: (a) classroom context, (b) cognitive factors, (c) motivational factors, and (d) conditions for conceptual change. This study specifically focused on perceived self-efficacy, identified as one of many motivational factors in this framework. Future studies could further examine the interplay among these various components in relation to students' conceptual change. Moreover, a specific focus on girls or comparative studies between boys and girls would further illuminate the role gender plays in girls' future science course, degree, and career trajectories.

Third, this study’s use of mixed methods may be used to contribute to the ongoing discourse surrounding paradigmatic considerations in research. Follow-up studies regarding design and methods on a similar topic may further refine the strategies employed in this study. By exploring other strategies and comparing findings, strengths and weaknesses to these decisions may be identified to contribute to a broader framework for conducting rigorous mixed methods research.

Limitations and Delimitations

A researcher's underlying ontological and epistemological beliefs shape paradigmatic assumptions regarding what reality is, what one may know about reality, what the researcher's position and role is, and how one learns about reality (Guba & Lincoln, 1994). From the lenses of the quantitative and qualitative paradigms, the answers to these questions may be quite polarized, resulting in studies of the same phenomenon that have unique sets of validity measures, affecting methods, significance, and perceived usefulness of a study's findings. The notions of paradigmatic assumptions, as Guba & Lincoln (1994) described, are "human constructions", meaning that no one paradigm is superior to the other by nature but rather through persuasion (p. 108).

The use of mixed methods, then, "most importantly offers dialogic opportunities to generate better understanding of important social phenomena *precisely because it legitimizes and respects multiple responses to these critical issues and invites dialogue among them*" (Greene, 2012, p. 757). As a result of this study's sequential design, it had both limitations and delimitations. These limitations and delimitations notwithstanding, the mixed methods approach can capitalize upon the strengths of each paradigm in a way that fosters complementarity and expansion (Collins & Onwuegbuzie, 2007; Greene, Caracelli, & Graham, 1989).

Generalization Versus Transferability

As it was not feasible to sample the entire student population involved in the DataStreme Project, the sampling methods were purposive. Purposive sampling methods in the quantitative strand do not support generalization to the larger population (Collins & Onwuegbuzie, 2007). Another limitation of the study is that its focus on a singular moment in time weakens its generalizability.

The study, instead, opted for transferability. The study not only may be used to "capture local idiosyncrasies", but also may be replicated in other settings to take into consideration their unique contextual factors (Remler & Van Ryzin, 2010, p. 141). The use of this study with similar studies conducted over time that include more emphasis on observations and interactions with participants may, qualitatively, aid in creating generalizable knowledge. Likewise, Remler and Van Ryzin (2010) noted that "small, confined, or highly self-selected samples can still be important - it may be part of a broader field of research that leads, eventually, to generalizable knowledge" (p. 142).

Causation Versus Essence

The study does not seek to predict or identify causal relationships among variables. It, instead, seeks to cover "depth and breadth" in the relationships between the variables using both quantitative and qualitative data sources (Tashokkori & Teddlie, 2003, p. 180). A larger sample size was chosen to allow for statistical analyses in the quantitative component (Remler & Van Ryzin, 2010, p. 165). A smaller sample size, however, was chosen for the qualitative component to increase the depth of information.

Tashakkori and Teddlie (2003) referred to this type of decision as the representativeness/saturation tradeoff: "as more emphasis is placed on the representativeness of the QUAN sample, less emphasis can be placed on saturation of the QUAL sample, and vice versa" (p. 184). This study's initial findings, then, could serve as preliminary considerations for future studies that make different decisions about the representativeness/saturation tradeoff to deepen understandings of potential causal relationships and intricacies of the essence of the studied phenomenon.

Organization of the Dissertation

Grounded in a pragmatic paradigm, the purpose of this mixed methods study is to examine the efficacy-activated processes related to girls' perceptions of viable science course options. It also seeks to examine the complementarity and expansion potentials of using mixed methods. This dissertation consists of six chapters. This first chapter sought to situate the research problem in the context of the larger social issue of sustainability and science education. It briefly described the purpose of the study, significance, related theories, and delimitations and limitations of findings. Chapter Two will further describe this study's theoretical framework and review literature related the manifestation of implicit biases of science and gender in the science educational context and how they inform students' efficacy-activated processes. Chapter Three will describe the study's methodology. Chapter Four will communicate the study's overall findings. Chapter Five will discuss findings, limitations, and implications for policy, practice, and research.

Chapter 2

Literature Review

As sustainability issues increase worldwide, there is urgency to prepare a capable and available STEM workforce. Student achievement data for science is often cited as evidence of our educational system's failure to prepare such a workforce (Fleischman, Hopstock, Pelczar, & Shelley, 2010; Gonzales et al., 2008; Martin, Mullis, Foy, & Stanco, 2012). Data regarding sex differences in achievement scores, advanced science course enrollments, degree attainments, and career pursuits are further used to critique our educational system's inability to bridge students', especially girls', educational experiences and preparation to workforce needs (Atkinson, 2012; Feinstein, Allen, & Jenkins, 2013; U.S. Department of Commerce, 2011). Missing from these critiques is an explanation of these trends as a function of gender.

The overemphasis on quantitative data provides little insight into potential practices, structures, or behaviors related to the science educational environment that are perpetuating these inequalities. Current achievement tests in New Jersey (N.J.), for example, assess the extent to which students have acquired the knowledge and skills that the N.J. Core Content Curriculum Standards define for an individual to be scientifically-literate. Findings from these assessments provide little information about other cognitive, affective, and motivational attributes that, ultimately, influence girls' decisions to pursue STEM courses, degrees, or careers. Similarly, data regarding the number of females enrolling in advanced STEM courses or pursuing STEM degrees or careers do not provide information about various internal and external factors related to gender that promoted or impeded their outcomes. Without a qualitative lens, girls, those who directly and indirectly interact and perceive the factors that impact their future behaviors, are kept silent. While quantitative data provides useful insight into patterns and associations among variables, the story behind the numbers is largely being ignored.

The purpose of this chapter is to, first, provide a background of the dominating viewpoints of why gender inequalities exist in STEM fields. While the study acknowledges the existence of structures that perpetuate inequalities, it is grounded in the assumption that those structures alone are not determining factors of life and career paths. Drawing from a social cognitive theoretical framework with an embedded feminist lens, the reviewed literature sought to identify how gender interplays with girls' science educational experiences to influence their perceived self-efficacy and subsequent perceptions of potential science course, degree, and career options. This chapter concludes with a synthesis of key concepts and identifies how this study builds upon those concepts and addresses gaps gleaned from the literature review.

Pipeline or Gender Filter?

The "leaky pipeline" often characterizes STEM careers because at multiple points of life tracks, more females than males discontinue pursuit of STEM degrees and careers (Sonnert & Holton, 1995, p. 8). Formal structures, such as laws, policies, and other agreements, have the potential to inhibit equality. Historically, the civil rights movement in the U.S. led to changes in legislation and other structures to promote gender equality. Before the adoption of Title IX, for example, girls did not have equal access to courses in science and math (Robelen, 2011). This was problematic in that girls were not given the opportunities to pursue specific coursework in middle and high school that were found to be related to keeping girls in the pipeline toward pursuance of STEM degrees and careers

(Adelman, 2006; Hanson, Schaub, & Baker, 1996). While formal structures are being dismantled, gender inequalities, as evidenced in STEM career and degree data, persist.

Informal structures, then, may continue to perpetuate gender inequalities in career and educational settings. Informal structures include, but are not limited to, less access to mentors, fewer promotions, lower teacher expectations, discrimination, and tokenism (Sonnert & Holton, 1995). A school's culture and values reflect particular cultural values that, if one is part of that culture, will have the advantage of growing up in a way that better prepares them to be successful in a school environment rooted in those shared values (Macleod, 1995). As gender constructs are socially-constructed, cultural values play a large role in determining gender appropriateness and the value placed upon gender identity and gender role socialization (Rogoff, 2003). Any disconnect between values may perpetuate inequalities through lower teacher expectations for certain populations, insufficient support, and inappropriate course, degree, or career advisement in the educational setting (Burger & Sandy, 2002; Hackett, 1995). Furthermore, these informal structures may have an indirect effect on girls and women in that their awareness, conscious or unconscious, of their existence may discourage them from considering science degrees and careers as viable options in the first place (Sonnert & Holton, 1995; Tai, Liu, Maltese, & Fan, 2006).

While these formal and informal structures may present challenges for girls and women, literature has found that internal factors, those that "lie within women themselves", have more of an impact on girls in earlier points in their life paths (Sonnert & Holton, 1995, p. 3). With respect to internal factors, gender plays a vital role in how girls interpret and act upon their K-12 educational experiences and make sense of their future educational and career options (Bussey & Bandura, 1999).

Research on the exit points of the leaky pipeline overwhelmingly emphasize the need to minimize the limiting effects of socio-cultural factors on educational and career trajectories in STEM domains (Barton & Tan, 2010; Blickenstaff, 2005). There is considerable agreement that awareness of gender constructs and roles begin at an early age as family and PreK-12 educational opportunities are most likely to influence girls' perceived STEM self-efficacy (Sonnert & Holton, 1995; Valian, 1999). To further examine this phenomenon, research has also focused on motivational components (Eccles, 1994; Pintrich & DeGroot, 1990; Martinez & Guzman, 2013; Simpkins, Davis-Kean, & Eccles, 2006), agency (Metcalf, 2010), and science identity development (Barton & Tan, 2010; Carlone & Johnson, 2007; Urrieta, 2007).

As the discourse surrounding this phenomenon expands, so does discussion surrounding whether or not the leaky pipeline metaphor is serving to reduce or perpetuate gender inequalities. The leaky pipeline metaphor has been used to promote policy regarding interventions to increase the number of women in STEM fields (National Academy of Sciences, 2007). Yet, in light of persisting gender inequalities, critics of the metaphor question the appropriateness of the metaphor itself and warn that it may instead perpetuate injustices through limiting the scope of potential policy interventions (Blickenstaff, 2005; Cannady, Greenwald, & Harris, 2014; Metcalf, 2010). For example, past literature and studies are limited in their ability to account for those individuals who deviate from the general findings or who do not follow the traditional benchmark trajectories implied in the pipeline metaphor (Cannady et al., 2014; Metcalf, 2010). A “multiple pathway” metaphor may better represent the multiple trajectories that an individual may take to a STEM career while still encompassing the many influencing factors related to the pipeline metaphor (Cannady et al., 2014, p. 455).

Many external and internal factors contribute to the phenomenon of the gender pipeline. From this study’s feminist lens of a social cognitive theoretical framework, this literature review will further examine internal factors related to how gender informs girls’ efficacy-activated processes related to science course, degree, and career trajectories. As it has been suggested that the pipeline may be more appropriately represented as having a “gender filter”, this literature review also seeks to further understand how gender and the science educational context may lead to girls perceiving science curricula as irrelevant, uninviting, or not an option (Blickenstaff, 2005, p. 369).

Theoretical Framework

This study’s social cognitive theoretical framework with an embedded feminist lens served to provide a framework from which to examine the multiple efficacy-activated processes related to girls’ perceived STEM self-efficacy. Social cognitive theory considers four primary sources of self-efficacy and the related processes by which individuals interpret the sources to determine their perceptions of their abilities and agency in given contexts. Likewise, the feminist lens of practice theory allows further examination of how gender informs those interpretations and self-efficacy determinations.

Social Cognitive Theory and Feminist Lens

Social cognitive theory deals with agency and provides a framework from which to examine the factors that influence an individual’s sense of agency (Bandura 1977, 1995). Widely cited are Bandura's (1977) four primary factors that influence self-efficacy levels, mastery experiences, vicarious experience, verbal persuasion, and physiological states. He found that mastery experiences, past successes in a similar task, tended to predict self-efficacy in a future related task. Vicarious experiences, the ability to visualize or participate in a simulated activity with success, increased self-efficacy in similar future tasks. Verbal persuasion referred to the amount of support that one receives during a task in relation to outcomes. Physiological states referred to an individual's emotional and other physiological reactions to a situation. A task that produces anxiety in an individual who dislikes the feeling will more likely have a lower self-efficacy in a future similar task. On the other hand, an individual that is motivated by anxiety, having increased energy or drive, may have a higher self-efficacy.

Self-efficacy levels "determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (Bandura, 1977, p.1). It is different from self-esteem and self-concept in that "it involves judgments of capabilities *specific to a particular task*" (Hoy & Hoy, 2006, p. 144). Differences in the strength of sources for different individuals may result from the interpretative processes related to perceived self-efficacy (Bandura, 1995). Drawing from cognitive motivational theories, perceived self-efficacy beliefs influence agency in that "they determine the goals people set for themselves, how much effort they will expend, how long they persevere in the face of difficulties, and their resilience to failure" (Bandura, 1995, p. 8). They, then, also have a narrowing or expanding influence on an individual's perceptions of the scope of potential paths to follow.

Four key efficacy-activated processes that relate to perceived self-efficacy are cognitive, motivational, affective, and selection (Bandura, 1995). While there are not clear distinctions between these different types of processes, Bandura (1995) found that they interact and overlap in influence. He further described that (a) cognitive processes tend to relate to self-regulation and meta-cognitive skills, (b) motivational processes tend to relate to factors that individuals attribute to success and failure, expectations of outcomes, values, and goal setting, (c) affective processes relate to how varying levels of stress in different situations affect performance, and (d) selection processes tend to influence an individual's perceptions of what future actions or choices are most likely to result in favorable outcomes. Perceived self-efficacy, then, is a dynamic interpretation of the varying sources of self-efficacy being filtered through these various processes. To narrow the scope of this literature review, it primarily focused on motivational and selection processes related to perceived self-efficacy.

Ultimately, the resulting perceptions of self-efficacy in a given context will relate to the type of agency, the subsequent action or behavior, that an individual or group will take. Social cognitive theory defines three different types of agency: personal, proxy, and collective. Personal agency is the resulting action of an individual in a given situation. The action must be intentional, result from interpreting and evaluating potential outcomes, and involve self-monitoring, motivation, and metacognitive skills (Bandura, 2001). As individuals are not always in a position to exercise control due to power relations or other factors, agency may result in advocating for another to exercise power. Proxy agency, then is when an individual seeks out the actions of another who has more power or control in a given situation. Collective agency is similar to personal agency, but it deals with group action. Bandura (2001) described the interaction of these types of agency as a triadic model of reciprocal causations (See Figure 2) where "internal personal factors in the form of cognitive, affective, and biological events, behavioral patterns, and environmental influences, all operate as interacting determinants that influence one another bidirectionally" (p. 14). With such a range of influencing internal factors, questions are raised regarding the interplay of gender, self-efficacy beliefs, and agency.

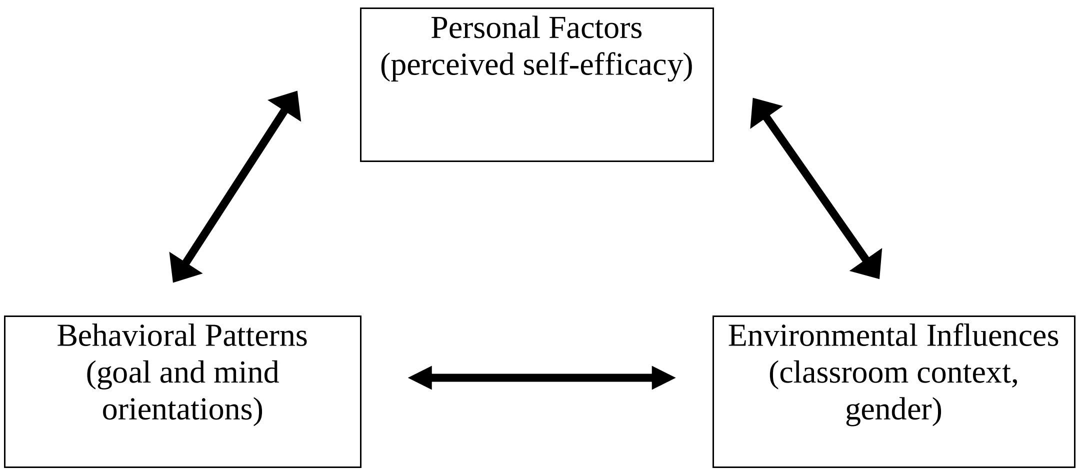

Figure 2. Triadic model of reciprocal causations in social cognitive theory.

Drawing from the principles of Bourdieu, Geertz, and others, the feminist lens of practice theory further considers the role of various political, economic, and social dimensions and other power structures that may serve to perpetuate injustices through their influence on self-efficacy determinations and related interpretive processes. As described in Ortner's (1984) widely cited article, *Theory in Anthropology Since the Sixties*, the way that the relationship between actors, individuals or groups, the actions that actors are undertaking, and larger structural entities evolves overtime. In earlier conceptualizations, there was a focus on symbols or economic structures and their impact on societal development and how actors behaved. Behaviors were considered outcomes of such developments. Little attention was given to the political and social nature of symbols or the processes by which they were created or maintained through actors' actions upon their interpretations of those symbols and processes (Ortner, 1984). Sadker and Zittleman (2005) offered a simple example to illustrate these points. They considered a typical classroom and its procedures. Oftentimes, students are divided into two teams, boys and girls, or asked to line up, boys in one line and girls in the other. They argued that such practices serve little academic purpose yet persist. Likewise, we would likely not see a teacher design teams or lines in such a way that White and Black students were divided. The example served to illustrate that practices, unintentionally, may contribute to gender biases and constructs in other settings.

This theoretical framework, then, examines the influence of gender on individual and collective agency. With respect to reducing gender inequalities in STEM, the application of social cognitive theory would assume that a strong sense of self-efficacy is needed to have the necessary effort and perseverance to pursue a STEM degree or career. While several sources are identified to inform self-efficacy belief development, they are, nonetheless, subject to the interpretive, efficacy-activated processes of the individual or collective that is making sense of them. As such, drawing from the feminist lens of practice theory, concerns about how girls' interpret and make sense of their efficacy and, subsequently, act upon them emerge. Applying this theoretical framework to educational research serves to better understand how gender informs the girls' perceptions of self-efficacy, task relevance, and potential science course enrollments.

Gender and Efficacy-Activated Processes

From these theoretical lenses, the reviewed literature in this section sought to understand what is known about the interpretive, efficacy-activated processes of perceived self-efficacy and how those processes relate to girls' behaviors in K-12 science educational settings.

Gender and Self-Efficacy

With respect to Bandura's (1977) four identified sources of self-efficacy, mastery experiences, in general, were consistently identified as the most predictive component of self-efficacy (Bandura, 1995; Britner & Parajes, 2006; Kiran & Sunger, 2012; Usher & Parajes, 2006). Less clear was the role that gender played in the strength of and interaction among these sources. Many studies found no differences in self-efficacy sources as a function of gender (Barnett, Vaughn, Strauss, & Cotter, 2011; Chen & Usher, 2013; Ricco, Pierce, & Medinilla, 2009). On the other hand, vicarious experiences had more of an influence on boys than girls (Usher & Parajes, 2008). Psychological responses, emotions, were also found to play a larger role in girls' self-efficacy development than for boys (Kiran & Sunger, 2012; Usher & Parajes, 2008). More specifically, girls tended to more often exhibit signs of depression and anxiety (Kiran & Sunger, 2012).

Differences in how these sources influence self-efficacy may be a result of related efficacy-activated processes inherent to how an individual develops their perceptions of their self-efficacy (Bandura, 1995). Resulting from different outcomes of these interpretative processes, outcomes between men and women varied in that they differed in motives for success, expectations for success, had different emotional reaction to success or failure, and developed different patterns of learned helplessness, all having an influence on perceived self-efficacy (Meece, Glienke, & Burg, 2006). As self-efficacy has been found to be domain-specific (Usher & Parajes, 2008), implicit gender biases related to specific domains may further complicate the meaning of these observed differences in strengths and interplay among various sources of self-efficacy.

Gendered Science

Traditionally, gender stereotypes associate males with science and females with humanities (Lane, Goh, & Driver-Linn, 2012; Nosek, Banaji, & Greenwald, 2003). In general, biological and socialization factors may play a role in the development of gender constructs and roles (Rogoff, 2003). Historically, as a result of biological differences, women tended to spend more time with child care, while pregnant and after. Continued observations and occurrences of this phenomenon may have led to the gender construct that women are more caring and tend the house and men work and provide material resources for the family (Rogoff, 2003). Similarly, gender constructs may have developed in male-dominated fields, such as science, as a result of less observed participation of females. Even though more women are working and entering traditionally male-associated careers, reproductive demands or residual stereotypes may dissuade initial pursuance or continuation in science fields (Tai, Lui, Maltese, & Fan, 2006). These gender constructs, in turn, may play a role in girls' efficacy-activated processes and subsequent perceptions of viable science course, degree, and career options.

While men and women are increasingly explicitly negating the masculinity of science and femininity of humanities, implicit bias assessments indicate that the traditional dichotomy persists subconsciously and could, unintentionally, influence other beliefs and behaviors (Nosek, Banaji, & Greenwald, 2002). One explanation for this discrepancy between explicit and implicit beliefs is that these explicit beliefs may be grounded in the recognition that more women are pursuing careers in biological sciences, ignoring the persisting underrepresentation of women in physical sciences (Leaper, Farkas, & Brown, 2012). Similarly, Ecklund, Lincoln, & Tansley (2012) found that scientists in these fields identified gender as a key contributor to the reason why more women pursue biological sciences and more men pursue physical science careers. Questions remain about the processes that underlie gender's influence on such decisions.

This has implications for science education because children have been found to recognize the gender stereotypes held by adults at an early age (Kurtz-Costes, Rowley, Harris-Britt, & Woods, 2008). Few studies, however, exist on children's perceptions of gender stereotypes and their perceptions of their efficacy in science. One study found that while both girls and boys recognized the traditional adult gender-stereotypes of associating women with humanities and men with math and science, they did not apply those stereotypes to their peers (Kurtz-Costes et al., 2008). Somewhat contradictory to these findings, the researchers also found that while boys and girls indicated that they believed girls were capable in math and science, individual girls' scores tended to indicate that they had low beliefs on ability with respect to math and science. Boys, on the other hand, found that the adult stereotypes supported higher individual beliefs on ability. These findings suggested that boys and girls interpret and act upon stereotypes differently and begin to do so at an early age.

The influence of implicit biases and interest in science may begin well before high school as more boys than girls entered high school with an interest in science

(Sadler, Sonnert, Hazari, & Tai, 2012). The accumulation of these experiences may, then, serve to limit girls' perceptions of viable future course, degree, and career options. High performing girls, for example, regardless of their involvement with science in or outside of school, were less likely to pursue advanced science courses if they held gender stereotypes about science (Joyce, 2000). In addition, girls who have a stronger female identity were less likely to consider future academic plans that do not conform to paths related to gender constructs (Lane, Goh, Driver-Linn, 2012). While questions remain about how exactly gender identity influences educational and career paths, literature suggests several key outcome differences between boys and girls in the science educational setting, suggesting the continued influence of implicit biases.

Implicit bias and perceptions of intelligence. Implicit bias may influence girls' perceptions of their intelligence and perceived self-efficacy in science. From a philosophical perspective, Dweck and Leggett (1988) identified two mind orientations, fixed and incremental, that correlated to students' motivational processes and achievement. They found that a fixed mindset led to success if the person had a high self-efficacy level or frustration if the person had a low self-efficacy level. On the other hand, an incremental mind set focused on learning and behaviors, regardless of the person having high or low self-efficacy levels, supported persistence. Because STEM careers require trial and error, experimentation, and innovation, individuals with fixed mind sets would be less likely have the persistence to pursue a STEM career (Hill, Corbett, & St. Rose, 2010).

Related to mind and goal orientations are perceptions of intelligence and talent. Intelligence and talent, from a fixed mindset, would assume that these attributes are innate, undevelopable. An incremental mindset, instead, would assume that these attributes may be developed over time (Dweck & Leggett, 1988). With respect to gender participation inequalities in physical sciences, awareness of fixed mindsets may discourage women from pursuing physical sciences (Leslie, Cimpian, Meyer, & Freeland, 2015; Wai, Lubinski, & Benbow, 2009). For example, women tend to have lower spatial visualization skills, commonly found to be related to one's ability to pursue and persist in STEM fields, than men (Wai, et al., 2009). From a fixed mind orientation, these types of findings may perpetuate gender role stereotypes in science, assuming that these skills are innate and undevelopable (Wai et al., 2009). Similarly, fixed mindsets regarding the type of talent needed for various disciplines, whether it is perceived as an innate ability or developable, may further inform perceptions of potential success and likelihood of pursuing various disciplines (Leslie, Cimpian, Meyer, & Freeland, 2015). As many in the field may hold the belief that talent in physical sciences is innate, particularly with respect to the male-gendered preference for systemizing over empathizing (Leslie et al., 2015), women and girls may be less likely to consider or participate in such fields. Perceptions of fixed math abilities may further marginalize women and girls from participation in science fields that are perceived to necessitate an innate talent and intelligence in math (Penner, 2015), perpetuating gender biases regarding math and limiting potential participation in specific science domains.

From an incremental mind orientation, however, it has been found that these skills may be fostered through specific instructional practices (Baenninger & Newcombe, 1989). Courses, for example, that specifically focus on developing these skills have shown to have a positive influence on women's persistence in STEM degree enrollment and/or attainment (Gerson, Sorby, Wysocki, & Baartmans, 2001). Women, though, that have fixed mind sets may not pursue such courses, assuming that they do not and cannot have the skills needed to pursue a STEM degree. Moreover, the persistent observation of such messages regarding the perceived innateness of talent and intelligence related to various science disciplinary fields may discourage women and girls from considering such paths in the first place, regardless of their personal mindset orientation (Sonnert & Holton, 1995). These findings have implications for girls' access to science and raise questions about the cumulative effects and the process of how girls perceive, interpret, and interact in current science educational settings.

Implicit bias and perceptions of achievement. Implicit bias may influence girls' interpretations of past achievements, a key component of self-efficacy, and their relation to future performance and options (Modi, Schoenberg, & Salmond, 2012). With respect to how students perceive their self-efficacy levels, there is disagreement in the literature about whether mastery experiences, successes and failures, are interpreted differently as a function of gender. Achievement levels, regardless of gender, are strong predictors of students' valuation of success (Ucak & Bag, 2012). On the other hand, boys may have higher perceptions of their ability than girls regardless of achievement levels (Britner & Parajes, 2006; DeBacker &Nelson, 2000; Leslie, McClure, & Oaxaca, 1998). When engaging in conceptual change in science, boys and girls varied in the amounts of interest, prior knowledge, and perceived self-efficacy needed to persevere in such a highly cognitive and demanding learning process (Linnenbrink-Garcia, Pugh, Koskey, & Stewart, 2012). These variations suggest that boys and girls interpret and act upon their self-efficacy in different ways.

Gender and Educational and Career Paths

All of the previously described effects of implicit bias on perceived self-efficacy also influence girls' determination of the relevance value of science in relation to their future course, degree, and career goals. Relevance, however, is a complicated topic. In response to Mayoh and Knutton's (1997) proposed two questions, "relevant to whom?" and "relevant to what", to define the concept of relevance, Aikenhead (2003) added an addition question of "'Relevant to which enculturation process?' – enculturation into a scientific discipline (the status quo), or enculturation into students' local, national, and global communities" (p. 26). Thus, the role of implicit biases should be considered.

Aikenhead (2003) described seven heuristic categories of science relevance related to public school curricula: wish-they-knew science, need-to-know science, functional science, enticed-to-know science, have-cause-to-know science, personal-curiosity science, and science-as-culture. Depending on girls' science and gender implicit biases, the relevancy value that they ascribe to science will vary. VanAlsvoort (2004) identified four types of relevance: personal, professional, social, and personal/social. Personal relevance related to the student's interest in the topic. Professional, social, and personal/social related to how the scientific knowledge and skills were perceived to be related to future careers, society, and responsible citizenry. While personal relevance has been found to be the most predictive of students' academic success in science (Bas, 2012), it is the other types of relevance that are more likely to increase the perceived self-efficacy for girls to pursue advanced STEM courses, degrees, or careers (Teppo & Rannikmae, 2003).

Perceptions of relevance inform the adoption of goal orientations. Goals are traditionally characterized as mastery or performance goals (Elliot & Harackiewicz, 1996). Mastery goals, those defined as having the objective of acquiring knowledge and skills, tend to be adopted by individuals who have a high perceived self-efficacy and an incremental mind orientation (Elliot & Harackiewicz, 1996). Further differentiating performance goals, those defined as dealing with recognition or avoidance of failure, to performance-approach and performance-avoidance goals, performance-approach goals strengthened the predictive value of perceived self-efficacy on subsequent agency (Hsiuh, Cho, Liu, & Schallert, 2008). The efficacy-activated processes underlying goal setting do not work in isolation from implicit biases and conceptualizations of relevance and have implications for how girls perceive the scope of their future course, degree, and career options.

Relevance and Gender Appropriateness

Implicit bias may limit educational and career trajectories because they have been found to influence the extent to which girls consider a course, degree, or career as gender appropriate. In general, girls and women tended to have lower perceived self-efficacy for careers with a strong masculine gender construct orientation, like math and science, possibly narrowing their agency beliefs about potential degree and career options (Bandura, 1997; Hackett, 1995; Lane, Goh, & Driver-Linn, 2012). Women who had a strong female gender identity, performed lower than men in math in comparison to women who did not associate with or place value on having a strong female gender identity (Schmader, 2002). Men, on the other hand, whether they had strong male gender identities or not, seemed to have the same level of math achievement (Schmader, 2002).

Similarly, women who did not consider math a part of their identity, perhaps as a result of gender constructs, were less likely to like math or pursue mathematics-related activities through an act of "self-imposed segregation" (Nosek, Banaji, & Greenwald, 2002, p. 50). Likewise, girls who did pursue traditionally masculine domains were found to have lower implicit biases regarding science than girls who pursued degrees in humanities (Smeding, 2012). While these biases may not always correlate with achievement scores (Kiefer & Sekaquaptewa, 2006; Smeding, 2012), the role of gender and agency regarding future course options is evident.

Girls' participation in social groups and with peers who share a strong gender identity may serve to perpetuate stereotypes about those who maintain gender roles and those who challenge them (Egan & Perry, 2001; Leaper, Farkeas, & Brown, 2012). The social construction and perpetuation of observed gendered roles and expectations may actually reinforce gender constructs and role socialization (Bussey & Bandura, 1999). For example, in K-12 educational settings, "a young woman with scientific aspirations may face a double marginalization: entering the stigmatized subculture of nerds, and then being an oddity among her fellow nerds because of her gender" (Sonnert & Holton, 1995, p. 5). These factors and lower perceived self-efficacy may discourage girls from considering science courses, majors, and careers as favorable or viable options in relation to their capabilities or realization of their goals.

Girls also tended to not view science as relevant to their goals of wanting to help others (Jones, Howe, & Rue, 2000; Ma, 2011). While it was found that many girls had an interest in science, wanted to make a difference in the world, and liked to solve problems, few made the connection between those attributes and STEM fields (Modi, Schoenberg,

& Salmond, 2012). To address this disconnect, there has been an attempt to provide lesson contexts that have a real world connection to broader social issues. For example, DiLisi, McMillin, & Virostek (2011) sought to identify how peer-teaching influenced STEM interest and career choices. They found that programs that incorporated both STEM content and pedagogy so that students can develop and teach STEM materials had a positive influence on female students. They particularly found that those students who had been undecided about a future career had a significantly greater interest as indicated on post surveys at the end of the program. Others have urged the inclusion of topics related to health, animals, and weather to increase relevancy for girls (Jones, Howe, & Rua, 2000; Wolter, Ludneberg, & Bergland, 2013). Questions remain about the extent to which these interventions perpetuate or challenge gender constructs as these studies failed to consider or identify existing gender and science-related stereotypes that influence relevancy determinations.

Relevance and Task Aspects

Delving further into the examination of how specific aspects of instructional practices maintain or challenge gender constructs is central to understanding girls' perceived STEM self-efficacy. When girls took an active role in science knowledge creation or discovery, they were more likely to find the task relevant, expanding their views of career options and increasing the likelihood of mastery goals adoptions (Bas, 2012; Chen & Howard, 2010). Girls, then, have been found to value authentic learning opportunities in science more than boys (Dijkstra & Goedhart, 2011).

To promote authentic learning opportunities, literature has supported the creation of partnerships between schools and professions in the industry (Barrett & Woods, 2012;

Ejiwale, 2012; Rahm, Miller, Hartley, & Moore, 2003; Watters & Diezmann, 2013). The dominating rationale was that partnerships support authentic learning environments and provide access to resources and tools specifically used in science fields to which schools would normally not have access. The use of tools from the field has the potential to increase students' motivation in science as students need "objects-to-think-with" (Kafai, 2006, p. 39). Literature has studied the use of specific resources from scientific organizations (Barnett & Woods, 2012), real time data (Baloian, Pino, & Hardings, 2011; Wyner, 2013), simulations (Chen & Howard, 2010), field tools (Barnett, Vaughn, Strauss, &Cotter, 2011), and incorporation of technology, (Ejiwale, 2012; Hsieh, Cho, Liu, & Shallert, 2008; Watters & Diezmann, 2013). In all of these studies, the use of tools were found to have positive effects on students' engagement. It was also unclear, though, how these tools achieved their impact and, moreover, how gender influenced perceptions of and the impact of the tools on girls' perceived STEM self-efficacy and perceptions of future science course options.

Conclusion

The literature clearly established that both external and internal factors influence girls' and women's persistence in STEM domains (Blickenstaff, 2005; Macleod, 1995; Hackett, 1995, Rogoff, 2003; Sonnert & Holton, 1995). Likewise, similar external and internal factors exist in K-12 educational systems and may influence girls' perceptions of viable course, degree, and career options. With a focus on internal factors through the lens of social cognitive theory, perceived self-efficacy was found to be strongly predictive of academic achievement, persistence, and agency (Bandura, 1995). Its interpretive nature was highly influential in the determination of mind and goal orientations (Bandura, 1995; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Hill, Corbett, & St. Rose, 2010; Hsiuh, Cho, Liu, & Schallert, 2008). From the feminist lens of practice theory, perceived self-efficacy was domain-specific (Usher & Parajes, 2008) and was found to be highly susceptible to implicit bias as a result of gender constructs and gender-role socialization (Hackett, 1995; Kiefer & Sekaquaptewa, 2006; Schmader, 2002). In general, boys and girls who adopted an incremental mindset and mastery or performance-approach goal orientations were more likely to develop sufficient perceived self-efficacy levels needed to persevere in STEM domains. However, when these orientations were combined with gender, the literature strongly indicated that implicit biases had a limiting and detrimental effect on girls' perceptions of intelligence, mastery experiences, and relevance, resulting in lower perceived self-efficacy levels and agency in traditionally male-associated domains (Britner & Parajes, 2006; DeBacker & Nelson, 2000; Teppo & Rannikmae, 2003; Wai, Lubinski, & Benbow, 2009).

While the literature provides valuable insight into the interplay of gender and perceived self-efficacy, there are three key gaps to which this study sought to contribute. First, the majority of studies failed to identify the underlying gender and science biases that girls brought to the classroom environment. Without identifying them, there is little understanding of how to plan, evaluate, and revise practices to reduce their inhibiting effects. Second, studies on programs and strategies to reduce the effects of implicit biases failed to address how specific aspects of a program, resource activity, or other intervention achieved their influence on girls' outcomes. Third, the majority of the reviewed studies were quantitative and lacked a qualitative lens. A qualitative phase would provide opportunities to understand the underlying interpretive processes of perceived self-efficacy in which girls engage.

While the literature has consistently provided evidence that perceived self-efficacy is strongly predictive of future academic achievement, course enrollments, and degree and career pursuits (Hackett, 1995; Zimmerman, 1995), it is less clear in what context and under what conditions this efficacy is developed. This study's research questions were designed to address the three primary gaps identified in the literature. This study will use both quantitative and qualitative data to examine girls' efficacy-activated processes in hopes of gaining a deeper understanding of how gender and local instructional practices may serve to expand or limit girls' future science course, degree, and career opportunities, particularly in the domain of physical sciences.

Chapter 3

Methodology

The purpose of this mixed methods study was to examine how gender and science task aspects inform the efficacy-activated processes of high school girls' perceptions of viable science course trajectories. This sequential design first collected quantitative data using a survey to describe the associations between girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits as well as the extent to which these associations align to social cognitive theory's underlying assumptions regarding self-efficacy. The qualitative phase followed-up with criterion cases using open-ended task surveys, focus groups, and interviews to further explore girls' perceptions of their science educational experiences and course options. In addition, field notes and researcher journal data sources were collected to supplement qualitative data's descriptions and to allow for bracketing of potential biases during analyses (Ahern, 1999; Borg, 2001). The embedded feminist lens in the theoretical framework of social cognitive theory, sought to illuminate possible internal factors that serve to narrow or expand girls' perceptions of potential science course options. The purpose of collecting both quantitative and qualitative data was to use the qualitative data to explain the quantitative results, invite dialog, and to gain a deeper understanding of the problem than would be obtained by a purely quantitative or qualitative study (Greene, 2012; Johnson & Onwuegbuzie, 2004).

1. What associations, if any, exist between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?
2. What factors do high school girls identify as informing their science course pursuits?

3. How do high school girls negotiate those factors?
4. What aspects of the DataStreme task do high school girls identify as informing their perceived STEM self-efficacy?
5. How do high school girls describe that these aspects achieve such influence?
6. How do high school girl's perceptions of influencing factors and DataStreme task aspects complement and expand our understandings of the associations found between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?

The purpose of this chapter is to present this study's methodological decisions to address these research questions. It will begin with a rationale for the use of mixed methods drawing from the worldview assumptions of pragmatism. It will continue with a description of the study's sequential, explanatory research design. It will also identify potential participants, the context, sampling methods and strategies, and procedures. Data collection methods and instrumentation will be presented as well as data analysis and merging strategies. It will conclude with a description of the measures that will be taken to promote validity and trustworthiness of findings and to account for other ethical considerations.

Assumption of and Rationale for Mixed Methods and Pragmatism

Research methodologies, especially in educational research, have been evolving as a result of two concurrent movements, an emphasis on evidence-based practice and an increase in qualitative research (Sandelowski, Voils, & Barroso, 2006). While educational research may be instrumental in informing policy, practice, and subsequent research, debate continues about what types of evidence constitute the many different complex phenomena related to education as well as how to measure them (Kennedy, 1999). Some researchers have argued that best practices drawn solely from quantitative or qualitative studies may miss valuable information that other data sources could provide (Abowitz & Toole, 2010; Greene, 2012). Others have argued that the use of multiple measures may help to increase a study's construct and decision validity while better promoting social justice (Brookhart, 2009). While there are a variety of ways to combine multiple measures in a study, questions remain about which measures and what combination of those measures are most appropriate to best represent and illuminate educational phenomena (Hoffman & Lowitzki, 2005; Noble & Sawyer, 2002).

This study's findings may be used to inform policy, practice, and research, encompassing a wide range of potential audiences. In light of these debates, Anfara, Brown, and Mangione (2002) suggested that researchers defend methods that deviate from the assumptions of post-positivist thinking, stating that the "worth of any research endeavor is assessed by a variety of audiences" (p. 28). In defense of this study's mixed methods design, it was chosen to attempt to rise above the familiar quantitative and qualitative paradigmatic tensions, emphasizing the larger role that research plays in promoting human well-being (Hostetler, 2005). This study assumed that human well-being is multi-faceted. It results from an intricate balance of structures and agency, encompassing both external and internal realities. As such, this study's methodology was also chosen to contribute to the ongoing, evolving, methodological debate by demonstrating the complementarity and explanatory potential of using both quantitative and qualitative methods in the same study (Collins & Onwuegbuzie, 2007).

This study's paradigmatic assumptions set aside traditional debates that polarize quantitative and qualitative paradigms and focused on human inquiry, acknowledging the existence of both structures and agency. The pragmatic paradigm assumes that we may not be able to generate an absolute Truth, but that knowledge is "both constructed *and* based on the reality of the world we experience and live in" (Johnson & Onwuegbuzie, 2004, p. 18). By rejecting traditional dualisms, this study's design and related data collection, analysis, and interpretation strategies served to describe and uncover the patterns and essence of efficacy-activated processes, respecting the objective and subjective realities of girls' science educational experiences.

Research Design

This study followed a fully mixed sequential equal status design, drawn from Leech and Onwuegbuzie's (2006) identified mixed methods typologies (See Figure 3). The first phase was a descriptive study in which attitudinal data was collected and statistical analyses were used to identify relationships between the data measures (Patton, 1991). Data from the first phase informed the selection of participants and related material culture for the second, qualitative strand that followed a phenomenological design. Quantitative and qualitative data were also merged during the interpretation stage. Greene, Caracelli, and Graham (1989) identified five key justifications for the mixing of methods: triangulation, complementarity, development, initiation, and expansion (p. 255). Because of the study's sequential design, the use of mixed methods in this study specifically have the purposes of complementarity and expansion (Collins & Onwuegbuzie, 2007).

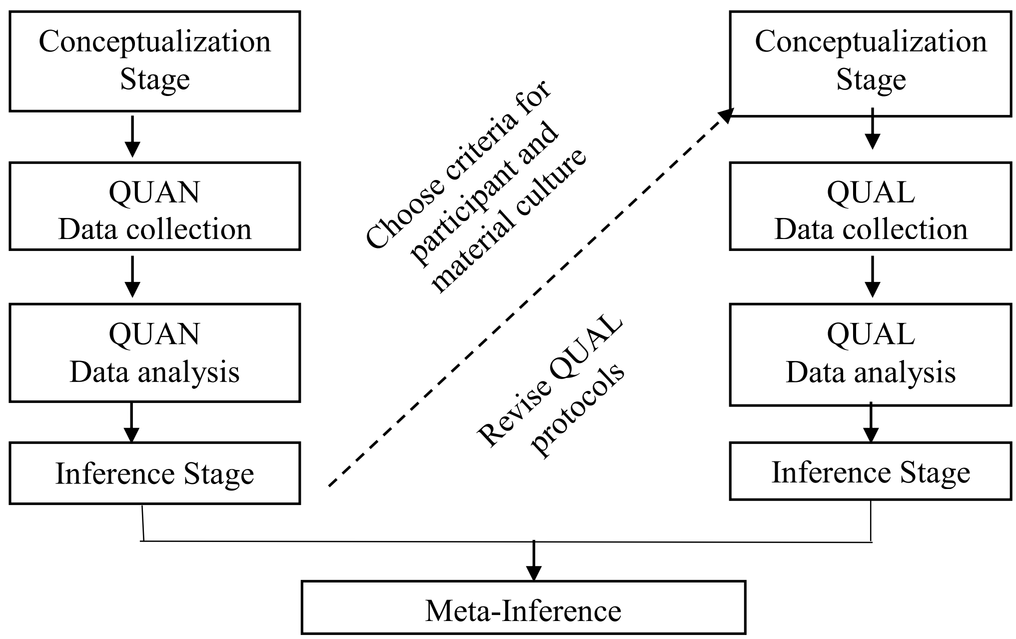

Figure 3. Sequential design. Tashakkori and Teddlie (2006) presented this figure to illustrate the sequential design (p. 22). It is modified here to further describe how the quantitative inference state informs the conceptualization stage of the qualitative phase.

This study's design is intentionally further defined as a mixed methods phenomenological research. In Mayoh and Onwuegbuzie's (2013) description of the historical and theoretical antecedents of descriptive phenomenology, they noted that:

> Husserl's descriptive phenomenology ultimately aids to make intelligible all objectivity, while also respecting the being-value of human subjectivity (Gadamer, 2004). This respectful appreciation of both subject and object highlights the potential philosophical complementarity between phenomenology and more objective forms of inquiry, and helps justify the inclusion of more deductive methods within an overarching inductive phenomenological framework. (pp. 5-6)

Drawing from this perspective, each strand of this study had a descriptive purpose, allowing for complementarity and expansion of interpretations. There were also specific aspects of descriptive phenomenology that, as Mayoh and Onwuegbuzie (2013) described, allowed for their seemingly disparate axiological, epistemological, and ontological assumptions of quantitative and qualitative paradigms to converge. For example, descriptive phenomenology encourages the use of bracketing to reduce the impact of the researcher's beliefs and prior knowledge on data collection and analysis methods, which may be complimentary to the post-positivism's need for researcher objectivity. In addition, qualitative research explores participants' "lived experiences", discovering the "*meanings* people place on the events, processes, and structures of their lives and for connecting these meanings to the *social world* around them" (Miles, Huberman, & Saldaña, 2014, Strengths of Qualitative Data, para. 4). The seeking of patterns provides opportunities for complementarity to the explanatory nature of more objective, post-positivistic approaches.

Context

New Jersey (N.J.) is an appropriate state in which to conduct this research as it has a strong reputation for its science educational program (National Center for Education Statistics [NCES], 2013; U.S. News, 2014; White & Cottle, 2011). N.J. students are generally achieving proficiency in science as evidenced in national and state data (NCES, 2013; N.J. Department of Education, 2012). This study will take place in a N.J., suburban high school. This school, in particular, was chosen because, while it has a strong reputation statewide and nationally for its STEM educational program, gender inequalities are persistently observed year after year in the advanced science courses, particularly in the physical science fields. In addition, students in the honors and Advanced Placement (AP) tracks tend to not pursue environmental science courses. As the students in this school are overall achieving on standardized testing measures, this site are appropriate for recruiting participants who are girls achieving in science, but choosing to not pursue advanced physical science courses. The sample population was drawn from the honors chemistry classes as those are the classes from which students are most likely to have the needed academic background and prerequisites to pursue and be successful in advanced physical science courses.

Furthermore, N.J. adopted the Next Generation Science Standards (NGSS) in July 2014 with anticipated implementation beginning during the 2015-2016 school year. With the NGSS' increased emphasis on earth sciences and identified cross-cutting concepts, teachers are beginning to integrate various resources into the curricula. The integration of the resources provides students with exposure to earth sciences, which, in this school, is generally not taken by students in the honors and AP curricular tracks. The teachers are also curious about the potential of integrating themes such as weather and earth sciences, with a heavier emphasis on crosscutting concepts related to physics and mathematics, into more traditional chemistry curricula to encourage more girls to pursue physical sciences. Two chemistry teachers in this high school recently completed DataStreme courses and shared the content and resources with the other two chemistry teachers in their department. These teachers also developed the DataStreme task that will be used in this study. As such, this site is also appropriate as teachers will benefit from participation in this study by gaining a deeper understanding how specific instructional practices and resource use may serve to expand girls' perceptions of potential advanced science course options, possibly increasing their participation in advanced physical science courses.

Sampling Method

This study’s underlying principles of pragmatism informed the sampling decisions by offering a “pragmatic method”, a “workable solution… to many of the longstanding philosophical dualisms” (Johnson & Onwuegbuzie, 2004, p. 18). Teddlie and Yu (2007) referred to these considerations in mixed methods research as the representativeness/saturation trade-off. Traditionally, quantitative strands employ probabilistic sampling methods to identify causal relationships and to increase generalizability to larger contexts, seeking to maximize representativeness (Patton, 1991). Regardless of a study’s purpose, however, Collins and Onwuegbuzie (2007) found that non-probabilistic sampling methods were frequently used for both quantitative and qualitative strands in mixed methods social science research.

Due to restraints in these school settings, probabilistic sampling is not feasible for the quantitative phase of this study. The context notwithstanding, purposive sampling is more aligned to the research questions and more appropriate for this study. It serves to represent and describe this school’s specific population and its characteristics, allowing for use of descriptive statistical analyses and transferability to other settings. The projected population of girls taking honors chemistry during the 2014-2015 school year is approximately 100 students. Gay, Mills, and Airasian (2012) suggested that a minimum of 50% was needed to generalize findings to the population and any percentage over that would serve to strengthen the confidence levels of your subsequent findings. Based on a 95% confidence level, a sample size of around 80 girls, approximately 80%, would be representative of the girls in these schools that are enrolled in Honors Chemistry (Krejcie & Morgan, 1970).

Purposeful sampling will be used in the second, qualitative phase, which is appropriate to elicit deep descriptions of the phenomenon. This study plans to use two sampling methods. To select participants for focus groups, a typical case sampling method will be used with the goal of achieving representativeness “of the most typical or representative instances of a phenomenon of interest” (Teddlie & Tashakkori, 2003, p. 176). To select participants for interviews, criterion sampling will be used to identify participants that had more a specific characteristic or set of characteristics in common, promoting homogeneity while also allowing for a more in-depth exploration of the phenomenon being studied. All girls who participate in either the focus groups and/or interviews will complete the open-ended survey to maximize representativeness of the second phase participants.

Participants chosen for the second phase of this study will participate in focus groups and/or interviews and complete an open-ended task survey. Each focus group is planned to consist of five to ten participants to provide opportunities without the threat of the group being too large and separating into smaller group discussions (Krueger & Casey, 2009). Initially, three focus groups will be planned, but saturation will be used as a determinant of the number of focus groups, defined as “the point where you have heard the range of ideas and aren’t getting new information” (Krueger & Casey, 2009, p. 21). For interviews, six to 12 interviews will be planned initially (Guest, Bunce, & Johnson, 2006), but, again, saturation will determine the final number of interviews to be conducted. As mentioned before, all girls who participate in the focus groups and/or interviews will also complete an open-ended task survey to elicit their perceptions of the DataStreme task.

Teddlie and Tashakkori (2003) identified several other aspects to consider when choosing mixed methods sampling strategies including the purpose of sampling, issue of generalizability, rationale for cases, sample size, timing, and type of collected data (p. 181). In this study, sampling techniques were chosen to address the research questions. The decision to use purposive sampling methods in both strands maximized the representativeness of the sample population, making the findings generalizable to the sample population and transferable to other settings. With respect to timing, these sampling techniques were chosen during the planning stages of this study. However, the study's design allows for emergence of methods based on findings from the quantitative strand. From a pragmatic lens, these sampling techniques will provide both numerical and narrative data that build upon each other to address the research questions through complementarity and expansion.

Participants

Four high school chemistry teachers and approximately 100 high school girls, ages 14-17, will be eligible to participate in this study. Of the teachers who volunteer to help with this study, all the girls in their honors chemistry will be eligible to participate in the study. This course level was chosen because students enrolled in Honors Chemistry were more likely in comparison to students enrolled in other levels of science to pursue four years of science and enroll in advanced physical science courses.

Procedures

To gain access to these research sites, I contacted the district's Supervisor of STEM and presented her with a research study proposal. She forwarded the proposal to Assistant Superintendent of Curriculum of Instruction for final approval.

Once I received the required approvals to conduct my research at the high school, I met with the chemistry teachers whose students would participate in this study. I first shared the background of the study, the study's purpose, and key findings from the literature review with them. This also allowed teachers the opportunity to share their perspectives and incorporate them into the design of the activity that would be used with the students during the study. The teachers collaboratively designed a STEM activity using the resources from the DataStreme courses to be used in their Honors Chemistry classes. The activity itself was designed around several key aspects identified in the literature to increase students' engagement. In addition, the teachers used the guidance of Krajcik, Codere, Dahsah, Bayer, and Mun (2014) to align lessons to the Next Generation Science Standards. Key aspects included the topic of weather, use of real-time data, use of resources from a scientific organization, use of technology, and a medium to high level of task difficulty (See Appendix A for the task).

I will provide consent forms for participation in this study to the teachers who will, in turn, distribute them to and collect them from their students. Being that the participants will be students, parents/guardians also have to consent to their child's participation in this study. Students who do not return consent forms are able to participate in the lesson without penalty. Data from those students, however, will not collected. Instruction, using the collaboratively developed activity, will take place over two class periods, approximately two hours. Data will be collected in two phases.

Data Collection Methods

This mixed methods study planned to employ both quantitative and qualitative data collection methods. It will collect data using a survey for the quantitative phase, drawing from the assumptions of survey research. It will then collect data using focus groups, interviews, field notes, and the researcher's journal, drawing from the assumptions of qualitative research. The field notes and researcher's journal will be used more to aid with analyses and reflexivity, rather than to provide specific data for results. Data will also be collected from open-ended task surveys, drawing from the assumptions of both survey and qualitative research. See Table 1 for a summary of the data sources in relation to research questions.

Table 1

Data sources in relation to research questions

Research Question	Data Sources		
	1	2	3
1. What associations, if any, exist between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?	survey	-	-
2. What factors do girls identify as informing their science course pursuits?	Focus group	Interview	Task survey
3. How do girls negotiate those factors?	Focus group	Interview	Task survey
4. What aspects of the DataStreme task do girls identify as informing their perceived STEM self-efficacy?	Focus group	Interview	Task survey
5. How do high girls describe that these aspects achieve such influence?	Focus group	Interview	Task survey
6. How do girl's perceptions of factors and task aspects complement and expand our understandings of the associations found between perceived STEM self-efficacy and perceived likelihood of science course pursuits?	All data sources		

This section will describe the theoretical assumptions of the strategies and specific methods as well as their appropriateness for collecting data to answer this study's research questions.

Survey Research Strategies

Surveys are defined as data collection methods that are "used to describe, compare, or explain individual and societal knowledge, feelings, values, preferences, and behavior" (Fink, 2013, p. 2). In this study, surveys are an appropriate data collection tool to collect data on girls' perceived STEM self-efficacy levels and to identify course preferences. Their cross sectional design provides a "snapshot of the current behaviors, attitudes, and beliefs in a population" (Gay, Mills, & Airasian, 2012, p. 185). The S-STEM survey included fixed items to determine associations between identified variables in the study. The task survey included open-ended survey items to collect data on girls' perceptions of an experience or phenomenon, allowing for more flexibility in responses than a closed-ended survey would provide.

According to mixed methods research typologies, surveys are also identified as an appropriate data collection method to acquire data and findings to inform the subsequent qualitative phase (Teddlie & Yu, 2007). In this study, a closed-ended survey findings will be used to inform the selection of participants for the qualitative phase as well as specific topics to include in the focus group and interview protocols. An open-ended survey will be used to elicit further descriptions of girls' perceptions of the DataStreme task and inform focus group and interview protocols.

Qualitative Research Strategies

Focus groups. While survey data provide insight into the research problem, other qualitative data sources provide opportunities for more in-depth investigation and description regarding the survey topics (Morgan, 1996). Focus groups are defined as "a research technique that collects data through group interaction on a topic determined by the researcher" (Morgan, 1996, p. 130). This study will employ a single category design and I will be the moderator. In this design, data is collected from only one type of participant, high school girls who meet the sampling criteria.

Focus groups are an appropriate method for this study because they will be used to gain insight into perceptions and feelings, understand an experience from a specific population's viewpoint, gain a deeper understanding of factors that influence behaviors, and further explain quantitative data (Krueger & Casey, 2009). The use of focus groups also supports this study's assumption that gender is socially-constructed and influences behaviors (Bussey & Bandura, 1999; Bandura, 1995), providing opportunities for participants to interact and socially-construct explanations as well. The focus group protocol includes some elements of standardization to promote comparability among groups through the use of some fixed questions (Morgan, 1996). It also allows time for exploration of emergent topics and issues through the use of probing questions. This semi-structured design, then, allows for both fixed and emergent topics. As sampling sought to increase the homogeneity of participants' characteristics of interest in this study, data analyses and the point of saturation, when there are "no significantly new explanations for data" (Miles, Huberman, & Saldaña, 2014, Memoing Advice section), will determine the sufficient number of focus groups to be conducted.

Interviews. Interviews, like focus groups, are an appropriate data collection strategy for this study because they provide the perspectives of participants, further describing how they experience and attribute meaning to those experiences. This study will employ semi-structured interviews. These interviews will be one-on-one, face-to-face, with my role as a facilitator of conversation around the research phenomenon. The interview will include both fixed questions and opportunities for follow-up and probe questions for clarification, elaboration, and pursuance of emergent topics.

The use of participants' perspectives as data is a valuable method because "individuals' consciousness gives access to the most complicated social and educational issues, because social and educational issues are abstractions based on the concrete experience of people" (Seidman, 2006, p. 7). To make sense of the context in which participants experience and make sense of their experiences, interview transcripts, in conjunction with other qualitative data sources may be used to examine how participants "symbolize their experience through language" (Seidman, 2006, p. 8), providing insight into the essence of the phenomenon being studied. This may be accomplished through rereading, sorting, and creation of analytic notes.

Field notes. Taking field notes are defined as "documenting observation" (Tjora, 2006, p. 429). I plan to use both observational and analytical field notes, differentiated as such in my field notebook (Glesne, 2006). First, field notes will begin with a description of the participants, the location, and the date. Subsequent notes will revolve around the guiding questions of "How are the participants interacting with each other?" and "How are participants interacting with the environment" (Craig, 2009, p. 144). Field notes also allow the researcher to have a record of facial expressions, pauses, movement, and other observatory behavior that may provide more context and insight into the surveys and focus group transcriptions during analyses (Glesne, 2006; Saldaña, 2009). Field notes are an appropriate data collection strategy because meaning is not conveyed in words alone. Field notes may also serve to aid in memory recall during subsequent research phases (Kreuger & Casey, 2009). This may be accomplished through rereading and reflection upon both descriptive and reflective memos in the field notes at later dates.

Researcher journal. In qualitative research, the researcher is also an instrument through which data collection and analysis occurs. A researcher journal is an appropriate data collection method to aid in increasing my awareness of my role and influence on the research processes as well as be able to communicate such roles and influence to others. Throughout the research process, I plan to keep a researcher's journal with the goal of having a product that would provide "instructive insight into specific aspects of the researcher process" (Borg, 2001, p. 161). As Janesick (1999) suggested, it may serve as a record of my feelings, biases, experiences, role as a researcher, participants' responses, and conflicts that arose. Likewise, as Borg (2001) suggested, these records also serve as a reminder of past events and plans that may be helpful in articulating the thought process and factors that drove research decisions and to promote further analysis and synthesis of data, theories, literature, and other ideas.

The researcher journal also promotes reflection upon and refinement of the role, motives, and influence of the researcher, gatekeepers, volunteers, and participants throughout the entire research process (Ahern, 1999; Janesick, 1999; Ortlipp, 2008). The instructive and reflective purposes of a researcher journal may be accomplished through rereading and reflection upon the lists, diagrams, and narrative journal entries.

Ultimately, as Ortlipp (2008) described, the records kept in the researcher journal serve to promote transparency, providing data that may be used to support and clearly articulate decisions made throughout the research process. This presentational purpose of the researcher journal may be accomplished by referencing specific journal entries to illustrate roles, motives, and underlying thought processes of decisions to evaluate, describe, and justify the effectiveness of decisions made throughout the research process (Ortlipp, 2008).

Instrumentation

Decisions regarding instrumentation were determined through a consistent focus on the research questions. Each data source was chosen, planned, and implemented in intentional ways to best elicit data that would contribute to answering the research questions. This section describes each data source's protocol and format in relation to the research questions and other instruments. See Appendix B for a summary of survey and protocol items in relation to the research questions.

S-STEM Survey Instrument

The Students' Attitudes toward STEM (S-STEM) survey (Friday Institute for Educational Innovation, 2012) will be primarily used to address the first research question, the relationship between students' perceived STEM self-efficacy and future science course enrollment interests. Procedurally, teachers will administer the survey before instruction using the DataStreme task. Teachers will be instructed to assign each girl who consented to participation in the study a code and to remove any identifiable student information collected data forms. The teachers will return this data to me and I will input the data into an Excel spreadsheet for analysis. If initial response rates do not support sufficient confidence levels, it may be needed to employ follow-up strategies that both remind potential participants to complete the survey and to reemphasize the importance of their responses (Gay, Mills, & Airasian, 2012). Strategies to increase response rate will include follow-up with email reminders to the teachers, verbal reminders to the students, and visitations to the classroom to reemphasize the importance of the study and how students' participation is valuable.

After reviewing several data collection tools used in related studies, this study chose to draw survey items from the S-STEM survey. The National Science Foundation funded the creation of the Maximizing the Impact of STEM Outreach (MISO) program at North Carolina State University. A part of the program's goals included the creation of teacher and student surveys to collect data to evaluate programs' effectiveness via measurable indicators. The original survey was designed to assess students' perceived STEM self-efficacy levels. The institute pilot tested the survey with approximately 100 middle and high school students to elicit feedback about the survey items. After revising the survey items, the survey was administered to approximately 9,000 middle and high school students for validity using explanatory factor analysis and Cronbach's Alpha. The math attitudes section was found to be reliable at 0.90, the science attitudes section at 0.89, and the engineering and technology section at 0.89. Teacher feedback about the readability and appropriateness of the survey was also elicited. Permission to use and modify the survey for this study was granted via email on September 30, 2013.

The original survey was reduced to only include items related to this study, resulting in a 31 item survey. The revised survey included 22 Likert scale format items with four scale choices ranging from "strongly disagree" to "strongly agree" to gain insight into girls' attitudes regarding their perceived STEM self-efficacy. The revised survey also included three additional Likert scale items with three scale choices ranging from "not very well" to "very well" to elicit girls' perceptions of their potential for success in various subject areas. In addition, four similar Likert scale items with three scale choices ranging from "not very likely" to "very likely" to elicit girls' perceptions of future science course pursuits. Because the survey was modified, Cronbach's alpha may be used to test for reliability. This test evaluates whether or not the removal of any of the items would compromise the reliability of the survey's results (Blaikie, 2003). See Appendix B for a matrix of survey items in relation to the research questions and Appendix C for the modified S-STEM survey instrument.

Task Survey Instrument

The task survey will primarily be used to answer the second, third, fourth, and fifth research questions. Girls chosen to participate in the focus groups will also be asked to complete an open-ended task survey beforehand. Drawing from the guidance of Craig (2009) and Fink (2013), I created an open-ended survey of four additional items to elicit girls' perceptions of the DataStreme task. See Appendix D for the task survey instrument. The items were pilot tested with 10 high school girls that would not be participating in the study. I employed a cognitive pretesting strategy where the girls talked aloud about what they were thinking about each item and how they arrived at their responses (Krosnick, 1999). Revisions were made to ensure the instrument's readability and age-appropriateness. See Appendix B for matrix of survey items in relation to the research questions.

Focus Group Protocol

Data collected from focus groups will be used to answer the second, third, fourth, and fifth research questions. These questions require elicitation of more in-depth descriptions of participants' perceptions and experiences. I will use initial analysis of these quantitative data to identify girls with shared characteristics, increasing homogeneity of group participants aligned to the purpose of the study (Krueger & Casey, 2009). Initial planning estimates the creation of approximately three focus groups with five to ten participants each. The final number of focus groups will be determined when analyses indicate data saturation. Terms of the consent forms and the purpose of the study will be shared with the girls before beginning the focus group discussions.

There were various aspects that I had to consider when creating the focus group protocol and planning for participants' active engagement in the focus groups. I scheduled focus groups during lunch periods to avoid having students miss class time. Since it was their lunch period, I planned to bring in pizza for the participants. I also planned for focus groups to be held at the school to foster a sense of familiarity for the students to engage in discussions. To encourage active participation, the protocol begins with an opening question asking each participant to say hello to the group and to state one thing that she noticed about science in her school. The goal of the opening question is to get all participants speaking early on in the discussion (Krueger & Casey, 2009). To promote engagement and interaction among the participants, I included a picture description technique in the focus group protocol (Krueger & Casey, 2009). As a teacher, I had used this type of activity to promote student engagement and found it to be appropriate for high school students. See Appendix E for the focus group protocol.

Once the focus group protocol was created, I piloted it with ten different high school girls that would not be participating in the study, forming two focus groups. I employed a behavior coding approach in which a colleague observed the focus groups and wrote notes about questions that needed clarification or elicited responses that were not clear, possibly as a result of confusion or misunderstanding (Krosnick, 1999). Questions or prompts that needed a lot of clarification were modified to better facilitate the focus group discussion. I also asked follow-up questions to elicit other possible question ideas and to get feedback on the protocol questions themselves. I made revisions to the questions based on the feedback to increase the likelihood that items were age and developmentally-appropriate. See Appendix B for matrix of protocol items in relation to the research questions.

Interview Protocol

Like focus group data, data collected from interviews will be used to answer the second, third, fourth, and fifth research questions. The inclusion of interviews as a data collection method serves two purposes. First, it sought to maximize potential participant participation. For example, some girls may not want to speak in groups or may not be able to attend the focus groups during lunch. The option of one-on-one interviews, then, would provide opportunities for those girls to participate. Second, interviews also allowed for more in depth follow-up of topics or themes that emerged during the focus groups. As Guest, Bunce, & Johnson (2006) suggested, initial planning estimates approximately six to twelve interviews. The final number of interviews will be determined when analyses indicate data saturation. Terms of the consent forms and the purpose of the study will also be shared with the girls before beginning the interviews.

Following the suggestions of Rubin and Rubin (2005), the semi-structured interview protocol included a combination of main, follow-up, and probe questions. The protocol includes eight main questions that directly relate to the phenomenon being studied. These types of questions are broad, conversational in nature, and serve as a "tour" of the phenomenon, asking participants to walk you through how they feel about or experience the phenomenon (Rubin & Rubin, 2005, p. 159). The protocol also included follow-up question prompt suggestions to arrive at the "depth, detail, vividness, richness, and nuance" of participants' responses (Rubin & Rubin, 2005, p. 129). Such prompts would ask about sequence, limits, exceptions, and exemplars. Rubin and Rubin (2005) also suggested that the researcher use "jottings" to help with creating follow-up questions during the interviews (p. 148). Probing questions will be used to clarify responses to follow-up questions, again with the goal of eliciting the underlying meaning and symbolism of participants' responses. The use of confirmatory questions may serve as an informal member check to test out initial themes gleaned from the interviews or interpretations of the interview conversation (Rubin & Rubin, 2005, p. 163).

Once the interview protocol was created, I piloted it with five different high school girls that would not be participating in the study. I conducted the interviews face to face with each girl individually. Like the pilot testing of the focus groups, I employed a think aloud approach where girls responded, but also talked me through the thought process to their response (Krosnick, 1999). Based on their responses and reflections, I asked follow-up questions to elicit feedback on the protocol and to identify other possible topics or questions to be added. I then made revisions to the protocol based on the insight provided from the pilot testing. See Appendix B for matrix of protocol items in relation to the research questions and Appendix F for the interview protocol.

Field Notes Protocol

Field notes, will be recorded during focus groups and interviews to supplement transcript data to answer the second, third, fourth, and fifth research questions. Field notes will be formatted using two columns, one side for observations and the other for analytic notes. For observation notes, I plan to take notes on observable characteristics that may provide insight into my research questions including what is occurring during pauses, facial expressions, emotional cues, and body language. For analytic notes, I plan to use the following guiding questions, based on Craig's (2009, p. 149) suggestions, to prompt reflection:

1. What happened during the event?
2. What were the participant reactions?
3. Did the focus groups go well?
4. Were the protocols appropriate?
5. Did any new patterns emerge?
6. What interactions took place?

These notes may be coded and used in conjunction with other qualitative data sources to support analyses. See Appendix B for matrix of protocol items in relation to the research questions and Appendix G for the field notes protocol.

Researcher Journal Protocol

Data from the researcher journal may be used to answer all of the research questions. Prior to the data collection phase, I kept an informal, handwritten journal in notebooks that served as a record of articles and theories that I had considered in planning this study. Each resource's source was documented along with a summary and relevant connections to other theories and literature examined similar to an annotated bibliography (Bisignani & Brizee, 2013). It was in these notebooks that I wrote out possible ways to connect the literature and theories and brainstormed how those connections would inform the research questions that, ultimately, drove the research process. Strategies to promote brainstorming and synthesis included lists and draft conceptual framework visuals (Maxwell, 2013).

Starting with the data collection phase, I plan to keep a more formal researcher journal electronically in addition to handwritten notes to engage in, as Ahern (1999) suggested, the "iterative, reflexive journey that entails preparation, action, evaluation, and systematic feedback about the effectiveness of the process" (p. 408). Drawing from the guidance of several sources (Ahern, 1999; Borg, 2001; Glesne, 2006; Janesick, 1999; Ortlipp, 2008; Tjora, 2006), I identified and used the following questions to guide my journal entries:

1. What happened today? What did I do today?
2. What accomplishments were achieved?
3. What challenges emerged? What decisions were made and why?
4. How did today's happenings refine my role as a researcher?
5. How did today's happenings refine my understandings of participants' responses?
6. What connections can I make between today's reflections and past literature, theories, or other events?
7. How do today's happenings align to the goals of this research?

See Appendix B for matrix of protocol items in relation to the research questions and Appendix H for the research journal protocol.

Data Analysis

Quantitative and qualitative data strands will be analyzed using paradigmatic appropriate strategies. Quantitative data analysis will occur after all quantitative data were collected. Descriptive and inferential statistical measures will be used to seek patterns and associations among variables (Blaikie, 2003). Qualitative data analysis is more of an ongoing process, including multiple iterations of coding. Analytical notes will be made for all data sources as a way to increase rigor and further analyze data.

Quantitative Strand

The S-STEM survey data yielded categorical data. As such, frequencies and distributions will be calculated. Survey data will be analyzed for patterns by first transforming responses into categories of strength. To do this, the Likert scale items of "strongly disagree", "disagree", “neither disagree nor agree”, "agree", and "strongly agree" will be assigned a number, one being associated with "strongly disagree" and five being associated with "strongly agree" or vice versa depending on whether or not the item related to a higher or lower perceived self-efficacy. Three approximately equal categories were created, "low", "moderate", and "high" based on the distribution of scores. These analyses will then be presented in tables (See Table 2 for sample data representation).

Table 2

Sample data analysis presentation for perceived STEM self-efficacy levels (N=a+b+c)

Self-efficacy	f	%
Low	A	a/(a+b+c)
Moderate	B	b/(a+b+c)
High	C	c/(a+b+c)
Total	(a+b+c)	100%

Frequencies and categories will be used to create contingency tables, presented in cross-tabulation matrices, to provide information about possible relationships between variables (See Table 3 for a sample table).

Table 3

Relationship between perceived STEM self-efficacy levels and future course enrollment interests (N=a+b+c+d)

	Course track interest		
Self-efficacy	Physical Science	No Physical Science	Total
Low	a	b	a+b
Moderate	c	d	c+d
High	e	f	e+f
Total	a+c+e	b+d+f	a+b+c+d+e+f

Using the contingency tables, data will be examined for three forms of association, positive or negative, linear or curvilinear, and symmetrical or asymmetrical. These forms of association provide information about whether a relationship exists or not between the variables. In addition, observed (O) and expected (E) frequencies will be calculated and analyzed (See Table 4 for a sample data table). For example, the expected frequency of girls with low STEM self-efficacy levels who want to take physical science courses would be calculated by taking the total of girls with low STEM self-efficacy (a+b), multiplying that number by (a+c+e), and then dividing that number by the total number of girls (a+b+c+d+e+f).

Table 4

Sample expected and observed data table.

	Course track interest		
Self-efficacy	Physical Science	No Physical Science	Total
Low	5 (5%) [9.75]	10 (10%) [5.25]	15 (15%)
Moderate	20 (20%) [22.75]	15 (15%) [12.25]	35 (35%)
High	40 (40%) [32.5]	10 (10%) [17.5]	50 (50%)
Total	65 (100%)	35(100%)	100 (100%)

The preceding analyses provide information about whether or not the two variables are associated, but did not give information about the strength of such association. To determine the strength of the association, a chi square test will be performed. The chi square formula is $x^2 = \sum \frac{(O-E)^2}{E}$. Using Table 4 as an example, this formula is used for each cell in the table. The sum of the results is 2.397, the chi square value. Degrees of freedom (df) may then be determined using the formula (number of columns-1)x(number of rows-1). In this example, the formula is (1x2) and df=2. For df=2, the statistical alpha, p-value, of a one-tailed direction hypothesis is 5.99 for 0.05, 9.21 for 0.01, and 13.82 for 0.001 probability levels. These values would indicate that the association was not significant because the value of 2.397 did not equal or exceed these values. Therefore, the alternative hypothesis could not be confirmed and the null hypothesis could not be rejected.

Qualitative Strand

To engage in qualitative data analysis, data must first be prepared in a way to facilitate analyses. Coding is a process to prepare data for analyses beginning as soon as data is collected. Saldaña (2009) defined a code as "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (p. 3). Coding is a cyclical process that consists of two primary coding cycles that may also, within cycles, consist of several coding iterations. In addition, coding cycles with initial sets of data may contribute to protocol revisions and/or a more refined focus for subsequent data collection.

In this study, First Cycle coding strategies will include a priori, descriptive, and in-vivo coding. A priori codes will be used to find segments of the text that related to the literature regarding sources of self-efficacy and efficacy-activated processes. Descriptive coding segments texts using words or phrases to describe what is going on and what the study is about (Saldaña, 2009). This coding strategy is appropriate because this study is a mixed methods descriptive phenomenological study. In-vivo coding uses participants' actual words as codes. This coding strategy is appropriate because this study's purpose sought to give voice to girls in science. Strauss suggested that in-vivo coding also helps to identify “behaviors or processes which will explain to the analyst how the basic problem of the actors is resolved or processed” (as cited in Saldaña, 2009, p. 76).

Based on the codes from First Cycle coding, this study will employ pattern coding as its Second Cycle coding strategy. Pattern coding “is a way to group those summaries [from First Cycle codes] into a smaller number of categories, themes, or constructs” (Miles, Huberman, & Saldaña, 2014, Pattern Codes section, para. 1). Miles et al. (2014) described how pattern coding may not necessarily replace first iteration codes, but may serve instead to further clarify them. To aid in identifying patterns, Miles et al. (2014) suggested the use of visual representations such as matrices. The matrices, for example, could have three columns. The first would list categories, the second would list related codes from the First Cycle coding processes, and the third column could be used for analytic notes. Further patterns may emerge from examination of the matrices. Once patterns are identified, Miles et al. (2014) also suggested to try to apply them to subsequent data sources’ codes to challenge them and identify possible alternative explanations, leading to further refinement of categories.

Categories will then be used to create themes. Strategies for theme generation include looking for repetitions, similarities and differences, and cutting and sorting (Ryan & Bernard, 2003) as well as the creation of matrices to further examine and refine patterns (Miles et al., 2014). To evaluate the appropriateness of identified themes, I will employ the “touch test”:

You can literally touch someone who is a mother, but you cannot physically

> touch the concept of "motherhood". You can touch an old house in poor disrepair, but you cannot touch the phenomenon of "poverty". And you can touch a painting an artist has rendered, but you cannot physically touch his "creative process". Those things that cannot literally be touched are conceptual, phenomenological, and processual, and represent forms of abstraction that most often suggest higher-level thinking. (Saldaña, 2009, p. 187)

I plan to use the computer program QDA Minor Lite to analyze qualitative data. I will also create a codebook and update it regularly to increase the rigor of coding strategies. The codebook will include a table of four columns. The first column will consist of codes, the second will define the codes, the third will limit the scope of the code through inclusion/exclusionary topics, and the fourth will provide a sample datum assigned that code. The codebook will also be used to reexamine codes to identify other categories or subcategories for subsequent theme generation to further analyses.

Merging and Interpretations

As this study followed a sequential design, data was merged across strands and during the interpretation stage. Across strands, the quantitative phase informed the sampling methods for identifying focus group participants. Merging the two data sets' initial analyses, will provide opportunities for new patterns, trends, and categories to emerge. For the quantitative data sources, I will draw conclusions from statistical analyses and use cross-tabulations to compare findings with other explanations. After merging the two data sets, I will ask for ideas from critical friends and crosstabulate data from the surveys and themes for further interpretation. For the qualitative data sets, I will make connections between the identified themes, making connections between the themes, theories, and literature. After merging, I will continue to use coding, categorical analysis, and frequency of themes for analysis and seek ideas from other colleagues to interpret the merged data.

With respect to the interpretation process, Tashakkori and Teddlie (2003) defined inferences as:

> A researcher's etic construction of the relationships among people, events, and variables; efforts to represent respondents' emic expressions, perceptions, behaviors, feelings, and interpretations; and construction of how these emic and etic constructions) relate to each other in a coherent and systematic manner. (p. 287)

They stressed the connection between the effectiveness of integrating quantitative and qualitative data in mixed methods and their potential descriptive and explanatory yields. They suggested that researchers consider the process, quality, and transferability of inferences as part of the study's interpretation stage. With respect to the inference process, this study will use member checks, make connections between the findings and literature, and consult teachers in the school to consider contextual factors that also relate to the study. Interpretations will be considered tentative and will be part of an ongoing process of revision and clarification (Tashakkori & Teddlie, 2003). To evaluate the quality of inferences, this study will utilize several strategies that Tashakkori and Teddlie (2003) suggested including the use of empirical questions, linking research to theory, asking for critique from critical friends and other colleagues, and employing rigorous data collection and analysis methods. With respect to transferability, this study's methodology considered connections between literature and theory to increase its inferences' potential to be applicable to other settings. While no two schools or individuals are exactly the same, this study recognized that some patterns may occur across settings.

Validity and Trustworthiness

Potential threats to this study included instrumentation, implementation, sample bias, and researcher bias. Strategies to increase validity, reliability, and objectivity of quantitative data analyses and interpretations were the use of a valid and reliable survey tool (S-STEM survey), alignment of survey items with literature and theoretical framework, pilot testing of the DataStreme task aspect survey and focus group protocols, and training of the teachers in the data collection tool implementation protocols. Strategies to increase credibility, transferability, dependability, and confirmability of qualitative data analyses and interpretations included bracketing, purposive sampling, multiple coding iterations, and triangulation of qualitative data sources (Anfara, Brown, & Mangione, 2002).

Throughout the entire research process, it will be important to examine data and analysis techniques to ensure that they are, indeed, contributing to answering the research questions. To reduce sample bias, appropriate sampling methods were supported by literature and aligned to research questions. To reduce researcher bias, Lather (1986) urged researchers to develop self-awareness and use triangulation, reflexivity, and member checks to reduce the effects of the researchers' own biases and assumptions of the phenomenon on conclusions. Following those suggestions, I plan to engage in reflexivity through use of a researcher's journal, use analytical notes on all data sources, use multiple data sources for triangulation, and seek guidance from the teachers involved in the study and other colleagues throughout the study to ensure that findings are well-supported by data and that their limitations are clearly articulated.

Johnson and Onwuegbuzie (2006) offered the term *legitimation* to refer to the quality of mixed methods research and identified several types of legitimation for mixed methods research. Typologies of legitimation related to this study include sample integration, weakness minimization, paradigmatic mixing, multiple validities, and political. With respect to sample integration and weakness minimization, cross-tabulation charts and continual reflection on the degree to which each research stage aligned to research questions will aid in ensuring that the purposes and methods of both quantitative and qualitative components are complimentary and serve to expand understandings. In addition, participants will be drawn from the first phase's participants to promote complementarity of findings. Acknowledging multiple validities, a larger sample size will be used for the quantitative phase to allow for the use of statistical analyses and a smaller sample size will be used for the qualitative phase to gain a deeper, descriptive explanation of findings. The study's design and paradigmatic assumptions support paradigmatic mixing. Multiple validities are accounted for in that methods related to quantitative and qualitative paradigms will be used respectively for data collection and analyses. Literature regarding the developing understandings of mixed methods research informed planning decisions regarding the merging of data and interpretation techniques (Cresswell & Plano Clark, 2011; Johnson & Onwuegbuzie, 2006). As Johnson and Onwuegbuzie (2006) suggested, meta-inferences may be made using joint displays of quantitative and qualitative data to use the qualitative data to further explain the quantitative findings. From the lens of political legitimization, I worked with the school district's administration to plan for sharing of the study's findings and plan to develop manuscripts in hopes of making a small, possibly significant, contribution to the larger context. See Appendix I for a summary of strategies and justification for reducing threats to this study's quality.

Role as a Researcher

I began my college career as physics major. Despite mentorship and three years of coursework, I changed my major to mathematics. Soon after, I switched to business, then music, and, after a semester overseas, to a Spanish major. Slowly but surely, I had transitioned from STEM fields to humanities. I oftentimes look back on my educational experiences and wonder why I thought it was feasible to learn a second language in my early twenties, in one year nonetheless, yet not possible to complete my original pursuit of a physics education degree. As I reflect upon my interest levels now in science education and my experiences, I cannot help but wonder what factors influenced my decision to abandon my own pursuit of a physics degree at such a late point in my college career. In light of persisting inequalities in the STEM workforce, I realize that I am not alone in this "leaky pipeline" phenomenon and further research is needed to better promote equitable opportunities for all students in the STEM fields (Sonnert & Holton, 1995, p. 8).

I have always been interested in educational research. While I was a physics major, I worked with my professors on various research projects, testing the accuracy of various tools that teachers could use during labs with students to teach a variety of physical science theories. My student research opportunities were primarily quantitatively driven and focused on the tools themselves and ignored how students would perceive and interpret the use of the tools and how such reactions would inform their learning and future opportunities. As I reflect upon those experiences and the literature for this study, there are numerous tools for teachers to use to enhance their students' science experiences, but little guidance is provided on how to most responsibly choose and evaluate the appropriateness of the various tools on informing various student outcomes.

The constant throughout my entire educational preparation and professional career was an interest in the dynamic relationship between teaching and learning. During my third year teaching Spanish, a colleague of mine introduced me to the DataStreme Project and I encouraged my colleagues in science departments to enroll. Through their experiences, I was immediately drawn to the DataStreme Project's mission to increase participation of underserved populations in STEM fields. I found myself attending statewide meetings, wanting to learn more about the activities. I even presented with other teacher and administrative representatives about classroom applications and interdisciplinary connections using the DataStreme activities in schools at the National Oceanic and Atmospheric Administration headquarters in 2009.

As a past school administrator and current supervisor of student teachers, I am interested in better understanding how specific aspects of the DataStreme resources may be integrated into our current science educational program to influence girls' perceived STEM self-efficacy to pursue advanced science courses. Further research regarding the role of gender and factors related to perceived STEM self-efficacy is needed as perceived STEM self-efficacy is a strongly predictive source of persistence in STEM course, degree, and career pursuits (Hackett, 1995; Zimmerman, 1995).

Ethical Considerations

Miles, Huberman, and Saldaña (2014) suggested that researchers reflect upon the worthiness of their study as well as its benefits, risks, and reciprocity with participants. In developing the first two chapters of this dissertation, I made a case for why this study was needed. In designing this study, I also worked with teachers to plan a study that would support their efforts to increase students' perceived STEM self-efficacy and likelihood of pursuing advanced physical science courses. I also planned to present findings at a district-wide STEM department meeting in hopes of contributing to the larger discussion of instructional and curricular strategies that promote gender equality in advanced STEM courses through fostering girls' perceived STEM self-efficacy. The girls themselves, the students who participate in the study, will also benefit from this study. Initial analyses will be shared with the girls who participate in the focus groups to elicit feedback and critique. Findings will also be shared with all of the girls who participate. In doing so, the girls' participation and voice will be validated. Findings will be shared with teachers in hopes that instructional and curricular changes may better support girls' perceived STEM self-efficacy, possibly opening up new opportunities for their students' future course and career paths.

Miles et al. (2014) encouraged researchers to consider their competence levels with varying facets of research. As a novice researcher, I carefully selected key individuals to serve as my dissertation committee members who had skills, knowledge, and expertise that complimented each other and would support my growth. I also joined a dissertation cohort that my dissertation chair organized for the students who she advises for the dissertation study. This group met monthly and provided opportunities to collaborate and share experiences as well as serve as a support system throughout this process. With every new conversation that I had, book I bought, or article I read about the potential study purpose, topic, and design, I was faced with the challenge of balancing what I would like to do and what I was able to do. This study was carefully designed with a lot of reflection to align with my current level of competence with respect to the all facets of the research process and to serve as a foundation for my future research endeavors.

Miles et al. (2014) also suggested that researchers consider issues related to informed consent, risks, and privacy. Because this research involved participation of human subjects, it will be conducted only after Rowan University's Institutional Review Board (IRB) reviewed and approved the study's proposal. The participants, the girls, and their parents/guardians will be informed of the study and be required to sign an informed consent form to participate in the study. The informed consent form will include the study's purpose, procedures, risks, benefits, description of confidentiality, information on how to withdraw, and my contact information along with relevant dissertation chairperson information. This study's methodological decisions recognized that a power relationship exists between teachers and students. As such, the surveys will not be graded, focus group and interview transcripts and related audiotape recordings will not be shared with the teachers or other personnel in the schools, and refusal to participate will not result in any consequences for the student. Access to and destruction of data sources will follow IRB procedures and requirements.

Strongly related to research ethics are the notions of validity and trustworthiness. As described earlier, several quantitative, qualitative, and mixed methods strategies were used to promote validity and trustworthiness of findings. To promote ethical use of this study's findings, I plan to share findings with teachers at a district-wide STEM department meeting. In addition, I will ensure that I clearly state the limitations of this study and how this study's findings may be used to inform practice, research, and policy in the discussion section of this dissertation.

Conclusion

This study's pragmatic paradigmatic assumptions informed subsequent methodological decisions. The study's explanatory, sequential design sought to use both quantitative and qualitative data sources with the goals of complementarity and expansion (Collins & Onwuegbuzie, 2007; Greene, Caracelli, & Graham, 1989) to examine the phenomenon of high school girls' determinations of potential science course pursuits. This study's methods and instruments were chosen to specifically align and address the research questions. Ethics, validity, and trustworthiness considerations were taken into account through the use of a variety of strategies. Through this study's design and methodology, it is anticipated that the subsequent analyses, inferences, and findings may be used to better understand how gender and specific science educational task aspects may serve to limit or expand girls' perceptions of STEM self-efficacy and the pursuit of physical sciences in their future science course trajectories.

Chapter 4

Findings

The purpose of this mixed methods study was to examine how high school girls make sense of their perceived STEM self-efficacy and potential science course paths. During the first, quantitative phase, survey data were collected to elicit participants' perceived STEM self-efficacy levels and science course preferences (Fink, 2013). This study's pragmatic paradigm assumed that knowledge is "both constructed *and* based on the reality of the world we experience and live in" (Johnson & Onwuegbuzie, 2004, p. 18). As such, findings based solely from quantitative or qualitative analyses may miss valuable information that other data sources could provide (Abowitz & Toole, 2010; Greene, 2012). To better understand the phenomenon of high school girls' perceived science course paths, then, qualitative data were collected to elicit more depth about the process by which girls' make sense of which paths are most favorable and likely for them to pursue (Miles, Huberman, & Saldaña, 2014). The second, qualitative phase, then, used data from focus groups, interviews, and open-ended task surveys to complement and expand quantitative findings (Collins & Onwuegbuzie, 2007; Greene, Caracelli, & Graham, 1989). In addition, field notes and researcher journal data sources were collected to supplement qualitative data's descriptions and to allow for bracketing of potential biases during analyses (Ahern, 1999; Borg, 2001).

This chapter communicates the findings from data analyses in relation to the research questions that guided this study. In addition, it seeks to make the data analysis decisions transparent to the reader to support the rigor of this study's findings (Anfara, Brown, & Mangione, 2002). This chapter is divided into two parts. First, this chapter will present preliminary statistical findings gleaned from descriptive and inferential analyses of the quantitative data collected in this study. Second, it will present themes that emerged from thematic analyses of the qualitative data collected from study participants. It concludes with a brief summary of findings resulting from the merging of preliminary quantitative and qualitative findings.

Quantitative Phase Overview

The first, quantitative phase of this study collected survey data to examine perceived STEM self-efficacy levels and perceived science course paths of high school girls enrolled in Honor Chemistry during the 2014-2015 school year. These data were collected to examine the relationships between perceived STEM self-efficacy and perceptions of future science course pursuits. These data were also used to inform the selection of participants and protocol revisions for the second, qualitative phase that sought to better understand why girls who are achieving in science are not pursuing advanced science courses, particularly those in the physical science fields.

Response Rate

To elicit demographic and perceptional data, teacher volunteers administered the surveys to their female students enrolled in Honors Chemistry in September. Consent forms were also distributed at that time. At the beginning of October, teacher volunteers administered the surveys to those who had consented to participate in the study. The total number of participants was 80, representing 80% of the girls currently enrolled in Honors Chemistry in the school context being studied. This percentage met Krejcie and Morgan's (1970) minimum participation requirement based on a 95% confidence interval for validity for a small sample population, promoting representativeness of statistical analyses with respect to that population.

Survey Participants' Demographic Data

Of the 80 participants, 74 were sophomores, five were juniors, and one was a freshman. Demographically, approximately 89% of the participants were Asian, 8% White, 1% Black, and 3% did not answer the question regarding demographics. To prepare data for analyses, I entered survey item responses into an Excel worksheet. The worksheet had a row for each participant, identified with a code, followed by her corresponding responses from the survey.

Preliminary Survey Data Findings

Survey data collected during the quantitative phase of this study sought to address the first research question, what associations exist between high school girls' perceived STEM self-efficacy levels and perceived likelihood of science course pursuits? Subquestions included:

1. What is the association between perceived science self-efficacy and perceived likelihood of science course pursuits?
2. What is the association between perceived math self-efficacy and perceived likelihood of science course pursuits?
3. What is the association between perceived engineering/technology self-efficacy and perceived likelihood of science course pursuits?

This phase collected data using a 31-item survey with 25 items eliciting attitudinal data regarding efficacy beliefs and four items eliciting perceptional data regarding future course enrollments. To identify the perceived self-efficacy level of the participants, three approximately equal categories were created, "low", "moderate", and "high" based on the distribution of scores. The categories, then, would represent the participant’s level of perceived self-efficacy in comparison to the other participants in this study. Counts and frequencies were calculated and organized in contingency tables. These tables were used to describe the number and percentage of participants whose scores fell into a specific strength category of efficacy beliefs in relation to the future likelihood of specific science course pursuits, not likely and somewhat likely survey responses were combined (NL/SW) and very likely remained its own category (V). Data analysis processes and statistical findings will be presented in this section.

Perceived STEM Self-Efficacy and Course Pursuits

The first research question asked, what associations, if any, exist between high school girls’ perceived STEM self-efficacy levels and perceived likelihood of science course pursuits? Initial examinations of the crosstabulation table indicated that there might be a positive association between perceived STEM self-efficacy levels and perceived likelihood of taking AP Chemistry and/or Physics. In other words, the observed trends indicated that the higher the perceived STEM self-efficacy, the higher perceived likelihood of taking those courses and, conversely, the lower the perceived STEM self-efficacy, the lower perceived likelihood of taking those courses. While participants with low perceived STEM self-efficacy levels were less likely to indicate a high perceived likelihood of taking AP Biology, increased levels of efficacy, from mid to high, did not indicate an increased perceived likelihood of taking the course. See Appendix J for a summary of these analyses.

A chi square test of goodness-of-fit was performed to determine the strength of these observed trends. The null hypothesis was that perceived STEM self-efficacy and perceived likelihood of taking advanced science courses were independent, the alternative hypothesis being that the differences between observed and expected values were significant, suggesting that the trends were not due to chance. The differences between observed and expected values were found to be statistically significant for AP Chemistry and Physics. The null hypothesis was rejected. Analyses, then, indicated that perceived STEM self-efficacy is positively associated with perceived likelihood of taking AP Chemistry and Physics, meaning the higher the perceived STEM self-efficacy, the higher the likelihood of taking those courses. The differences between observed and expected values were not found to be statistically significant for AP Biology. The null hypothesis was accepted, meaning that perceived STEM self-efficacy and likelihood of taking AP Biology are independent. See Appendix K for a summary of these associations.

The survey instrument assumed that STEM self-efficacy levels could be determined using a sum of the efficacy levels of science, math, engineering, and technology. Because of this, I also examined the association between each of the domain-specific efficacy levels and perceived likelihood of science course pursuits. Initial analyses of the contingency tables indicated varying trends that may provide further insight into the associations found between perceived STEM self-efficacy and perceived science course pursuits.

Perceived science self-efficacy and perceived course pursuits. The first subquestion asked, what is the association between perceived science self-efficacy and perceived likelihood of science course pursuits? Initial examination of the crosstabulation table indicated a positive association between perceived science self-efficacy and perceived likelihood of taking AP Biology and/or AP Chemistry. While participants with a high perceived science self-efficacy level were more likely to indicate a high perceived likelihood of taking Physics, increased levels of efficacy, from low to mid, did not indicate an increased perceived likelihood of taking the course. See Appendix L for a summary of these analyses.

A chi square test of goodness-of-fit was again performed to determine the strength of the observed trends. The null hypothesis was that perceived science self-efficacy and perceived likelihood of taking advanced science courses were independent, the alternative hypothesis being that the association was significant enough to not be attributed to chance. The differences between observed and expected values were found to be statistically significant for AP Biology and AP Chemistry, not for Physics. The null hypothesis was rejected for AP Biology and AP Chemistry. Analyses, then, indicated a positive association with statistical significance between perceived science self-efficacy and perceived likelihood of taking AP Chemistry and/or AP Biology. The null hypothesis was accepted for Physics, meaning that the association observed between perceived science self-efficacy and perceived likelihood of taking Physics may be due to chance. See Appendix M for a summary of these associations.

Perceived math self-efficacy and perceived course pursuits. The second subquestion asked, what is the association between perceived math self-efficacy and perceived likelihood of science course pursuits? Initial examination of the crosstabulation table indicated that there might be a positive association between perceived math self-efficacy and perceived likelihood of taking AP Chemistry and/or Physics. While analyses indicated that a lower perceived math self-efficacy was associated with a low perceived likelihood of taking AP Biology, increased levels of efficacy, from mid to high, did not indicate an increased perceived likelihood of taking the course. See Appendix N for a summary of these analyses.

A chi square test for goodness-of-fit was again performed to determine the strength of these observed trends. The null hypothesis was that perceived math efficacy and perceived likelihood of taking advanced science courses were independent, the alternative hypothesis being that the differences between expected and observed values were significant enough to suggest an a statistically significant association. The differences between expected and observed values were found to be statistically significant for AP Chemistry and Physics. The null hypothesis was rejected for AP Chemistry and Physics as analyses indicated a positive association between perceived math self-efficacy and perceived likelihood of taking those courses. The null hypothesis was accepted for AP Biology, meaning that the observed trends may be due to chance as they were not found to have statistical significance. See Appendix O for a summary of these associations.

Perceived engineering/technology self-efficacy and perceived course pursuits. The third subquestion asked, what is the association between perceived engineering/technology (Eng/T) self-efficacy and perceived likelihood of science course pursuits? Initial examination of the crosstabulation table indicated that there may be an inverse association between perceived Eng/T self-efficacy and perceived likelihood of taking AP Biology, the lower the perceived Eng/T self-efficacy, the higher the perceived likelihood of taking AP Biology. While analyses indicated that it may be more likely that a mid or high perceived Eng/T self-efficacy level may be associated with a high perceived likelihood of taking AP Chemistry, the increased levels of efficacy, from mid to high, did not indicate an increased perceived likelihood of taking the course. Initial analyses also indicated a positive association between perceived Eng/T self-efficacy and perceived likelihood of taking Physics. See Appendix P for a summary of these analyses.

A chi-square test of goodness-of-fit was performed to determine the strength of these observed observations. The null hypothesis was that the association between perceived Eng/T self-efficacy levels and perceived likelihood of advanced science course pursuits were independent, and the alternative hypothesis was that the two variables were not independent. The differences between observed and expected values were found to be statistically significant for Physics, not for AP Chemistry or AP Biology. The null hypothesis is rejected for Physics, indicating that there is a statistically significant, positive association between perceived Eng/T self-efficacy and perceived likelihood of taking Physics. The null hypothesis was accepted for AP Chemistry and AP Biology, meaning that the observed trends may be due to chance and the variables were independent. See Appendix Q for a summary of these associations.

Summary of Quantitative Findings

These analyses and findings help us to address the first research question, identifying the relationships between high school girls' perceived STEM self-efficacy, and its domain-specific components, and perceived likelihood of taking advanced science courses. A positive, statistically significant association was found between perceived STEM self-efficacy and perceived likelihood of taking AP Chemistry and Physics. Upon examination of the STEM domains separately, a positive, statistically significant association was found between perceived science self-efficacy and perceived likelihood of taking AP Biology and AP Chemistry. A positive, statistically significant association was found between perceived math self-efficacy and perceived likelihood of taking AP Chemistry and Physics. A positive, statistically significant association was found between perceived engineering/technology (Eng/T) self-efficacy and perceived likelihood of taking Physics. In other words, perceived science self-efficacy may play a role in perceived likelihood of taking AP Biology, perceived STEM, science, and math self-efficacy may play a role in perceived likelihood of taking AP Chemistry, and perceived STEM, science, math, and Eng/T self-efficacy may play a role in taking Physics.

Qualitative Phase Overview

The second, qualitative phase of this study collected open-ended task survey, interview, and focus group data with the purpose of expanding and complementing quantitative findings (Collins & Onwuegbuzie, 2007; Greene, Caracelli, & Graham, 1989). Priority was given to this phase to further explain the phenomenon of how high school girls make sense of their potential science course pursuits. Additionally, these data were used to elicit high school girls' perceptions of a DataStreme task and to explain which and how efficacy-activated processes, defined by Bandura (1995) as cognitive, motivational, affective, and selection processes, are activated in the context of a science educational task in relation to their perceptions of potential science course pursuits. As this study followed a sequential, explanatory mixed methods design, quantitative findings, informed both the selection of participants for the qualitative phase and revision to interview and focus group protocols (Tashakkori & Teddlie, 2006). As quantitative findings found an association between specific STEM domain-related efficacy beliefs and varying science course preferences, qualitative protocols were revised to elicit a deeper understanding of the efficacy-activated processes underlying these trends. These qualitative data were used to generate themes (Miles, Huberman, & Saldaña, 2014) to help us better understand how high school girls make sense of their science educational paths.

Procedures and Analysis of Qualitative Data

To elicit participants' perceptions of the DataStreme task and their considerations when determining their science course pursuits, participants completed an open-ended task survey and participated in focus groups and interviews. The open-ended task survey consisted of four open-ended questions about the DataStreme task. Semi-structured focus group and interview protocols elicited participants' perceptions of both the DataStreme task and their considerations when determining their science course pursuits. Four focus groups were conducted lasting approximately 40 minutes each. After initial analyses of focus group data, I planned follow-up interviews. Interviews were conducted with all of the focus group participants to follow-up on focus group discussions as a measure to lessen the impact of "group think" on findings (Janis, 1995). Each follow-up interview lasted approximately 30-50 minutes. Throughout the study, I kept a researcher journal and took field notes during focus groups and interviews. These two data sources served more as a record of field work and methodological decisions (Borg, 2001) and, while valuable to promote reflexivity (Janesick, 1999), analysis priority during theme generation was given to the focus group, interview, and task survey data.

Qualitative Sample Criteria and Demographic Data

Participants for the qualitative phase were selected using a criterion sampling strategy. Criteria were selected to delve further into the perceptions of high school girls whose associations between perceived STEM self-efficacy and perceived likelihood of certain science course pursuits did not conform to the theoretical assumptions of this study's theoretical framework. In other words, criteria were chosen to identify potential participants who, theoretically, had the perceived STEM self-efficacy levels to widen the scope of potential science course paths, but, instead, quantitative data analyses indicated that their science course paths were narrower than expected. The criteria for the sampling strategy, then, were a mid to high perceived STEM self-efficacy level and low to mid perceived likelihood of taking Physics during high school. Of the 80 participants, 39 participants met both criteria. Of those 39 potential participants, 16 participated in the qualitative phase. Four focus groups were conducted and the same 16 participants participated individually in a follow-up interview and completed a task survey. Demographically, 13 participants were sophomores and three were juniors. Of those participants, one was White, one was Black, and 14 were Asian, primarily of Indian decent with two being of Chinese decent.

Qualitative Data Findings

Theme generation from analysis of collected focus group, interview, and open-ended task survey data sought to help us answer the following research questions:

1. What factors do high school girls identify as informing their science course pursuits?
2. How do high school girls negotiate those factors?

3. What aspects of the DataStreme task do high school girls identify as informing their perceived STEM self-efficacy?
4. How do high school girls describe that these aspects achieve such influence?

These three sources of qualitative data were initially transcribed and coded using a priori, descriptive, and in-vivo coding strategies. A priori codes were based on social cognitive theory's assumptions of self-efficacy, using each of the sources as a code. A priori codes were: (a) mastery experiences, (b) vicarious experiences, (c) physiological states, and (d) verbal persuasion. Efficacy-activated processes were also used as a priori codes: (a) cognitive, (b) motivational, (c) affective, and (d) selection. Process coding, then, was additionally performed as these initial codes began to suggest other related processes. Pattern coding then was used as a second coding cycle strategy (Saldaña, 2009). This type of coding was used to group the codes into categories. These categories were then used to create themes through strategies like looking for similarities and differences and repetitions (Miles, Huberman, & Saldaña, 2014; Ryan & Bernard, 2003).

Three primary themes emerged from analyses. The first theme depicts participants as strategic and emotionally-charged competitors in response to a competitive school culture with respect to grades and courses. Central to this theme is the identification of peers as competitors, the engagement in competitive peer comparisons, a heightened sense of doubt and insecurity, and the adoption of specific strategies with respect to choosing science course pursuits to maximize college admissions candidacy. The second theme, obligation-based goal setting, illuminates the participants' career goal orientations as a strategy for merging parental and school culture pressures. The theme also brings awareness to the influence of emotional responses and social persuasion on career goal adoptions. The third theme, metacognitive tools as empowerment, further illuminates how participants identify their own form of metacognitive tools to take action, accommodating for the restraints and limitations of guidance, and to determine the relevance of their science learning environment to further inform their perceived science course paths. Together, these themes and subthemes illustrate the context and the efficacy-activated processes in which participants made sense of their perceived STEM self-efficacy and potential science educational and career paths. In the following sections, data will be used to provide evidence of and support rationales for the identification of these themes.

Strategic and Emotionally-Charged Competitors

Participants adopted roles as competitors in response to the perceived competitive environment of their school. Participants consistently depicted their school as competitive. As one participant explained, "The standards are so high here in comparison to other schools in like you could be considered really smart in one school, but here you're considered average." More specifically, this participant explained:

> Well, we're not like a typical high school where everyone is chill, chill about their grades. But, here, you have to get an A, if you don't, you're not considered one of the smart ones, or the normal ones. So, that's, since you want to keep up with everyone else, you want to try harder and that's the competitiveness.

These data typify the context in which participants make science course pursuit decisions and further illuminate the underlying emotions and strategies to their science course selection-making processes.

Central to this theme is the participants' identification of peers as competition and strategic intentionality with science course selection and scheduling. The first subtheme, emotional toll of competition, will highlight how participants, in seeking a competitive edge, engaged in self-appraisal processes through peer comparisons. It will further provide evidence of how these comparisons tended to elicit negative emotional responses, leading participants to focus their attention on developing strategies to select and schedule science courses that they believed would have the most potential to maximize their college admissions candidacy.

Emotional toll of competition. Participants viewed peers as competition with respect to college admissions. As this participant explained, "technically speaking, everyone in your class is competition. You're in competition with them." Another participant stated,

> "I guess it's kind of a shallow perspective, but you know these are the people that colleges are going to be looking at, too, and in life, I mean, they're your friends, which is the hardest part, 'cause you're friends with all of them but then, at the same time, you want whatever the grade is… you want to be the person who's the best in the class and people think of you as an intelligent person."

As peers were perceived as competition, participants consistently expressed a desire to be the best student in the class.

To that point, another participant shared, "It's the environment that to be able to say 'I got a 100 on the last test, what did you get', like you want to be able to say that." As that comment suggests, this desire to be the smart one in class fueled participants' tendency to compare themselves with peers to make determinations about their progress toward maximizing their college admissions candidacy. As one participant explained:

> So you have to work a lot harder to like make yourself noticed in this school… multiple APs, you're taking like really hard courses freshman year or earlier, things like that, a lot of extracurriculars and sports.

As illustrated in that comment, participants' valued high grades and enrollment in advanced level courses were perceived as evidence of a competitive edge. In addition to high grades and advanced course enrollment, participants consistently identified quality class participation as another competitive criteria to "make yourself noticed" among peers. For example, this participant described how she identified smart peers:

> I think you would know depending on the questions they ask, if they're like complicated or they go further into the topic. And, like, if they answer questions and get them right.

Likewise, another participant identified smart peers as those "who you always ask questions to and rely for like help." When participants observed their peers and interpreted their own abilities based on what they saw them doing, they tended to come to the conclusion that their peers' abilities were stronger than their own. Thus, they experienced a heightened sense of negative emotional responses, higher levels of self-doubt and insecurity.

Grades. With respect to grades, low grades or the possibility of earning low grades elicited negative emotional responses. Participants consistently expressed the desire, consistently referred to as "pressure" to earn high grades for college admissions. For example, one participant mentioned, "an average (school name removed) student, if they get a bad grade, their first thought is I won't get into college." To that point, another participant described, "If I get a single bad grade or your grade drops for a while and you don't know, there's a lot of unknown. You don't know if you'll get into college or the right college."

In fact, many participants expressed concern over how their achievement would be viewed inside and outside the school building. A negative social stigma was also attached to lower grade achievement. One participant described, "Especially in this community, I feel like being successful is only defined as oh you have an A or oh you have a B." Illustrating how this expectation manifested itself in the school environment, another participant shared:

> My sister, for instance, she's doing fine this year, but she was having a hard time adjusting to junior year. And when she told her friends that she got a B, they just looked at her completely shocked. Personally, I mean, I can see why Cs aren't great things to have. I just wish people were more ok with getting Bs. Bs aren't terrible, not as good as an A, but they're not terrible.

Participants, then, felt more pressure to achieve certain grades as they believed others would use them to judge their abilities.

Furthermore, participants' observations of higher success levels, oftentimes measured through the use of grades, discouraged them and lowered their sense of progress toward their career goals. As this participant's comments illustrated:

> You know, the comparing can really bring you down. You could think that someone is not as bright as you and then in your class you see they're scoring

higher than you on a bunch of tests, and like, if I can't do better than this person, why am I even thinking about applying to this college.

As these comments illustrated, the perceived influence of grades on college admissions and their appearance of smartness in comparison to others heightened emotional responses and insecurity regarding their ability to achieve in the future.

Course levels. Girls also had to consider what level of a course they would want to pursue, general, Honors, or Advanced Placement (AP). With increasing workload and difficulty considerations, the increasing course levels could, in turn, affect grade outcomes. Nonetheless, participants felt pressure to conform to the school's competitive norm of taking advanced courses. As this participant explained, "You're kind of expected to, you now, you like go up a grade, you're expected to take harder courses… harder in like higher level." Comparison with peers using course levels as a competitive comparison criterion elicited negative emotions in two primary ways, an increased sense of inadequacy and an increased impetus to catch up.

First, participants expressed that, since they had not participated in programs or courses outside of their school like other students, they were at a disadvantage course-wise. As this participant's comments illustrated, participants evaluated their potential to be admitted to college in comparison to their peers' qualifications:

> I have friends in calculus, I have friends who have already taken two AP sciences, it's you feel left behind and you worry, you worry if colleges only take two students from your school, you're not going to be one of them.

Another participant expressed similar pressures:

> There are people in my grade who took AP Chemistry as a freshman; they took Chemistry over the summer between eighth and ninth grade. And now, sophomore year, they’re taking AP Biology. So, I’m two years behind, that’s definitely a pressure, I’m competing with these people in this school itself who have already taken these courses.

Participants felt that they were at a disadvantage course-wise with respect to their college admissions candidacy. As they perceived these peers as their competitors for college admissions, they felt even more pressure to maximize the amount of AP courses in their schedules to prove that they, too, could take advanced courses.

Second, course level comparisons elicited negative emotional responses as participants felt pressure to take honors and AP courses, regardless of whether or not they felt they were prepared to be successful in those course levels. One participant stated, "Sometimes I think I would fit better in regular, but since, for the future, honors would be a better choice.” Another participant had similar experiences her sophomore year noting, "I actually was going to choose regular Chem, but then my parents told me to take honors.” Like lower grades, lower course levels had a negative social stigma. This participant, for example, described enrollment in lower level courses as “you can’t keep up, or you’re not smart enough.” Another participant explained the social pressure she felt to take advanced courses regardless of her ability or interest levels:

> Like we’re a tough school I would say if you compare with other schools with respect to grades and courses… I feel like that like based off of friends, I would feel kind of not with them if I took regular, but sometimes I feel that maybe it’s the best option for me, but I’m not sure… I might consider taking just regular

> physics, like I do enjoy science, but grade-wise I'm not doing as well as I wanted to and I'm just going and trying my best.

As indicated in these comments, inappropriate course placements further exacerbated negative emotions due to pressures to appear smart and maximize college admissions candidacy.

Participation and classroom behaviors. With respect to classroom behaviors, comparisons with peers also tended to elicit negative emotional responses. For example, with respect to ease of learning and quality class participation, emotional responses were elicited when participants observed higher frequency or stronger evidence of these criteria in their peers' behaviors. As this participant explained her self-doubt:

> I have to work a lot harder than some of my friends and, I don't know, they're good and they understand, but for me, I don't really understand science. It's usually that I sit at home and memorize everything the night before and I don't understand it while everyone else is talking about it and seeming like they're understanding it and saying the class is so easy.

In response to these comparison criteria, participants' self-doubt led to insecurity, feeling "inferior" to others, and limited their participation in class and pursuit of additional help or supports. They felt that "you'll be judged if you ask", limiting participation as they felt "intimidated…behind everyone else, because some people are more advanced." It was not uncommon for participants to express hesitation in asking for help because of the insecurities.

> When I get that support, I utilize it, but I'm not always quick to ask for it. I guess I feel, I don't know, self-conscious. If I ask for help, you know, then I'm not good enough or something like that.

As evident in these data, these negative emotional responses and subsequently adopted classroom behaviors had a limiting effect on the amount of help participants received, which could present future struggles with respect to grades and subsequent, advanced course enrollments.

Strategic intentionality. To mitigate these negative emotional responses, like self-doubt, insecurity, and pressure, participants became strategic competitors. As competitors, they weighed the advantages and disadvantages of taking varying science course selections on their potential to support their college admissions candidacy. Subsequently, they developed specific strategies to support the realization of their college admissions goals. This development of strategy was, in part, due to participants' recognition that they had a limited number of available course scheduling slots. As this participant related:

> The thing is, is that I'm kind of frustrated because, ok, I want to learn how the world works, but I can't learn that if I only have so much room in my schedule to take it. I mean, I only have room in my schedule to ok, like, take two AP Chemistry classes in the future with other courses. That means I won't have any room for Physics and or I might not have room for HAP, human anatomy and physiology. I have to choose between Physics and HAP.

Likewise, another participant shared a similar situation:

> I think I'll take AP Chemistry and um that's probably it. I don't think I will take Physics because I don't have that much time and I have to take electives and a lot of stuff that I want to and need to.

As such, participants developed strategies to choose science course selections based on expected grade outcomes, course levels, alignment to career goals, and observed trends in hopes of maximizing their college admissions candidacy.

Grade expectancy. To support grade expectations for college admissions, it was common for participants to choose courses based on their expected grade outcomes. In response to factors that influenced her science course selections, this participant stated:

> Seeing how much confidence you have in the subject you're going in, like how well you do in that subject. Like you might not like a certain subject, but you might do really good and it's good for your GPA [grade point average] and stuff so you might take a higher level of that subject.

Likewise, regarding her friend's decision to take AP Chemistry over AP Biology, this participant shared, "I know someone who took it because she got a better grade in Chem honors than she did in Bio honors." Thus, past earned grades informed course considerations.

Participants expressed avoidance or hesitation with taking Physics due to their fear of getting a lower grade in the course as a result of the course's perceived difficulty. Explaining her decision to not take Physics because of the grade she thought she would receive, this participant stated:

> I heard that Physics was a super hard subject and I was, I am totally scared of taking it… My senior friends say that they really enjoy Physics but I am so scared

> of taking it because I've heard the stereotypes that it's really hard, even if it's honors, is equivalent to an AP course.

Similarly, another participant shared her concerns about grades in response to how she would feel about taking Physics instead of AP Chemistry the coming school year. She stated, "I think my confidence would still be the same. I would be really cautious about it, I'd be more cautious about this than Chem." The possibility of taking Physics with its perceived difficulty level, then, conflicted with participants' strategy for grade point average expectations.

Course levels. Participants also considered what they believed colleges would want to see on transcripts in terms of course levels in their selection processes. Participants prioritized the taking of Advanced Placement (AP) courses their junior year. As one participant stated about her desire to take both AP Biology and AP Chemistry junior year, "it's your last year to prove yourself, you are what you are and what you like." Likewise, the majority of participants expressed desire to take AP Biology and/or AP Chemistry during their junior years. As one participant explained, "A lot of people tend to take AP Bio their senior year, but I definitely want to take it next year… because junior year is an important year and colleges look at it." In response to her decision to take as many APs as possible her junior year, this participant stated:

> Junior year is a really important year for college and like senior year counts but they don't get to see the grades for senior year so I think junior year would be the best year to take the hardest work junior year and to do well.

Participants, then, tended to reserve non-AP courses for senior year. When asked about potential science course enrollments for senior year, participants oftentimes expressed that they would take either honors or general level Physics and Human Anatomy and Physiology, a general level elective. Participants also expressed the possibility of taking Honors or general Physics senior year to support pursuits of science careers in the future. As this participant stated:

> My chemistry teacher, she told us you should take it if you want to a science major in college, they're going to make you take it. And if you take it in college, it's going to be super hard. You should take it now.

Reserving a physics course for senior year denies participants access to AP Physics due to scheduling and being their last year of high school. This scheduling strategy, then, inherently limits the pursuit of advanced paths in physics-related courses during high school.

Courses and career goals. When negotiating grade expectancies with course levels, participants prioritized the taking of courses that they believed aligned to their career goals. Participants with career goals in medical fields consistently, as illustrated in the following comment, associated those career goals with the necessity to take AP Biology.

> I plan on taking AP Bio probably more than the other AP sciences. My own reasoning behind it is because I want to go into medicine. I guess that requires usually AP Bio and Chem.

All of the participants agreed with this connection. The majority of participants identified career aspirations in the medical field. With the exception of two participants, they all expressed plans to take AP Biology their junior year. Participants also associated taking AP Chemistry with careers in the medical field. As this participant noted:

> I don't think a lot of people want to take AP Chemistry because they actually want to go into researching fields in chemistry, but because they want to go into medicine and medicine requires chemistry knowledge.

Participants' perceived connections, then, between science courses and their career goals in medicine informed their perceived likelihood of taking AP Biology and AP Chemistry.

While participants recognized the connection between biology and chemistry knowledge and medical career pursuits, only one participant, who had moved from another country and had taken Physics when she was younger for several years, mentioned the need to take Physics to meet her medical career aspirations. She stated:

> Most of the people think we don't need physics because physics is more like architecture and engineering, but I think if you study biology, you need physics and same with chemistry. To understand the world better, you need to understand all sciences. Even if you're in medical school, you need to know basic stuff.

The majority of participants, however, failed to see the connection between physics knowledge and career pursuits in medical fields. For example, when one participant was asked if an understanding of physics was related to medicine, she replied without hesitation, "I don't think it's really connected." In fact, that lack of perceived connection led to a dismissal of that course in her perceived science course paths. She further described:

> I was thinking of taking HAP (which is human anatomy and physiology)… That's more in particular to my interests that I want to take as a major in college. So, next year, I might take HAP or physics senior year. So let's say next year I take AP Bio or AP Chem, then senior year, I have to decide if I still want to go in the

> medical field… If I don't, then, but I'm still interested in science, I'll take Physics. But, if I am, then I will take HAP. So, it's a dilemma.

Furthermore, participants were not able to make clear connections between physics and careers paths in general. Related careers that participants could identify were limited to engineering, architect, physicist, or astronaut. To that point, this participant shared:

> I've heard a lot of people say you know, I want to be a doctor, veterinarian, pediatrician, you know, all the things that we've held on to since kindergarten and still want to be today. So, yeah, physics is not one of those things that people say they want to pursue.

Despite a lack of perceived connection to career goals and interest in physics, participants, at times, recognized the need to consider enrollment in a physics course as a strategy to meet college admissions requirements. As this participant's comment illustrated:

> I know so many people who take Physics just for the credit. Like, hey, colleges may like the fact that I'm taking Physics. You know, if I want to be a doctor, I should take Physics because I like science.

Participants, then, considered the course's connection to their career goals as well as its potential on their transcript to maximize their college admissions candidacy in weighing the likelihood of future science course pursuits.

Observed trends. Participants used observed common trends in science course enrollments to make determinations of their science course pursuits. First, when seeking guidance, participants oftentimes sought advice from those they felt were smart and successful, hoping for similar results if they followed similar paths. As this participant stated, “I talk to others, I talk to my cousin who just graduated last year because she’s going to UPenn, too, so she definitely did something right.” Participants associated commonality with safety, less risk of failure, and tended to follow such paths, typically identified as taking AP Biology and AP Chemistry. In response to saying why she would take AP Biology and AP Chemistry, this participant remarked:

> I don’t think physics is as common as bio or chem and it’s like I don’t know many people who have a big interest in physics, it’s either bio or chemistry because those are like the major, I mean, the major or common direction in which everyone goes in.

Likewise, in response to saying why she would take AP Chemistry, this participant stated that “maybe cause Chem is the most common… Chemistry is what most people choose.” While observations of common trends most commonly encouraged participants to take AP Biology and AP Chemistry, they often dissuaded them from taking Physics. As this participant stated, in defense of taking AP Chemistry and not Physics, “Chemistry is what most people choose. People don't really feel comfortable to take physics.” Participants, then, in acknowledgement of the observed high ability levels of their peers and their school’s competitive culture, viewed commonly pursued courses as those most appropriate to maximize college admissions candidacy. The observed trend that taking Physics was not a common path conflicted with participants’ notions of safety in commonality.

Notions of safety in commonality were also threatened as participants’ observed differences between boys and girls with respect to classroom behaviors related to participation and science course enrollments. These observed differences often served to dissuade participants' pursuance of certain science courses. First, participants observed a difference in how boys and girls participate in class. One participant explained, "I feel like boys participate more and girls are more listening and taking notes." Another participant felt self-doubt as a result of these participation differences:

> I just find that sometimes in class, the boys tend to speak a little more like when you see someone getting stuff right and you have no idea whatsoever you start wondering if it's the right course for you.

These data illustrated that participants' participation preferences may not always conform to their perceptions of those needed for success in a competitive school culture resulting in lower valuations of competence and feelings of self-doubt and insecurities. In response, participants justified pursuits of more common paths for girls, like AP Biology and AP Chemistry, as a variation in interest. As this participant stated:

> I see that boys are more inclined to take physics and girls are more inclined to take Chem and Bio… very few girls are extremely, they may not be averse to physics, but they're not really interested in it either.

In response to these observed trends, this participant stated:

> For me, it makes me feel more pressure to go like if I were to go into a field of biology, it makes me feel more pressure to go into a biology field than to go into a field of engineering or something.

Thus, participants' interpretations of how boys and girls engage in the learning environment and what that means for their valuations of comfort and competency, play a role in their determinations of potential science course pursuits.

Obligation-Driven Goal Setting

This theme, obligation-driven goal setting, helps us to better understand parental and emotional factors that inform participants' perceived science course pursuits. Parental expectations further exacerbated the competitive school environmental pressures that participants experienced with respect to grade and course level expectations. With respect to grade expectations, one participant noted:

> If I get an A, they're like good job and then if I get a B, they're like you need to get an A. Then, even if it's like a low A, like a 95, it needs to be a high A like a 98.

Another participant stated, in response to her parents' expectations of her grades, "my parents do not accept bad grades." Similarly, participants felt pressure from their parents regarding the necessity to take advanced courses in lieu of general level courses. As one participant described:

> I guess the name of the course, AP, AP anything, people and parents encourage students to take AP courses. So, even if they're not interested, they may, you know, have to take it given the condition of their environment.

In general, parental pressure focused on positioning participants to be successful professionally. As this participant described her parents' guidance on course selections, she stated, "They're courses to prepare you for good professions."

Central to this theme is participants' internalization of parental pressures as a sense of obligation through career attainments, leading to the adoption of career goals and strategies to best attain those goals. In the first subsection, sense of obligation, further description and evidence of how participants have internalized parental pressures will be presented. It will further present how this sense of obligation elicited emotional responses related to an increased sense of urgency to choose career paths, oftentimes resulting in the supplanting of personal interests for those of others. The second subsection, socially persuaded career paths, presents further description and evidence of how social persuasion informs participants' perceptions of potential science course and career pursuits.

Sense of obligation. Participants expressed a personal obligation to be successful academically. One participant expressed the obligation of meeting college admission requirements in terms of her grades, "my grades are very important for me and I need to be responsible." The majority of participants described that if they felt they were not reaching their goals, they were disappointing themselves. For example, a poor grade or setbacks were viewed as "discouraging" and participants often blamed themselves, stating that they didn't study enough or sufficiently. This self-blame is evident in this participant's comments about getting a poor grade:

> And like I know that I would have to try better next time, but maybe I didn't study as much or do lots of practice so I would look at it as how can I improve to make my next grade better.

Another participant noted that efforts to improve grades were a way to "redeem yourself and if you don't then you won't be successful." This sense of disappointment and need for redemption was, in part, a result of participants' perceptions of high grades in courses related to potential career paths as necessary benchmarks toward their college admissions and career goals. For example, this participant, reflecting upon the grades she needs to pursue a career in medicine, explained:

> If I like follow true the path to become a (profession removed), then I know the grades I need to get to get in to the course I want and the program I want to get into and to like follow true in (profession removed), if for instance, I slipped into a C in Chem, I wouldn't be able to take AP Chem, or AP Bio for that matter. It can hamper my future plans.

Participants, then, valued high grades and put pressure on themselves to earn high grades to support their future college and career goals.

This sense of personal responsibility also encompassed a sense of obligation to others. Participants' repeated comments about making their parents "happy" or "proud" fueled the pressure they put on themselves to be successful. One participant described how her desire to please others led to a fear of disappointing others. When asked what would encourage her to take Physics, which she had previously dismissed as an option, she responded, "Knowing that even if you don't do as well as someone wants you that they won't be disappointed." Underlying this desire to please was an internal sense of altruism. To illustrate this point, this participant stated, "I want to give back to my parents for how much they've given me." She further described this sense of obligation as:

> My parents have been through a lot for me to go to this school… it's a lot of pressure because you feel bad if you don't do something with your life or something valuable because they want to see me succeed when they really didn't have any options.

While this sense of obligation was felt as a pressure, another girl described that it helped her because she believed that her parents have her best interests in mind:

> Our parents want us to do well and want us to like get a good job with a good salary because they want us to be happy in the end.

Participants, then, often characterized this sense of giving back as being successful professionally.

As such, participants identified certain career paths, particularly those in the medical fields, as increasing the likelihood of them being successful and, thus, allowing them to fulfill their sense of obligation toward pleasing and giving back to their parents. When describing a preference toward medical fields, one participant stated, "I think you're like guaranteed to have a job. If you do something like arts, you're not guaranteed to go anywhere." Similarly, another participant justified her preference toward a career in medical fields with the following rationale:

> Doctors and the like are held at such a high esteem that like it's almost guaranteed, like a life in the future that you don't have to worry about income because you have a steady job and it's a well-paying job as well.

The scope of participant's potential career paths was primarily limited to those in medical fields. As the adoption of career goals, then, as seen in the previous theme, play a role in participants' perceptions of potential science course pursuits, science course paths are potentially limited to those that have a perceived alignment to career goals in medicine.

Socially persuaded career paths. Participants adopted career goals primarily through social persuasion, from what others suggest they do. Parental advice was based in their concepts of appropriate career paths for their children, which could serve as encouragement or discouragement. As one participant explained her choice to pursue a career in medicine, "I've been told my whole life that it's great to become a doctor.

You're a highly valued member of the community, of any community in the world." On the other hand, this participant's comments provided evidence of how parental advice could dissuade pursuance of certain paths:

> I look at my mom sometimes, when she used to work as a computer programmer for IT, she would always be so stressed out… she's basically told me her whole life to not do that.

Regardless of whether the advice persuaded or dissuaded pursuance of certain careers, participants consistently felt pressure from their parents to identify a career path. In some cases, this social persuasion was based in parents' desire for their child to live up to the success levels of a sibling. As this participant shared:

> I guess my family has helped me a lot and my sister is currently in a medical school so she definitely has set some standards for me. So, having that pushes me further and going to a school like this where it's considered cool to be smart, I guess, is helpful, seeing, and having a lot of opportunities and having a lot of classes also helps.

Yet another participant experienced similar pressures:

> Both my parents insist that I have to know what I want to do now. I know that I don't, but having the pressure of them asking me constantly. And, then, other family members, especially 'cause my sister went to Princeton and now she's going to UPenn, when we have graduation parties, they're all asking me and telling me I have very big shoes to fill… and it's a lot of pressure.

Thus, college and career paths of siblings play a role in the advice participants' receive from their families.

Social persuasion could also be the result of parents' concepts of appropriate career paths based on their childhood experiences or upbringing. As this participant stated:

> So, my mom was raised on like, so my mom's family is pretty successful in (country name removed). So, like she was kind of raised, I feel like she was raised on slightly outdated beliefs. Like, um, she's told me all of my life, don't go into surgery, it's too tiring. Um… do something that's, that guarantees a stable lifestyle, I guess like a substantial amount of money, that isn't as tiring.

Most often, participants experienced this social persuasion as the need to conform to parents' concepts of progress timelines. As evidence of this type of pressure, this participant shared, "My mom said, 'After tenth grade, I knew what to do. Why don't you have an idea of what you want to do?'" These comments served, too, to illustrate the elicitation of a wide range of emotional responses to parental pressure regarding career goal setting.

For those less clear on their career goals, the sense of urgency and emotional responses to pressure, often led to the consideration and adoption of career goals that supplanted personal interests. As one participant stated, "You might not be interested in something, but if your parents want you to be interested in something then you have to take it to make them happy." Similarly, this participant remarked:

> I think like parents and the pressure from them, it plays a big role in the courses you take because they also kind of influence what you want to be in the future. Like, if you want to make them happy, or if you want to make them proud, you

> might go for a career they want you to go for rather than like your own personal interest.

Another participant further described this pressure:

> But my grandma puts so much pressure on me. I guess cause like, 'oh, how can you have a B, we need A's you should work and have A's in all classes and you should take science because I want you to be a doctor,' but I don't want to be a doctor, but she does not care about that. So, maybe that's why I feel I should be a doctor because she pushes, pushes me to do it, but I don't like it.

Not all participants felt pressure, per se, but they all received career advice from their parents. This participant explained, "My parents want me to go into something medical. They're not forcing me, but, because I don't know where to go yet, that's where they want me to go." Social persuasion, then, may be limited in scope with respect to both parents' and participants' career awareness. As evidenced in this theme, the strong connection between career identification and science course paths has the potential to narrow participants' scope of potential science course paths as a result of the identified career field.

Metacognitive Tools as Empowerment

This theme helps us to understand how participants take action to accommodate for restraints and limitations in their own experiences and the guidance they receive in hopes of meeting their college and career goals through appropriate science course selections. Central to this theme is participants' consistent acknowledgement of the limitations of guidance they receive regarding their science course selections and career goals. As many of the participants' parents grew up outside of the United States, they realized that their parents' guidance was based on their experiences in other countries. To that point, this participant remarked, "They're giving me input but they don't know how this system works." Participants also consistently found guidance from teachers and guidance counselors as grades-driven. As one participant stated about grades, "they're really used to judge a lot of things in high school." One participant described her past year teacher's guidance on her current science course enrollment as the following:

> I remember last year my biology teacher, we went over whether to take Honors Chem or regular Chem and he based in on like your grades like if you're like a C-average person then you should take honors or reg, he based it on grades not your interests.

With respect to guidance counselors, participants felt similar sentiments regarding the limitation of their guidance as a result of their inability to get to know each student individually. As one participant remarked, "they're not just interested in you, they're interested in everyone, well, alphabetically." Likewise, another participant explained grade-driven guidance:

> I actually am really close with my guidance counselor but not in like, I don't talk to her about school as much, but just of life in general. So, when she, when I ask about courses I might want to take, she can only base it off my grades in previous classes and, like we were saying before, grades might not account for everything. So, I guess my guidance counselor can't help that much in that aspect.

To that point, another participant stated that, "when we meet with guidance, you have to tell them what you want or they'll assume you'll just take that", referring to either lower level courses or electives that may possibly be misaligned to personal college and career goals. Participants, then, needed to identify appropriate science courses, and levels that were most aligned the pursuance of future career goals through maximizing their college admissions candidacy. As they perceived a lack of guidance with respect to these considerations, they began to make up their own rules.

As seen in previous themes, participants take action by becoming strategic competitors and adopting obligation-oriented college and career goals. Moreover, and more central to this theme, participants, then, sought metacognitive tools that could accommodate for the restraints they felt as a result of the school's competitive culture and limitations of the guidance they received regarding courses and career pursuits. The first and second subsections, relevant experiences and experiential career awareness, presents further description and evidence of how participants identify the relevance and use of past experiences to inform their perceptions of their abilities and potential science educational and career paths. In the third subsection, community identity, further description and evidence of how participants value a sense of community to mitigate the negative emotional responses, those evidenced in previous themes, will be presented. To better address the research questions about *what* and *how* factors and DataStreme task aspects inform participants' perceptions of potential science course pursuits, all three subsections will particularly focus on aspects of the science learning environment that participants identified as informing their determinations of the relevance of experiences and their empowerment potential.

Relevant experiences. Participants consistently identified past exposure to a topic or type of science as highly influential in their science course selection processes. With each new experience, participants reevaluated their perceived ability and confidence levels with those they perceived as necessary to be successful in future related science courses.

Participants viewed positive experiences with past related courses as encouraging to take more advanced courses in that subject area. For the participants, positive experiences were most often described as those in which they liked the teacher and believed they understood the course's content. For example, this participant, describing her desire to take AP Biology as a result of her teacher and her instructional practices, stated, "I liked biology and maybe that's because of my teacher… She's great. She taught us to do new experiments and to think about it more." Determinations of positive experiences with respect to having an understanding of the course's content morphed over time. As this participant, describing her desire to take both AP Biology and AP Chemistry, explained:

> I actually like bio and chem because I understand it. Like, at first, I didn't like bio at all because I didn't understand it and when, like at the beginning of the year, we did organic chemistry and I kind of had in my mind that I wouldn't like chemistry at all, like when I started. But, I actually really like it now because I understand it.

Thus, participants who had positive experiences, interpreted through their perceptions of their teachers, instructional practices, and competence, felt encouraged to pursue related science courses.

On the other hand, negative experiences dissuaded participants from pursuing related courses. Participants most often expressed that dissatisfaction with earned or expected grades was discouraging. Reflecting upon her current grade in Honors Chemistry, this participant described her hesitation to take AP Chemistry in the future:

> If I were to do chemistry and um I would have to do it pretty cautiously, I think, because chemistry right now is good but it's not one of my best grades and like I wouldn't, probably, wouldn't dare to really like take a class.

Similarly, this participant explained her frustration with the grade she earned in biology as the reason that she is not pursuing AP Biology:

> I took biology honors and I didn't really like it. The subject area material was interesting, uh, for the class and the teacher I had, I studied really hard, like I haven't studied harder for anything… I want to get a 4.0 G.P.A. [grade point average], but like after like two months, I knew that wasn't going to happen.

Negative interpretations of earned and expected grade outcomes, then, had the potential to dissuade participants from pursuing related courses.

Exacerbating these grade concerns, participants expressed less certainty of pursuing certain science courses when exposure was limited. One participant, for example, stated that "I'm not really sure if I want to take AP Chem because I haven't explored all of chemistry yet" and another participant stated, "I haven't gotten to experience much in physics so I don't know, as of now, if I'll like it as much or better than bio or chem or at all." Exposure to topics and courses, then, played a major role in participants' perceptions of abilities and confidence with respect to future pursuance of related courses.

More specifically, little to no experience with physics topics denied participants opportunities to use past experiences to inform their decisions of whether or not to pursue certain science course paths. As this participant's comments demonstrated:

> I guess it's like completely new. In all of our years of education, we haven't had any exposure to physics, we've had chemistry, like solids, liquids, and gas. We've had that since kindergarten. I guess there's like a comfort aspect, too.

In the absence of physics-specific science course experiences, participants turned to their experiences with math to inform agency beliefs toward pursuit of physics. Those who had favorable perceptions of their math abilities, expressed that those abilities would support their potential success in Physics. Upon further reflection, this participant shared:

> I said I'll take AP Chem and AP Bio, but now that I really think about it, I kind of want to take Physics because I'm really math-oriented and my dad keeps telling me that I'd really like Physics.

Those who had less favorable opinions of their math abilities, were less confident in their abilities to be successful in Physics. As this participant stated,

> I think like me personally, especially toward physics I guess… my opinion toward physics is that I'm not, I'm not someone who's very good at math, physics is generally assumed to contain a lot of math in it and that really influence my opinion toward physics. I'm not good at it, my grades reflect that.

These comments, illustrating participants' use of past math experiences to make interpretations and valuations of their abilities in potential science courses, provided evidence that participants found math experiences relevant to making sense of their potential science course pursuits.

Participants' exposure to math was not limited to math classes as math experiences in science class could also support their perceptions of their math abilities. In response to the DataStreme task, participants consistently stated that the task's design supported their mathematical skills development and application of graphing skills. Not only were participants graphing and finding slopes, they mentioned how the task supported their skills in assigning meaning to the graphs. As participants described the impact of the lesson on the math abilities, they focused on sense making. As these data illustrate, participants explained that they had to "interpret what the graph meant", "determine the connection between the slope of the data and the real life meaning", and "show what someone can learn by reading a graph." One participant described, "the questions for the analysis encouraged me to form my own ideas rather than just telling me what the slope of the graph meant." Furthermore, participants recognized that scientists would need mastery of these types of skills. As this participant stated, "it's extremely crucial to be able to do such because the foundation of science is dictated by a desire to acquire more knowledge, done by analyzing data." Participants also identified continued exposure to similar activities as beneficial for developing skills and knowledge for future course pursuits in subjects, which they specifically identified as meteorology, environmental sciences, chemistry, and biology. Physics, however, was not mentioned, which may relate to their lack of previous exposure to physics-related concepts and courses.

Experiential career awareness. In recognition that career goals inform science course selections, participants valued opportunities for guidance regarding the connection between careers and courses. As this participant stated:

> I wish we knew more about the actual subjects before we took them. Like what careers they would lead to and where we would actually use them in real life because personally I know it's sophomore year and a lot of people already know what they want to do in college and I have never actually been focused.

This frustration was also related to the sense of urgency they felt to choose career paths.

> When I was a kid, my parents would ask me what I wanted to be, I would always answer happy… I know in high school it's more you're learning the subjects and you're learning what they're about but we're picking these courses and they do affect college and what courses we'll be taking if we just knew where the paths were leading, it would be a lot more helpful.

Participants, then, sought to find meaning in other experiences to expand their current scope of career awareness. This oftentimes was the result of knowing someone in the professional field. One participant shared that she learned about her career interest in medicine from her aunt, stating, "She has her own clinic. So, when I visit her I see whatever she does." Another shared that she learned about potential medical fields when she visited her sister in college, "I got to visit her at her school and she took me and my dad into her anatomy room and we looked at cadavers with her and that was really cool." Like the earlier subtheme of socially-persuaded career paths, these examples provided evidence that participants value experience and exposure to careers to increase their career awareness.

Participants also noted that classroom activities could provide career awareness and guidance. With respect to the DataStreme task, the novelty of the topics increased participants' career awareness. As participants remarked, "I also like that I got to learn a little more about how meteorologists take data about weather." Likewise, this participant stated, "the background knowledge about the NOAA [National Oceanic and Atmospheric Administration] also helped me develop an interest in the topic so I believe that can be used to encourage learning in the future." Such comments illustrated that, while the topic was not commonly taught, participants still found it relevant. These aspects, then, the topic and NOAA website, provided participants an opportunity to expand their knowledge and career awareness in another area of science.

It should also be noted, however, that not all participants experienced an increased interest or career awareness. This participant suggested that subsequent activities should instead make connections with science domains with which the individual has already developed a personal interest. More specifically, she suggested:

> I think one way to improve this lesson would be to use different data to make a graph. For example, I didn't think many people are interested in atmospheric temperatures. Most students are probably interested in different types of science, especially if that science is relevant to a student's life. I personally like biology, so I would have liked plotting data about, say, the number of carnivorous plants located in different sections of a swamp.

Such data indicated a desire to continue to develop further in previously learned topics, particularly those of relevance to already identified career and college goals, referring back to the previous concerns about lack of exposure to certain topics. In general, though, this subsection highlighted how participants used past experiences related to careers increased their interest and perceptions of their potential to follow such career paths.

Community identity. In response to the negative emotional responses that restraints of the competitive culture of the school and limitations of guidance produced, participants sought reassurances and found comfort in community. While participants viewed their peers as competition, as described in a previous theme, they also sought a sense of community with them through their shared experiences to lessen the negative emotions that they felt. One participant, for example, shared that she felt reassured when "there's people around me to go to for help… you get feeling like you're not in it all by yourself." Another participant shared that she seeks reassurance through "knowing that I'm not the only one struggling sometimes or like sometimes you feel intimidated by other classmates who may be like really intelligent and doing well." In light of the participants' perceptions of the school's competitive environment and their peers as competitors, these data illustrate their desire for community rather than isolation.

Subsequently, study participants valued classroom experiences in which they could work with others. For example, with respect to the DataStreme activity, a participant stated, "the fact that we had to work with partners allowed us to bounce ideas off each other and that's the whole thing about support." To that point, another participant shared about a blog activity:

> I really liked that because it gave you time to organize what you were going to say before you actually said it and you could do your research and everyone had the same chance because everyone had to participate but you didn't say it out loud and you had lot of time to prepare.

Activities with similar supports, then, like working with partners or having time to prepare ahead of time, lessened participants' emotional responses to participation expectations, promoting their active participation in classroom activities and membership to the class community.

Participants also sought a sense of community with the larger science community. Participants described that the use of real time data increased their valuations of the DataStreme task's relevance because of its authenticity. As evidenced in this participant's comments:

> I like using NOAA's [National Oceanic and Atmospheric Administration] data more because it made more sense. Recently we did this lab where we counted beans for it was, there was this element beanium and you were to find isotopes and stuff like that… You get that you're doing it and you get that it does apply in the real world, but when you have data from actual real world situations, it just makes it seem more…

Another participant completed her sentence with "important" and the original girl affirmed that statement. Another participant echoed these sentiments through comparing the use of real time data to teacher prepared data sets.

> I think that the lesson's materials were better than similar webquests, especially the website. Other similar activities, like webquests, usually are education school websites. This activity used the NOAA's website instead, which is not school-geared like other websites, making it more realistic, but just as educational. I also thought the activity was a nice way to connect graphing and practical application.

These data illustrate that potential of using scientific tools to validate participants' perceptions of their abilities and confidence may result from their desire for a sense of community with their classmates and larger scientific community.

Participants also described a sense of increased confidence through the use of real time data because, as this participant explained, “it's like a different experience like you get to see like the data actual scientists collected on their own in their own format.” Similarly, participants described how the use of real time data validated their potential as scientists, members of the scientific community. As one participant stated:

> And also that you're being treated the same as all the other scientists. So, it's not really based on how old you are, but your ability to read the data.

Comments like these highlighted the participants’ desire to lessen insecurities and the potential of membership in class-based and scientific communities to lessen such insecurities, potentially widening perceptions of potential science educational and career paths.

Integration of Findings

Merging quantitative and qualitative findings helps us to answer the final research question, how do qualitative findings complement or expand efficacy and course associations gleaned from the quantitative phase to help us better understand how high school girls make sense of their potential science course and career paths? In alignment to this study’s mixed methods design, this section will present how the qualitative findings complemented and expanded the quantitative findings.

Qualitative data complimented many of the associations gleaned from the quantitative data analyses. Initial quantitative data suggested that participants considered different efficacy components when making their decisions about the likelihood of pursuing various science courses during high school. In light of qualitative findings, it was not surprising that the quantitative findings indicated that perceived science self-efficacy was the only STEM self-efficacy component associated with a high likelihood of taking AP Biology with statistical significance. Due to the nature of the attitudinal survey items related to calculating perceived science efficacy, the majority of them related the efficacy domain with personal interest and connection to career goals. As the qualitative themes illuminated, participants were generally persuaded to have career goals in the medical fields and they consistently associated the necessity of taking AP Biology with medical career pursuits. Likewise, it was not surprising that quantitative findings indicated that perceived math self-efficacy was associated with a high likelihood of taking both AP Chemistry and Physics, a stronger association with Physics. The qualitative findings complemented these findings as participants consistently associated math abilities with chemistry and more so for physics.

With respect to past experiences with math and participants' valuation of those experiences and their ability levels, participants that expressed a higher math ability were more likely to express a higher likelihood of taking AP Chemistry and/or Physics. Quantitative findings indicated that perceived engineering/technology self-efficacy was only associated with a high likelihood of pursuing Physics with statistical significance. Qualitative findings did not compliment this finding. Instead, the qualitative themes illuminated other factors that dissuaded participants from taking Physics or perceiving it as a probable course path.

Qualitative findings, then, expanded the quantitative findings through their illumination of how multiple factors activated participants' efficacy-activated processes related to perceived likelihoods of perceived science course pursuits, primarily with respect to motivational and affective processes. The school's competitive culture and the resulting emotional responses led participants to make science course selections that were strategic in nature. The strategies that participants adopted were not necessarily based on their efficacy beliefs as measured by the survey, but rather their perceptions of which science course paths would best support their college admissions candidacy and future attainment of career goals. As the themes illustrated, their strategies, as a result of lack of experience with certain topics or conformance to school norms and observed, common course enrollment trends, led to the premature dismissal or hesitation toward certain course paths, primarily the taking of Physics.

The elicitation of participants' perceptions of the DataStreme task provided further insight into how participants determine the relevance of classroom tasks and, subsequently, how they use those relevance determinations as an influencing factor in their perceptions of potential science course pursuits. Integrating their perceptions in the framework of the quantitative, perceived STEM self-efficacy survey, perceptions aligned primarily to items related to perceived math and science self-efficacy components. Participants' identification of addition math practice and success in the DataStreme task in light of their reliance on math related experiences gleaned from qualitative themes, could support increased perceptions of math efficacy. Specific survey items that may relate were: (a) "I am the type of student who does well in math", (b) "I am sure that I could do advanced work in math", and (c) "math is hard for me." Participants' identification of science career connections, the use of scientific tools, and success in the DataStreme task in light of their career goal orientation and desire for metacognitive tools to evaluate their progress gleaned from qualitative themes, could support increased perceptions of science efficacy. Specific survey items that may relate were: (a) "I am sure of myself when I do science", (b) I would consider a career in science", (c) I know I can do well in science", and "I am sure I could do advanced work in science." With respect to perceived engineering/technology (Eng/T) self-efficacy survey items, participants' responses regarding the integration of math in the context of science may support the survey item of "Knowing how to use math and science together will allow me to invent useful things". However, the invention component was absent from participants' perceptions. The survey items related to perceived Eng/T self-efficacy included words and phrases like "creating new products", "building and fixing things", "designing products", "use creativity and innovation", and "career in engineering". These topics were absent from girls' perceptions of the DataStreme task and did not emerge in the qualitative themes. Participants' identified DataStreme task aspects that they found relevant would potentially support their interpretations of perceived math and science self-efficacy, but not perceived Eng/T self-efficacy.

Both the quantitative and qualitative findings answered respective paradigmatic research questions related to the association between perceived STEM self-efficacy and high school girls' perceptions of their course selection considerations and the DataStreme task. When merged, they addressed the final research question of how qualitative findings complement and expand our understandings of the phenomenon of how high school girls make sense of their potential science educational and career paths.

Conclusion

This chapter presented findings from both the quantitative and qualitative phases of this study. Quantitative findings help us understand the associations between perceived STEM self-efficacy levels and perceived likelihood of various science course pursuits of the study's participants. Qualitative findings help us to better understand what factors and how participants negotiate those factors to make sense of their potential science course pursuits. The themes of strategic and emotionally-charged competitors, obligation-driven goal setting, and metacognitive tools as empowerment complemented and expanded quantitative findings in several ways. Chapter Five, then, will present these findings in light of reviewed literature and the study's framework, highlighting their potential contributions to the larger discourse and limitations. It will conclude with a discussion of the findings' implications for policy, practice, and research.

Chapter 5

Discussion, Implications, and Conclusion

This study sought to examine how gender and science task aspects, and related DataStreme earth science resources, inform efficacy-activated processes related to high school girls' perceptions of potential advanced science course paths within a secondary school context affiliated with the DataStreme Project. This chapter will discuss findings related to gender inequalities in advanced science courses, with a particular focus on girls who had mid to high perceived STEM self-efficacy levels, yet failed to translate those agency beliefs, in light of the current discourse on women in STEM and self-efficacy scholarship.

This chapter will begin with a brief summary of findings from Chapter Four in relation to the research questions that guided this study. It will continue with a discussion of the extent to which findings aligned with the study's theoretical framework. Hence, a particular focus will be on efficacy sources, efficacy-activated processes, gender constructs, and gender role socialization. It will conclude with a discussion of implications for policy, research, and practice related to the larger discourse surrounding the promotion of gender equality in science educational and career participation.

Summary of Findings

While Chapter Four presented the results of the study, this chapter seeks to further connect the findings with the research questions, literature, and theory that guided the research, overall. The six research questions were:

1. What associations, if any, exist between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?

2. What factors do high school girls identify as informing their science course pursuits?
3. How do high school girls negotiate those factors?
4. What aspects of the DataStreme task do high school girls identify as informing their perceived STEM self-efficacy?
5. How do high school girls describe that these aspects achieve such influence?
6. How do high school girl's perceptions of influencing factors and DataStreme task aspects complement and expand our understandings of the associations found between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?

Perceived Efficacy and Course Pursuit Relationships

The first research question asked, what associations, if any, exist between high school girls' perceived STEM self-efficacy and future science course interests? Several relationships existed between high school girls' perceived STEM self-efficacy and perceived science course pursuit likelihoods. Perceived STEM self-efficacy was positively associated with perceived likelihoods of pursuing advanced science courses, such as AP Chemistry and Physics. Further examination of the subdomains of perceived STEM self-efficacy helped to explain this deviation from theory. Perceived science self-efficacy had an influence on girls' perceptions of pursuing AP Biology, AP Chemistry, and Physics. Perceived math self-efficacy had an influence on girls' perceptions of pursuing AP Chemistry and Physics. Perceived Eng/T self-efficacy had an influence on girls' perceptions of pursuing Physics. The additional considerations of math and Eng/T efficacies narrowed the scope of course interests. These trends, however, did not fully account for girls' perceived science course pursuits and, as such, the subsequent qualitative findings sought explanations for these deviations from the statistical trends.

Influencing Factors and Negotiation

The second and third research questions asked, what factors do high school girls identify as influencing their perceptions of potential science course pursuits and how do they negotiate those factors. Specific factors used by the participants to interpret potential science course pursuits included past experiences in related courses, grades, confidence levels, math abilities, parental pressures, peer comparisons, college admissions requirements, and competitive school culture. As seen throughout the qualitative findings, girls negotiated these factors by adopting a competitive mindset, prioritizing science course pursuits that they believed would best support their college admissions candidacy and give them a competitive edge over their peers.

To maximize their college admissions candidacy, the qualitative theme of strategic and emotionally charged competitors further depicted girls as competitors that weighed their perceived position among their peers with perceived science course pursuits. Parental pressure and girls' resulting sense of obligation, as seen in the qualitative theme of obligation-driven goal setting, further informed girls' perceptions of potential science course pursuits. These girls' self-imposed expectation to conform to competitive norms led to the adoption of strategies that they believed would maximize their college admissions candidacy. In doing so, however, their competitive strategies through peer comparisons and outcome expectancies, heightened negative emotional responses, such as self-doubt and insecurities.

Furthermore, girls experienced a sense of personal and family obligation, leading to premature adoption of career goals, oftentimes socially-persuaded paths aligned to others' expectations. While the adoption of career goals lessened some of the negative emotions due to competition by providing the girls with more direction and intentionality to their strategies to maximize their college admissions candidacy, the lack of guidance heightened them once again. While these limitations made them feel restrained and frustrated, they felt motivated to rationalize previous feelings of self-doubt or insecurity. Girls were in this constant battle, then, to manage their emotional responses in a context of limited guidance and competitive restraints. Their preferred science course pursuits, then, were those that they felt would best support their likelihood of meeting their college and career goals, balancing both internal and external pressures.

Task Aspects and Perceptions of Their Influence

The fourth and fifth research questions asked, what aspects of the DataStreme task do girls identify as influencing their perceived STEM self-efficacy and how do they describe that the aspects achieve such influence? Girls indicated that the topic of weather, use of real-time data, opportunities to work with partners, integration of mathematical processes, and the National Oceanic and Atmospheric Administration (NOAA) website were task aspects that they found relevant to their considerations of potential science course pursuits. Participants described that the tasks increased their interest in other science topics, abilities in creating and interpreting graphs, and career awareness. They described that the task aspects achieved their influence through their novelty, real world application, and authenticity. A key finding, then, was that participants found these task aspects relevant to their interpretations of their interest levels and math abilities in relation to perceptions of future success in related activities. Thus, the task aspects achieved their influence on girls' perceptions of science course pursuits by playing a role in girls' determinations of outcome expectancies.

Discussion

This section will address the extent to which key findings identified in Chapter Four support, disconfirm, and contribute to the reviewed literature and theoretical assumptions set forth in Chapter Two. From the theoretical lens of this study, reviewed literature focused on the influence of gender on girls' efficacy source preferences and efficacy-activated processes and gender role socialization on persisting gender inequalities in science course and career participation. A major finding of this study was that the girls' lack of information regarding science course and career paths allowed for the persisting influence of gender constructs and gender role socialization on their perceptions of potential paths. As such, this discussion will focus on how this study's findings support, (dis)confirm, and/or contribute to understandings of the influence of gender role socialization on efficacy beliefs related to girls' perceptions of potential science course pursuits.

Gendered Efficacy Beliefs

Self-efficacy sources were widely cited in the literature, using Bandura's (1977) work, as mastery experiences, verbal persuasion, physiological states, and vicarious experiences. He found that mastery experiences, past successes in a similar task, tended to predict self-efficacy in a future related task. Vicarious experiences, the ability to visualize or participate in a simulated activity with success, increased self-efficacy in similar future tasks. Verbal persuasion referred to the amount of support that one receives during a task in relation to outcomes. Physiological states referred to an individual's emotional and other physiological reactions to a situation. This study's findings suggested that gender role socialization resulted in varying strengths of three of these sources on high school girls' perceptions of potential science courses, mastery experiences, physiological states, and vicarious experiences. With the exception of a couple discrete data points, verbal persuasion did not play a significant role in findings.

Mastery experiences. A key finding of this study was that girls most prominently used mastery experiences, specifically those in science and math courses, as influencing factors in their efficacy beliefs toward certain science course selections. Positive interpretations of past experiences, most often defined in terms of earned grades, influenced their perceptions of potentially pursuing a related advanced course. Girls consistently associated higher grades, along with a perceived favorable experience with the class, for example, they liked their teacher or the content, as having a positive influence on their perceptions of possibly pursuing related advanced courses. This finding confirmed the vast agreement among literature regarding the strength of mastery experiences, positive valuations of past experiences, on increasing perceived self-efficacy (Bandura, 1995; Britner & Parajes, 2006; Kiran & Sunger, 2012). Girls' use of grades was also supported in the literature as achievement levels have been found to be strong predictors of students' valuation of success (Ucak & Bag, 2012).

Regardless of achievement levels, the girls tended to have low perceived math self-efficacy and expressed hesitation to take Physics. One explanation for this is that the girls who participated in this study had limited to no exposure to physics, denying them past opportunities to develop related efficacy beliefs through mastery experiences

(Bandura, 1995). On the other hand, this may suggest the influence of gender role socialization through persisting gendered science and math constructs. Research has found that girls tend to have lower self-efficacies for math and science, with the exception of biology, than boys (Uitto, 2014). More specifically, girls had lowest self-efficacies toward physics (Uitto, 2014), which may account for the girls' higher perceived efficacy toward biology in comparison to other physical science courses regardless of other grade, course level, or career goal considerations.

Gender role socialization regarding gendered math perceptions became most apparent through the girls' perceptions and use of their math competency in science course pursuit considerations. In the absence of mastery experiences in Physics, the girls accommodated by turning to their perceived math efficacy to inform their perceptions of potential pursuit of Physics. The girls, in general, expressed low perceptions of their math competency and, in turn, were less likely to consider Physics as a potential science course pursuit. This finding may support research regarding the negative influence of gendered math constructs and perceptions of math abilities as innate, undevelopable, on girls' efficacy beliefs toward domains that require such skills (Leslie, Cimpian, Meyer, & Freeland, 2015; Penner, 2015). This finding also expanded upon the concept of domain-specific mastery experiences. Research has found that mastery experiences were domain-specific, meaning that the past experience only influenced perceptions of future success in related experiences (Usher & Parajes, 2008). In this finding, those participants who had higher perceptions of their math competency were more likely to express a higher likelihood of taking Physics, regardless of their science competency. Domain-specific considerations, then, were ultimately determined by the girls' self-identified perceived skills needed to be successful in subsequent courses. In the case of taking Physics, girls' prioritized their interpretations of their math abilities over science abilities.

These findings regarding gender role socialization may, in part account for the identified associations between perceived STEM self-efficacy and perceived likelihood of science course pursuits. Findings from quantitative data disconfirmed the persistence of gender constructs related to the association of males with science and females with humanities (Lane, Goh, & Driver-Linn, 2012; Nosek, Banji, & Greenwald, 2003) as the majority of participants had mid to high perceived STEM self-efficacy levels. Quantitative findings, however, confirmed the persistence of gendered science constructs as perceived likelihoods of course pursuits were highest for AP Biology, a little lower for AP Chemistry, and much lower for Physics. Research regarding gendered science constructs has found that biology was oftentimes considered a more feminine science in comparison to physical sciences (Cervoni & Ivinson, 2011; Jones, Howe, & Rua, 2000). Literature regarding the construct of masculinity often associated with physical sciences, math, technology and engineering may further account for the perpetuation of these efficacy and course association trends (Bandura, 1997; Hackett, 1995; Lane, Goh, & Driver-Linn, 2012).

Vicarious experiences and physiological states. Another key finding of this study was that vicarious experiences aroused emotional responses throughout the themes. These emotional responses emerged specifically as self-doubt and insecurity. Physiological states in the context of peer observations of others engaged in tasks, a form of vicarious experiences, initially weakened efficacy beliefs. For example, the girls began to doubt their abilities or feel insecure if their interpretations of their observations exceeded their perceptions of their own competency. Likewise, the girls' observations of stress levels of their peers in certain courses, another vicarious experience, initially had a weakening effect on their efficacy beliefs. While these findings confirmed research findings that suggest that vicarious experiences manifest themselves in academic settings though peer comparisons (Schunk & Meece, 2005; Usher & Parajes, 2008), these specific physiological states that girls experienced may also suggest the influence of gender role socialization on their gendered emotional and behavioral patterns.

As these physiological states particularly occurred in their comparisons with boys, gendered constructs regarding the hypoemotionality of boys and hyperemotionality of girls (Heesacker et al., 1999) may have played a role in potentially biasing interpretations of their own or peers' competency as a result of observed or experienced emotions. These findings further confirm research regarding girls' tendency to experience higher levels of stress and anxiety when making determinations of their competency and efficacy beliefs (Kiran & Sunger, 2012; Usher & Parajes, 2008). Research has also found that girls experience higher levels of science anxiety, regardless of efficacy levels (Mallow, 2006; Udo, Ramsey, & Mallow, 2004). This could, then, account for girls' tendency to stay enrolled in courses rather than drop out, despite these initial physiological responses.

To that point, this study's findings illuminated that, with more experience, girls used other types of vicarious experiences to actually lessen potential negative effects of these physiological states on efficacy beliefs. Girls' desire for community, membership in their school community through their appearance of smartness and membership in the larger scientific community through their use of authentic tools, outweighed their competency considerations and physiological responses. Likewise, the girls' observations of common course paths, another vicarious experience, among those they held in esteem competency-wise had a positive influence on efficacy beliefs toward choosing course paths that aligned to those they were observing regardless of whether or not those courses were appropriate grade or course level-wise. This finding, then, may account for tendency of girls to take both AP Biology and AP Chemistry, regardless of workload and competency considerations, as a result of them prioritizing their sense of safety in commonality and community over other considerations.

Gender role socialization may also account for this trend. This study's findings confirmed the influence of observed gendered science participation trends on perceived likelihood of pursuing various science courses. The girls looked to their peers and the courses that they took to make determinations of appropriate science course pursuits. They found comfort and safety in commonality. As an interpretation of their observations, the girls acknowledged that medical fields and/or the taking of AP Biology and AP Chemistry were common trends among their peers and that boys tended to pursue physical sciences more than girls. They tended to accept these trends with little question. This phenomenon was referred to in the literature as "self imposed segregation" (Nosek, Banji, & Greenwald, 2002, p. 50). These findings, then, support research that girls may choose to limit the scope of their potential science course options as a result of the perceived gender inappropriateness of taking physics and lack of guidance or encouragement to pursue certain male-gendered science courses (Mallow, 2006).

With respect to guidance, gender role socialization may serve to perpetuate gendered science educational and career paths through its influence on parents' advice and girls' interpretations of observed course participation trends. The girls' description of parental pressure to identify careers and the limited scope of suggested paths, narrowed primarily to the medical fields, presented challenges for girls to expand beyond the status quo. Existing research may help to explain this limited parental guidance as a result of capital, referring to cultural and gendered assumptions of appropriate career paths (Schunk & Meece, 2005). Another explanation may be that girls' and women's acknowledgement and continued observance of gendered science participation trends and stereotypes perpetuate lower efficacy beliefs toward actual pursuit of those types of fields (BarNir,Watson, & Hutchins, 2011; Hill, Corbett, & St. Rose, 2010; Rivera, Chen, Flores, Blumberg, & Ponterotto, 2007).

Gendered Motivation

The interplay among interrelated efficacy-activated processes, identified as motivational, cognitive, affective, and selection processes, help to determine the directional strength of efficacy sources on efficacy beliefs (Bandura, 1995). As Bandura (1995) explained, motivational processes were related to outcome expectancies and goal setting, cognitive processes were related to metacognition, affective processes were related to stress levels, and selection processes were related to the selection of favorable outcomes.

Findings most prominently illustrated how girls' outcome expectancies and goals highly informed their perceptions of potential science course selections across qualitative themes. In addition, findings illuminated the influence of gender role socialization on girls' interpretations of grade expectancies and appropriate college and career goals. Gender role socialization's influence on motivational processes, then, with their interrelatedness to cognitive, affective, and selection processes, primarily informed girls' adopted strategies to maximize their college admissions candidacy through their science course pursuits. These two subsections, outcome expectancy and goal setting, will further illuminate the influence of gender role socialization on how girls engaged in these interrelated efficacy-activated processes in their adopted science course pursuit strategies.

Outcome expectancy. Girls' interpretive determinations of outcome expectancies were prevalent throughout the themes, particularly in the first theme, strategic and emotionally charged competitors. Cognitive processes informed motivational processes through girls' use of grade expectancy outcomes in their adopted strategies to make sense of potential science course pursuits. In doing so, girls consistently weighed their perceptions of what grades they would receive in subsequent courses with the potential impact such outcomes would have on their strategies to maximize their college admissions candidacy. Findings also indicated that affective processes were inherent to girls' interpretations of grades. As a result of peer comparisons, they began interpreting their grades and grade expectancies in other courses in a context of heightened emotions, primarily self-doubt and insecurities. Selection processes, then, used girls' grade and perceived grade potential interpretations to inform their perceptions of potential science courses. Favorable interpretations of the grade they would receive led to an increased perceived likelihood of pursuing related courses and, on the other hand, unfavorable interpretations had the opposite effect, leading to hesitation or avoidance of related courses.

These findings suggest the influence of gender role socialization on girls' perceptions and interpretations of grades and competency. Research has warned of the discouraging effect of grade expectancy use and interpretations of abilities as girls tended to have lower perceptions of their abilities than boys regardless of achievement levels (Britner & Parajes, 2006; DeBacker & Nelson, 2000; Leslie, McClure, & Oaxaca, 1998). Research has particularly found that girls tend to have lower perceived self-efficacy for math and science, particularly physics (Uitto, 2014). The girls' interpretations of expected outcomes may, then, be inferior to actual performance outcomes, prematurely narrowing agency beliefs toward pursuit of certain science course paths. On the other hand, in response to affective pressures, the girls rationalized grades or other potential limitations, as seen in the themes related to career goal orientation, which could lead to overconfidence, and pursuit of inappropriate course level pursuits to meet career goal orientations or course level expectations. Research regarding the adoption of professional goals, those aligned to career attainment, over mastery goals, those aligned to learning, may account for this increased efficacy toward certain domains, regardless of achievement (Bandura, Barbaranelli, Caprara, & Pastorelli, 200). In either case, inappropriate course pursuits and level placements can present a serious challenge to girls' attainment of their college and career goals.

Goal setting. Girls consistently adopted strategies to meet their career goals through maximization of their college admissions candidacy. Cognitive processes informed motivational processes when girls sought guidance to make interpretations of which courses would best align to their career goals. They recognized that guidance was limited and, as such, turned to observed trends and parents' advice, seeking safety and comfort in commonality, to interpret the appropriateness of course pursuits. Affective processes informed motivational processes as career goal orientation was inherently based in decisions that would manage emotional responses of urgency, responsibility, and obligation. As the second theme illuminated, these emotional responses oftentimes led to premature adoption of career goals that may or may not align to personal interest. With respect to selection processes, then, girls prioritized the taking of courses that they believed best aligned to attainment of their career goals. This was particularly evident in girls' tendency to pursue AP Biology and AP Chemistry as they believed those courses most aligned with pursuance of future careers in medical fields. On the other hand, courses that they viewed as irrelevant to career goals, like Physics, were dismissed or reserved for senior year when they would not have as much influence on what colleges saw on their transcripts.

With respect to goal themselves, the girls adopted goals based on their own perceptions of professional relevance and, as such, expressed desire to take both AP Biology and AP Chemistry. This finding confirms research regarding the association between goals based on professional relevance and the increased pursuit of advanced courses (Teppo & Rannikmae, 2003). This study's findings clarified this concept in that the pursuance of advanced courses only occurred if the girls perceived a direct alignment of the course, particularly its content, to career goals. This would account for the finding that career goals oftentimes led to the exclusion of or lower perceived likelihood of taking Physics as girls did not find the course relevant to career goals in the medical fields. These strategy outcomes illuminated that girls, by nature of their outcome expectancies and goals, prematurely dismissed courses that may, consequently, serve to inhibit attainment of their future science educational and career goals.

Moreover, with the exception of AP Biology, girls' perceived science course pursuits were generally not based on personal relevance, interest in the subject. Research, however, has found that goals based on personal relevance were the most predictive of students' academic success in science (Bas, 2012). The lack of personal relevance, then, may pose problems with girls' achievement outcomes in courses chosen solely based on career goal orientation. These issues, in turn, may further put those girls at a disadvantage, grade-wise and course-wise, for their college admissions candidacy. These findings support research's findings that efficacy plays a stronger role in career goals than achievement, possibly resulting from gender role socialization toward certain career paths (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001).

More specifically, these findings suggest the influence of gender role socialization on the girls' preference toward career goals in life sciences over physical sciences. One way that research has accounted for this is the persistence of gendered constructs of talent. For example, literature has found that girls tend to be underrepresented in jobs that require more systemizing, "the ability to think systematically and abstractly", in comparison to jobs that require empathizing, "the ability to understand thoughts and emotions in an insightful way" (Leslie, Cimpian, Meyer, & Freeland, 2015, p. 262). Likewise, research has accounted for this underrepresentation as a result of girls' failure to make connections between science career goals and their desire to be in a helping profession (Jones, Howe, & Rue, 2000; Ma, 2011). This study's findings seemed to disconfirm this as the girls made a connection between science and helping others through medical career goals. However, the science fields that girls in this study found relevant to those goals were limited to biology, and, at times, chemistry. To that point, findings, instead, served to clarify the literature's assertion in that girls' ability to see connections between science and their desire to help others was limited to pursuit of medical career fields. Girls failed, then, to make a connection between other careers and their desire to help others and, perhaps more problematic, the connection between Physics and their medical career goals. Another way that research has accounted for this perceived disconnect is the lack of guidance that girls receive regarding science, particularly physics in relation to educational and career goals (Mallow, 2006).

Gendered Competition

Another major finding of this study was that girls became competitors. Findings further suggest that gender role socialization regarding how men and women perceive, interpret, and act in competitive situations influenced the girls' perceptions of potential science course pursuits. Research has found that women are equally competitive as men when competing against other women in competitive situations (Niederle & Vesterlund, 2008). However, when competing against men, they become less competitive (Niederle & Vesterlund, 2008). Furthermore, research has found that men's performance increased when competing regardless of whether they were competing against men or women (Niederle & Vesterlund, 2008; Uri & Aldo, 2004). Men were also more likely than women to employ sabotage strategies to increase their chances of winning and women anticipated their use of sabotage for a competitive edge (Dato & Nieken, 2014). This phenomenon of gendered competition attributed a "psychic lost" to women and "psychic benefit" to men in competitive situations (Niederle & Vesterlund, 2008, p. 449).

This study's findings contribute to research regarding gendered competition by placing this concept in the science educational setting. Related to gendered competition's concept of losses and benefits, notions of success and failure were inherent to girls' engagement in the school's competitive environment. Gender role socialization influences perceptions of intelligence, evidenced in how girls and boys have been found to attribute success and failure to different conditions (Sadker & Zittleman, 2005). As Sadker and Zittleman (2005) explained these perceptions of success and failure in the school context:

> Boys typically attribute success to intelligence and failure to bad luck or insufficient effort. Girls are more likely to attribute success to good luck and failure to inability. This belief creates a harmful, self-fulfilling prophecy for girls: trying harder or risking a new approach won't make much difference because you're simply not smart enough. (p. 30)

The majority of the girls in this study exhibited signs of fixed mindsets regarding math abilities needed to take physics. While they expressed they could improve math skills through practice and other classroom opportunities, they persistently expressed that their skills were not, and would not, be sufficient for success in physics. This may be problematic as fixed mindsets, which attribute failure to inability, have less influence on success than incremental mindsets, which attribute failure to insufficient effort (Dweck & Leggett, 1988; Hill, Corbett, & St. Rose, 2010). Moreover, research has found that incremental mindsets were associated with mastery goal orientations, those defined as having the objective of acquiring knowledge and skills (Elliot & Harackiewicz, 1996), which were found to have the strongest predictive value on perceived self-efficacy and subsequent agency (Hsiuh, Cho, Liu, & Schallert, 2008). These research findings may account for the girls’ lower perceived self-efficacies toward math and physics in that the professional goals they consider in their science course selection strategies tend to lack a mastery goal orientation.

Gender role socialization regarding competition may also explain girls' adoption of fixed mindsets with respect to math needed for physics. Gender participation and performance differed when men and women competed in gender-stereotyped tasks (Dreber, von Essen, & Ranhill, 2014; Schmader, 2002). For example, men were more likely than women to compete in math tasks in comparison to equal willingness to compete in verbal tasks (Dreber et al., 2014). In competitive situations, women were more likely to decrease performance on a math task if they had a strong female gender identity, while men, regardless of the strength of their male gender identity, performed at the same level (Schmader, 2002). While unanticipated, the topic of gendered competition, then, may be another way that gender role socialization influences how girls performed in the science and math classroom settings, how they interpreted their competency, and, in turn, how they determined their perceptions of potential science course pursuits.

Limitations

In the process of developing the dissertation proposal and engaging in field work and analysis, several decisions were made and reflected upon to promote the rigor of this study's findings. Nonetheless, there are multiple paths that researchers may take to address research questions and purpose, all of which have their own advantages and disadvantages. This section will present the limitations of this study's findings as a result of methodological and procedural decisions.

While the findings provide valuable insight into how high school girls make sense of their potential science course paths, they are not generalizable due to the purposive sampling methods in the quantitative strand and its focus on a singular moment in time (Collins & Onwuegbuzie, 2007). In mixed methods research, decisions regarding design and sample size consider, as Tashakkori and Teddlie (2003) defined, the "representativeness/saturation tradeoff" (p. 184). As a result of this study's sequential design, the purpose of the quantitative phase was descriptive. Its findings were then used to inform qualitative sampling strategies with the purpose of increasing the depth of information. As a result, findings, instead, may be transferable to other settings (Remler & Van Ryzin, 2010, p. 141). For example, other schools that share similar descriptive trends of girls' achievement, yet underrepresentation in physics, may use these findings to understand influential factors that may be perpetuating these trends in their school setting. Future studies in similar contexts would support the development of more generalizable findings over time. Likewise, longitudinal studies could be designed to better examine, quantitatively, the impact of resources over time on efficacy and achievement, and qualitatively, girls' perceptions about resources and potential science course pursuits.

The findings did not indicate a causal relationship among variables, but rather described the context in which certain patterns are emerging with respect to girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits. Future studies that use a larger sample size would allow for statistical analyses to examine correlation and causation. Nonetheless, mixed methods research seeks to "draw from the strengths and minimize the weaknesses of both [quantitative and qualitative approaches] in single research studies and across studies" (Johnson & Onwuegbuzie, 2004, pp. 14-15). As this study sought to complement and expand quantitative findings with qualitative descriptions of the essence of girls' perceptions of efficacy and course pursuits, priority was given to the qualitative phase (Collins & Onwuegbuzie, 2007).

Continued studies in similar contexts with priorities given to different phases may provide more depth and breadth to this phenomenon.

The data collection instruments, themselves, present limitations to the study's findings. With respect to the survey, perceived STEM self-efficacy was calculated as a summation of the various perceived efficacies for science, math, and engineering/technology. As the term STEM has an evolving meaning in policy, research, and practice, the assumptions of this survey instrument aligned to this study's definition of STEM, but may not necessarily align with another's definition of STEM. Other studies that wish to use this survey may need to revise it to better align with their definition of perceived STEM self-efficacy. With respect to the qualitative instruments, the use of semi-structured focus groups and interviews provided rich data aligned to the study's purpose. A more open-ended structure, though, may have allowed for more emergent topics, possibly providing greater insight into the phenomenon.

While member checks and reflexivity were used to minimize the effect of scheduling on this study's findings, timing of data collection may have influenced the findings in some manner. During the second phase, girls participated in three different activities for data collection, an open-ended task survey, focus group, and follow-up interview. As the collection of data took place over the course of two months, the time lapse may have affected elicited opinions about chemistry and the DataStreme task. For example, focus groups occurred in October and follow-up interviews occurred throughout November and December. As such, the amount of exposure participants had to chemistry and time lapse between doing the DataStreme task and talking about it varied depending on when their interviews were scheduled. It is recommended that future studies consider the training of a co-researcher to help with data collection or consider other data collection strategies such as online blogs that would allow for participants to participate at other times of the day outside of the restraints of the school schedule. Mixed methods research from a pragmatic worldview, however, assumes that knowledge changes over time and "what we obtain on a daily basis in research should be viewed as provisional truths" (Johnson & Onwuegbuzie, 2004, p. 18). As such, these findings focused more on emerging processes related to efficacy beliefs than the beliefs themselves. Future studies may contribute to a deeper understanding of the evolution of beliefs as a result of those processes over time.

Finally, this study used practice theory as a lens through which to view social cognitive theory, adding a feminist perspective to the study. While it was found to be sufficient as a general feminist lens to elicit broad findings about the influence of gender on efficacy and girls' perceptions of potential science course paths, it's assumptions were not specific enough to narrow its focus. To that point, continued studies should consider a more defined feminist approach either by theory or phenomenon to delve further into the influence of gender illuminated from this study's findings. In narrowing the focus, continued studies could shed more light on the phenomenon of gendered competition, gender constructs, or gender role socialization on girls' perceived science course paths, strengthening its contribution to feminist research in educational settings.

Implications

These limitations notwithstanding, this study's findings have implications for policy, research, and practice. A primary issue gleaned from findings was that the lack of information regarding science course pursuits and their connections to college admissions requirements and possible careers led to the persisting influence of gender constructs and gender role socialization on girls' perceptions of potential science course pursuits. To that point, the following implications seek to provide recommendations for action based on the discussion of findings that may be first steps toward increasing gender equality in science educational and career participation.

Policy

Findings have implications for policies related to scientific organization's educational programs, high school course scheduling, and higher educational admissions.

AMS implementation policy. The American Meteorological Society's DataStreme Project had the goals of affecting student outcomes, particularly those of traditionally underserved populations like girls, by supporting their STEM literacy development, increasing their interest in earth sciences, and expanding their career awareness (Brey, 2009). This study's findings supported research's findings that partnerships between scientific organizations and K-12 schools have the potential to promote students' interest, particularly through the provision of resources (Barrett & Woods, 2012; Ejiwale, 2012; Rahm, Miller, Hartley, & Moore, 2003; Watters & Diezmann, 2013). Findings particularly illuminated the potential influence of real time data integration and other science organization's resources on students' interest through increased perceptions of topic and task relevance as well as an increased scope of career awareness.

Current policies, however, evaluate the implementation of the DataStreme Project based on teachers' acquisition of content knowledge. As this study's findings indicated, even with increased content knowledge and skills, the implementation of these resources may not achieve their goals if implemented in ways that do not account for the challenges girls face in the science education setting. Policy regarding follow-up with teachers would provide the scientific organization with more feedback regarding its resources and the challenges to implementation. In turn, this feedback could inform revisions and improvements to available resources.

Policy should also consider the creation and maintenance of a website that provides teachers with access to potential resource implementation ideas. As each teacher participant is already required to create an action plan as the final course assignment to describe how he or she will implement the resources into practice, these action plans may serve as initial ideas. Such a collaborative forum would provide the scientific organization data to reflect upon the project's implementation and possible influence on student outcomes as well as provide teachers with further guidance about how to best integrate resources into curricula. With the current emphasis on accountability, such suggestions would better position the scientific organization to promote use of its resources as well as continually reflect upon and respond to the needs of teachers through revision of its courses and resources to meet their needs. Partnership potential is maximized through collaboration, truly creating an interdependent union (Bransford, Brown, & Cocking, 2000; Flower & Heath, 2000).

High school guidance policy. School policies regarding the guidance of girls' science course pursuits need a stronger emphasis on access to and provision of information to help both students and parents broaden their awareness of potential careers, college admissions requirements, and alternative course paths. Policies should emphasize the development of a collaborative team comprised of teachers, guidance counselors, college admissions offices, and scientific organizations. As research has indicated that gender constructs and gender role socialization are perpetuated through limited scopes of guidance (Hackett, 1995), this team could develop materials for dissemination to empower all those involved in the guidance of girls' science course pursuits with current information.

The provision of information, however, requires a group effort. Teacher input would be valuable in providing information about grades and how girls should interpret those grades in light of the workloads they can expect in certain course enrollments to aid in their outcome expectancy considerations. Guidance counselor input would be valuable in communicating to stakeholders what courses align to certain career goals and dispel myths regarding college admissions requirements. With the lack of such communication, girls created their own ideas about admission requirements or simply adopted course selection strategies based on what they saw their peers doing, such as taking as many Advanced Placement courses as possible. Input from higher educational institutions about college admission requirements would provide input into which course pursuits are most valuable depending on potential major declarations. Scientific organizations could also provide insight into potential career paths. No one source of guidance is sufficient as each stakeholder provides a unique perspective and another facet of the larger context in which girls will enter after high school. Policy, however, may help to begin the collaborative discussion.

College admissions policy. While college and departmental admissions requirements vary across and within institutions, findings have implications for admissions requirements. The admissions requirement of taking multiple Advanced

Placement (AP) courses had a narrowing effect on the scope of science course pursuits. As a result, girls tended to consider taking both AP Biology and AP Chemistry their junior years to avoid too long of a time lapse between their taking of initial biology and chemistry courses. In doing so, Physics was relegated to a senior year course, meaning there was no possibility for girls to pursue AP Physics during high school. Furthermore, in response to demands for more education regarding earth sciences, high schools were faced with a scheduling dilemma as a rigorous course in earth sciences would require a basic knowledge of biology, chemistry, and physics (American Geosciences Institute, 2013). If Physics remains reserved for senior year, girls will continue to be denied access to potential advanced courses in both Physics and earth sciences. Girls' science educational well roundedness, then, is compromised as a result of prioritizing the taking of AP courses for college admissions candidacy.

Research

Findings have implications for continued research regarding the perceived STEM self-efficacy and the impact of resources on perceived STEM self-efficacy, course pursuits, and achievement. This study's findings identified specific influencing factors and task aspects that high school girls used as they made sense of their potential science course pursuits. Such findings, then, may be used to develop subsequent lessons using the DataStreme resources that seek to maximize those factors' encouraging potential toward higher likelihoods of advanced science course pursuits, particularly in Physics. Longitudinal studies could be implemented to measure the efficacy levels and perceptions over time to further examine the impact of the DataStreme resources' on efficacy levels and actual course pursuits. Such research would further contribute to the larger discourse surrounding efficacy development and effective STEM education practices.

A focus on culture may further illuminate social constructs regarding gender and science that expand and narrow girls' perceptions of potential science educational and career paths. This school was also a high achieving, suburban high school. Additional studies, then, in similar contexts would promote generalizability of findings. On the other hand, continued studies in other contexts would provide insight into the various challenges that girls, as a function of socioeconomics, race, and other variables, face with respect to science educational and career pursuits.

Likewise, this study focused on girls and how they make sense of their science educational paths. As the larger discourse surrounding efficacy development is inconclusive of whether or not girls and boys develop efficacy in different ways, future comparative studies would build upon this study's findings. Comparative studies would also help to identify which resources and strategies are general best practice and which have the most potential to reduce gender barriers, for either boys or girls, to equal participation in science educational and career paths.

Practice

Findings have implications for instructional practices. First, findings illuminated the potential influence of various aspects of the DataStreme task on girls' personal and professional relevance toward earth and, more broadly, physical sciences. Their identification of the topic of weather supported research regarding the potential of topics like health, animals, and weather to increase relevancy for girls (Jones, Howe, & Rua, 2000; Wolter, Lundeberg, & Bergland, 2013). Their identification of the use of real time data and the scientific organization's website supported research regarding the higher value girls place on authentic learning opportunities than boys (Dijkstra & Goadhart, 2011). Likewise, girls felt that the task expanded their science career awareness. It is recommended that teachers who wish to increase the task relevance of existing lessons or curricula consider the integration of earth science topics through use of the DataStreme resources. To integrate resources, it is recommended that teachers use the Next Generation Science Standards' (NGSS) crosscutting concepts to identify potential lessons for resource integration. In doing so, teachers may more easily communicate the connections between these tasks and supporting the knowledge or skills needed to be successful in Physics using references to the crosscutting concepts to help girls expand their scope of perceived connections.

In light of this study's findings, though, integration of the resources may not be sufficient to increase girls' participation in advanced physical science courses. While the topic and resources increased girls' valuations of the task's personal and professional relevance, findings indicated that it is the structure of the lesson, itself, that mitigates other classroom factors that may be inhibiting their participation. Girls' participation was found to be highly susceptible to peer comparisons and their desire to appear smart. As peer comparisons led to feelings of self-doubt or insecurities, they tended to not participate as much or ask for help. It is recommended, then, that lessons introducing new topics or skills include structural supports in the form of partner work or online blog formats to foster a safe, low-risk learning environment. When possible, it is also recommended that girls have the choice to work with other girls to reduce threats of gendered competition on their performance.

Findings indicated that girls tended to have a fixed mindset with respect to their math abilities. Research found that incremental mindsets were highly associated with success in STEM fields (Hill, Corbett, & St. Rose, 2010), the provision of reflective tools in the form of reflective journals and the sharing of successes and failures openly after a lesson's conclusion may help build girls' confidence and comfort with such processes. The use of formative assessments and self-evaluation tools may also help girls better gauge their math competency in relation to what is needed to accomplish various classroom tasks and to be successful in future science course enrollments.

Conclusion

This dissertation sought to examine how gender and science educational tasks inform high school girls' efficacy-activated processes related to their perceptions of potential science course pursuits. The purpose of this study was rooted in the practical problem of understanding why high school girls who were achieving in science were not pursuing advanced physical science courses, asking how girls were making sense of their potential science course pursuits.

This study's findings indicated that girls' lack of guidance regarding science course selections led to the persistent influence of gender constructs and gender role socialization on the narrowing of their potential science course pursuits. In addition, scheduling, college admissions, parental pressures, and internal emotional struggles all led to course selection strategies that would limit or prevent girls' access to advanced physical science courses during high school. Findings highlighted how the use of real time data and scientific organization's resources may increase girls' interests and career awareness, addressing some of the guidance issues. However, if other issues are left unaddressed, the integration of these resources in this context will serve only to further perpetuate girls' underrepresentation in physical science fields.

Increasing girls' participation in high school advanced physical sciences courses is a necessary step to provide all students the opportunities to develop the foundational knowledge and skills required for further development in all science domains. Without these experiences, how can we expect girls to have the competency required to contribute to the STEM workforce? How can we expect them to develop the needed STEM literacy, particularly with an understanding of the earth as a system, to combat sustainability threats through personal and professional actions? Moreover, without exposure to these learning opportunities, how can we expect them to develop the necessary agency beliefs to consider actual pursuit of STEM-related careers?

This study's findings are timely as recently the Next Generation Science Standards' (NGSS) increased expectations for students to have an understanding of the earth as a system. These understandings require foundational skills and knowledge of physical sciences, necessitating the need for gender equality regarding access to and participation in advanced physical science courses. Implications for policy, research, and practice focused on increased collaboration among all stakeholders involved in girls' science course path decisions. Particularly, the establishment of more collaborative partnerships between scientific organizations and K-12 school settings is needed to fully harness the unique knowledge and expertise of both sectors to develop and implement earth science resources across science domains in ways that promote more quality, gender appropriate learning opportunities. In addition, partnerships may serve to better communicate and disseminate information regarding potential science educational and professional trajectories. The NGSS movement is more than a set of standards, it is a call to action. It is a call to build all students' knowledge of earth as a system to meet demands for a STEM-literate workforce. Maximizing potential contributors to the STEM workforce through gender equality in science educational and career paths is one way that we may, collectively, better promote sustainability and human welfare.

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Appendix A

DataStreme Lesson Plan and Task

Lesson title: Graphing activity using real-time atmospheric data

Objectives: Students will demonstrate knowledge of graphing skills, slope calculation, and real-life interpretation of a slope by graphing real-time atmospheric data and analyzing the results in pairs.

Enduring Understandings: The vertical profile of the atmosphere varies with season and location. The slope value of a best-fit line has a physical meaning that can be used to discuss relationships between the data sets.

Essential Question: Why do we monitor the chemistry and physical structure of the atmosphere?

Class Activities: Introduce the Essential Question on the board, and discuss the properties of the atmosphere (chemical composition, troposphere/stratosphere boundary, measurable properties, etc). Emphasize the importance of understanding and modeling global climate change, and its impact on society. Then monitor as students complete the graphing activity in pairs at the lab tables. Students may have to share the laptop computers as they complete the activity, or they may use their own devices to access the background information and data sets required.

Assessment: Student graphing and analysis work will be assessed to determine level of competence in graphing, significant figures application, and data interpretation skills. This activity serves as a formative assessment in preparation for the midterm summative assessment of graphing and slope interpretation skills.

DataStreme Task

Big Ideas:

1. Atmospheric data is collected often and regularly, in order to build models of the atmosphere which help to predict future weather.
2. A graph is a useful scientific tool that allows you to determine the mathematical relationship between
   two data sets.

Step One: Introduction to the National Weather Service: Complete the following questions using the links below.

http://www.nws.noaa.gov/pa/history/
http://www.nws.noaa.gov/pa/history/140anniversary.php

1. On February 9, 1870, which President authorized the establishment of a national weather service, and for what purpose?

2. How many weather reporting stations existed in 1870 and to where did they telegraph their reports?

3. Why do you think it was important for the stations to collect weather observations at the same time of day?

4. The Weather Bureau was organized under the Department of Agriculture from 1891 to 1940. Why was it transferred to the Department of Commerce in 1940?

5. In 1970, the name of the Weather Bureau was changed to the National Weather Service, and the agency became a component of NOAA. What does NOAA stand for?

How is atmospheric data collected? A ***radiosonde***, which is a small instrument package equipped with a radio transmitter, is carried up into the atmosphere by a helium or hydrogen filled balloon. The instrument transmits readings of pressure, temperature, dewpoint, and wind speed/direction taken at different altitudes to a ground station.

Today, radiosondes are launched simultaneously, twice a day, from hundreds of ground stations around the world. However, the balloon bursts at an altitude of about 30,000 meters, and so that altitude is the limit of data collection via weather balloons and radiosondes.

Step 2: Graphing Activity.

Go to this website: http://www.ametsoc.org/amsedu/dstreme/index.html

Scroll down to **Upper Air**, then click on **Upper Air Data – text**.

Directions for graphing:

1. One partner will choose to graph Miami data, the other partner will graph Anchorage data. But we are not going to graph all of that data! You need to choose 12 data points of altitude and temperature from your city. Choose data points evenly spaced between ground level and 12,000 meters only. Looking at the data set on the computer screen (or handout), decide which data points you will graph and record them below.

Which city did you choose? Circle one: **Anchorage, Alaska** **Miami, Florida**		
HGHT (altitude in meters)	**Convert this altitude to km**	**TMPC (temperature in °C)**

Construct your graph, plotting altitude (in kilometers) on the x axis and temperature (in °C) on the y axis. Use a ruler to draw a best-fit line through the data. Make sure that the best-fit line passes through at least two of your points.

Step 3: Analysis.

1. Calculate the slope of the best-fit line. You can do the math work right on the graph paper. Make sure to show all your work, including units and follow the rules of significant figures. When calculating the slope, choose points <u>from your data set</u> that fall on (or very near to) your best-fit line. Keep the sig figs from the data when calculating the slope value!

2. What does this slope value represent? Write a sentence explaining what this slope value means. *Do not use the word "per" in your sentence.*

3. Compare your slope value to your partner's slope value for the other city. The values should be different. Write down both slope values here.

Anchorage: ________________________ Miami: ________________________

4. As an air sample rises, it expands (due to the dropping atmospheric pressure) and cools. This phenomenon of rising, expansion and cooling explains how clouds form – an air sample containing water vapor rises, cools, and as long as the air is saturated with water vapor, the water vapor ultimately condenses into small liquid droplets and fine ice particles that collect to form a cloud.

a. Thinking about this information, and the slope values calculated, which city has air that is cooling at a faster rate as it rises?

b. As it rises, dry (unsaturated) air cools at a rate of 9.8 degrees Celsius per 1 km, while moist (saturated) air cools at a rate of approximately 6 degrees Celsius per 1 km. Thinking about this information, which city more likely has cloud cover – Anchorage or Miami?

Appendix B

Survey and Protocol Items in Relation to Research Questions

Research Questions	Instruments: Surveys	Focus groups	Interviews	Notes and Journal
What relationships, if any, exist between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?	S1-22, S26-29	-	-	-
What factors do high school girls identify as informing their science course pursuits?	-	FG1-6, FG8	I1-6, I8	FN_o1-5, FN_A1-5 RJ1-7
How do girls negotiate those factors?	-	FG1-6, FG8	I1-6, I8	FN_o1-5, FN_A1-5 RJ1-7
What aspects of the DataStreme task do high school girls identify as informing their perceived STEM self-efficacy?	DS1-4	FG7	I7	FN_o1-5, FN_A1-5 RJ1-7
How do girls describe that these aspects achieve such influence?	DS1-4	FG7	I7	FN_o1-5, FN_A1-5 RJ1-7
How do girl's perceptions of influencing factors and DataStreme task aspects complement and expand our understandings of the associations found between high school girls' perceived STEM self-efficacy and perceived likelihood of science course pursuits?	All survey and protocol items			

Note. The following abbreviations are used in this table: S=survey, DS=task survey, FG=focus groups, I=interview, FN_o= field notes, FN_A=Analytic field notes, and RJ=researcher journal. These abbreviations are also used to identify the protocol items in subsequent appendices.

Appendix C

STEM Literacy Survey Protocol

Code (NO NAMES, PLEASE):

Please fill in the circle that describes whether you agree or disagree with the statement. There are no right or wrong answers! The only correct responses are those that are *true for you*! Even though some statements are very similar, please answer each item.

Math (S1-S7)	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Math has been my worst subject.	◯	◯	◯	◯
2. I would consider choosing a career that uses math.	◯	◯	◯	◯
3. Math is hard for me.	◯	◯	◯	◯
4. I am the type of student who does well in math.	◯	◯	◯	◯
5. I can handle most subjects well, but I cannot do a good job with math.	◯	◯	◯	◯
6. I am sure that I could do advanced work in math.	◯	◯	◯	◯
7. I can get good grades in math.	◯	◯	◯	◯

Science (S8-15)	Strongly Disagree	Disagree	Agree	Strongly Agree
8. I am sure of myself when I do science.	◯	◯	◯	◯
9. I would consider a career in science.	◯	◯	◯	◯
10. I expect to use science when I get out of school.	◯	◯	◯	◯
11. Knowing science will help me earn a living.	◯	◯	◯	◯
12. I know I can do well in science.	◯	◯	◯	◯
13. Science will be important in my life.	◯	◯	◯	◯
14. I can handle most subjects well, but I cannot do a good job with science.	◯	◯	◯	◯
15. I am sure I could do advanced work in science.	◯	◯	◯	◯

Engineering and Technology (S16-S22)	Strongly Disagree	Disagree	Agree	Strongly Agree
16. I like to imagine creating new products.	○	○	○	○
17. If I learn engineering, then I can improve things that people use every day.	○	○	○	○
18. I am good at building and fixing things.	○	○	○	○
19. Designing products or structures will be important in my future work.	○	○	○	○
20. I would like to use creativity and innovation in my future job.	○	○	○	○
21. Knowing how to use math and science together will allow me to invent useful things.	○	○	○	○
22. I believe I can be successful in a career in engineering.	○	○	○	○

How well do you expect to do this year in the following classes (Fill in the circle): (S23-25)	Not Very Well	Ok/Pretty Well	Very Well
23. English/Language Arts class?	○	○	○
24. Math class?	○	○	○
25. Science class?	○	○	○

Course Interests (S26-29)

How likely is it that you will take the following courses in high school (Fill in the circle):	Not Very Likely	Somewhat Likely	Very Likely
23. AP Biology?	○	○	○
24. AP Chemistry?	○	○	○
25. Honors or AP Physics?	○	○	○
26. Environmental?	○	○	○

S30. Demographics – Please circle your race or ethnicity:

White Black Asian Hispanic Other

S31. Grade level – Please circle your grade level:

9 10 11 12

Thank you for your participation!

Appendix D

DataStreme Task Survey

DS1. Think about the lesson that you just completed in class. What did you like about it? What did you dislike?

DS2. What did you think of the lesson's materials?

DS3. What do you think was the purpose of the lesson? To what extent do you think you think you achieved the lesson's goals?

DS4. How can we improve this science lesson? What would make the lesson and its materials better?

Note. The open-ended questionnaire protocol was adapted from examples that Craig (2009) provide in her book *Action research essentials* (p.142).

Appendix E

Focus Group Protocol

(Script after consent forms) Welcome. Thanks for taking the time to join our discussion about girls and science. My name is Mrs. Patterson. The purpose of this discussion is to learn more about how you feel about science classes. This study benefits you because we are using the data to inform instructional and curricular decisions to help you reach your full potential in science.

Let's first establish some ground rules. First, there are no right or wrong answers. If you have a different opinion, please share it. I do not anticipate that all of you will have the exact same opinion. I am recording this session because I want to make sure that I do not miss any important information from our discussion. No names will be included in any reports and your comments are confidential. It is my hope that everyone will have an opportunity to share and comment about if they agree, disagree, or want to give another example of something someone else has said.

FG1. Say "hello" to the group and share something about science in your school.

FG2. What are your future aspirations with respect to science?

- In general, why would someone study chemistry? Physics?

FG3. Walk me through how you choose the science courses you will take in high school.

FG4. Under what circumstances would a girl choose to take AP Chemistry?

- Could you give me an example of an incident that discouraged you from taking AP Chemistry?
- Looking at the picture, which person represents how confident you are that you would be successful in AP Chemistry?

FG5. Under what circumstances would a girl choose to take physics?

- Could you give me an example of an incident that discouraged you from taking physics?
- Looking at the picture, which person represents how confident you are that you would be successful in physics?

FG6. What kind of guidance do you receive with respect to choosing science courses?

FG7. Walk me through the NOAA lesson. Could you give me an example from the lesson that increased your confidence in some aspect of science?

FG8. What do you wish your teachers or school knew to support you to take advanced science courses?

Note. The focus group protocol was adapted from examples that Krueger and Casey (2009) provided in their book *Focus Groups: A Practical Guide for Applied Research*.

Appendix F

Interview Protocol

I1. What are your future aspirations?

I2. Walk me through the courses you have already taken in high school and the ones that you are currently planning on taking.

I3. What type of guidance do you receive with respect to choosing future science courses? Degrees? Careers?

I4. Describe your confidence in biology? How confident are you that you would be successful in AP Biology? How did you determine that?

I5. Describe your confidence in chemistry? How confident are you that you would be successful in AP Chemistry? How did you determine that?

I6. Describe how confident you are that you would be successful in Physics? How did you determine that?

17. Walk me through the DataStreme task. What did you like/dislike about the activity?

I8. Follow-up on emerging themes or topics from focus groups. Agreements/disagreements about topics, etc.

Appendix G

Field Notes Protocol

Observational notes	Analytic notes
FN_o1. What is going on during pauses? FN_o2. Facial expressions FN_o3. Emotional cues FN_o4. Body language FN_o5. Other movements	FN_A1. What happened during the event? FN_A2. What were the participants' reactions? FN_A3. Did the focus group/protocols go well? FN_A4. Did any new patterns emerge? FN_A5. What interactions took place?

Appendix H

Researcher Journal Protocol

Journal Entry Date:
RJ1. What happened today? What did I do today? RJ2. What accomplishments were achieved? RJ3. What challenges emerged? What decisions were made and why? RJ4. How did today's happenings refine my role as a researcher? RJ5. How did today's happenings refine my understandings of participants' responses? RJ6. What connections can I make between today's reflections and past literature, theories, or other events? RJ7. How do today's happenings align to the goals of this research?

Appendix I

Research Quality and Rigor

Assessment criteria	Strategies
Internal validity	Alignment between survey items and literature/theory; Training of teachers in survey implementation
External validity	Multiple classroom settings
Reliability	Use of proven reliable and valid survey instrument (S-STEM survey); pilot testing (DataStreme Task survey)
Objectivity	Scale scores of survey items
Credibility	Member checks
Transferability	Multiple classrooms
Dependability	Multiple coding iterations
Confirmability	Triangulation
Sample integration	Justification of sample sizes and sampling methods
Weakness minimization	Cross-tabulation charts of themes and survey data
Paradigmatic mixing	Cross-tabulation charts of themes and survey data
Multiple validities	Using both quantitative and qualitative methods appropriate to each phase
Political	Sought district support; collaborated with teachers; manuscripts

Note. The first part refers to quantitative measures, the second part refers to qualitative measures, and the third part refers to measures of validity in mixed methods research.

Appendix J

Frequency Distribution of Course Pursuit Likelihood in Relation to Perceived STEM Self-Efficacy Levels

	Likelihood of Course Pursuits					
STEM	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=9)	7 (77.7%)	2 (22.2%)	6 (66.7%)	3 (33.3%)	7 (77.8%)	2 (22.2%)
Mid (n=48)	19 (39.6%)	29 (60.4%)	26 (54.2%)	22 (45.8%)	32 (66.7%)	16 (33.3%)
High (n=23)	11 (47.8%)	12 (52.2%)	6 (26.1%)	17 (73.9%)	7 (30.4%)	16 (69.6%)

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.

Appendix K

Observed and Expected Outcomes of the Association Between Perceived STEM Self-Efficacy Levels and Perceived Science Course Pursuit Likelihoods

	Likelihood of Course Pursuits					
STEM	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=9)	7 (77.7%) [4.2]	2 (22.2%) [4.8]	6 (66.7%) [4.3]*	3 (33.3%) [4.7]*	7 (77.8%) [5.2]**	2 (22.2%) [3.8]**
Mid (n=48)	19 (39.6%) [22.2]	29 (60.4%) [25.8]	26 (54.2%) [22.8]*	22 (45.8%) [25.2]*	32 (66.7%) [27.6]**	16 (33.3%) [20.4]**
High (n=23)	11 (47.8%) [10.6]	12 (52.2%) [12.4]	6 (26.1%) [10.9]*	17 (73.9%) [12.1]*	7 (30.4%) [13.2]**	16 (69.6%) [9.8]**

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix L

Frequency Distribution of Course Pursuit Likelihood in Relation to Perceived Science Self-Efficacy Levels

	Likelihood of Course Pursuits					
Science	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=11)	9(81.8%)	2 (18.2%)	7 (63.6%)	4 (36.4%)	7 (63.6%)	4 (36.4%)
Mid (n=34)	17 (50.0%)	17 (50.0%)	20 (58.8%)	14 (41.2%)	23 (67.6%)	11 (32.4%)
High (n=35)	11 (18.2%)	24 (81.8%)	11 (31.4%)	24 (68.6%)	16 (45.7%)	19 (54.3%)

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.

Appendix M

Observed and Expected Outcomes of the Association Between Perceived Science Self-Efficacy Levels and Perceived Science Course Pursuit Likelihoods

	Likelihood of Course Pursuits					
Science	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=11)	9(81.8%) [5.1]*	2 (18.2%) [5.9]*	7 (63.6%) [5.2]*	4 (36.4%) [5.8]*	7 (63.6%) [6.3]	4 (36.4%) [4.7]
Mid (n=34)	17 (50.0%) [15.7]*	17 (50.0%) [18.3]*	20 (58.8%) [16.2]*	14 (41.2%) [17.9]*	23 (67.6%) [19.6]	11 (32.4%) [14.5]
High (n=35)	11 (18.2%) [16.2]*	24 (81.8%) [18.8]*	11 (31.4%) [16.6]*	24 (68.6%) [18.4]*	16 (45.7%) [20.1]	19 (54.3%) [14.9]

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix N

Frequency Distribution of Course Pursuit Likelihood in Relation to Perceived Math Self-Efficacy Levels

	Likelihood of Course Pursuits					
Math	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=10)	6 (60.0%)	4 (40.0%)	8 (80.0%)	2 (20.0%)	8 (80.0%)	2 (20.0%)
Mid (n=43)	19 (44.2%)	24 (55.8%)	23 (53.5%)	20 (46.5%)	32 (74.4%)	11 (25.6%)
High (n=27)	12 (44.4%)	15 (55.6%)	7 (25.9%)	20 (74.1%)	6 (22.2%)	21 (77.8%)

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.

Appendix O

Observed and Expected Outcomes of the Association Between Perceived Math Self-Efficacy Levels and Perceived Science Course Pursuit Likelihoods

Math	Likelihood of Course Pursuits					
	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=10)	6 (60.0%) [4.6]	4 (40.0%) [5.4]	8 (80.0%) [4.8]**	2 (20.0%) [5.3]**	8 (80.0%) [5.8]***	2 (20.0%) [4.3]***
Mid (n=43)	19 (44.2%) [19.9]	24 (55.8%) [23.1]	23 (53.5%) [20.4]**	20 (46.5%) [22.6]**	32 (74.4%) [24.7]***	11 (25.6%) [18.3]***
High (n=27)	12 (44.4%) [12.5]	15 (55.6%) [14.5]	7 (25.9%) [12.8]**	20 (74.1%) [14.2]**	6 (22.2%) 15.5]***	21 (77.8%) [11.5]***

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix P

Frequency Distribution of Course Pursuit Likelihood in Relation to Perceived Engineering/Technology Self-Efficacy Levels

	Likelihood of Course Pursuits					
Eng/T	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=21)	7 (33.3%)	14 (66.7%)	13 (61.9%)	8 (38.1%)	16 (76.2%)	5 (23.8%)
Mid (n=44)	20 (45.5%)	24 (54.5%)	19 (43.2%)	25 (56.8%)	27 (61.4%)	17 (38.6%)
High (n=15)	10 (66.7%)	5 (33.3%)	6 (40.0%)	9 (60.0%)	3 (20.0%)	12 (80.0%)

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.

Appendix Q

Observed and Expected Outcomes of the Association Between Perceived Engineering/Technology Self-Efficacy Levels and Perceived Science Course Pursuit Likelihoods

	Likelihood of Course Pursuits					
Eng/T	AP Biology		AP Chemistry		Physics	
Efficacy	NL/SW	V	NL/SW	V	NL/SW	V
Low (n=21)	7 (33.3%) [9.7]	14 (66.7%) [11.3]	13 (61.9%) [10.0]	8 (38.1%) [11.0]	16 (76.2%) [12.1]**	5 (23.8%) [8.9]**
Mid (n=44)	20 (45.5%) [20.4]	24 (54.5%) [23.7]	19 (43.2%) [20.9]	25 (56.8%) [23.1]	27 (61.4%) [25.3]**	17 (38.6%) [18.7]**
High (n=15)	10 (66.7%) [6.9]	5 (33.3%) [8.1]	6 (40.0%) [7.1]	9 (60.0%) [7.9]	3 (20.0%) [8.6]**	12 (80.0%) [6.4]**

Note. NL/SW = Not likely or somewhat likely to take the course as survey response. V = Very likely to take the course as survey response.

* $p < .05$. ** $p < .01$. *** $p < .001$.