My Sister is My Role Model: Why Girls Choose Science

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My Sister is My Role Model: Why Girls Choose Science

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By

Patricia Butler
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Dedication

I dedicate this dissertation to my family. I would like to start by thanking my husband. I could not ask for a better partner in life. You are an amazing man who has supported and loved me for my entire adult life. You have stood by through all that life has thrown at us and you are still by my side in this moment of joy at the completion of this undertaking. I would like to thank my daughter, Victoria, who, because you are the oldest, helped me to become the mother and woman that I am today. Additionally, I want to thank Joey for living through this process with me and listening to me as we drive to and from school together. Lastly, I want to thank Greg for putting up with having a very distracted mother and for helping me remember to try and have some fun along the way. I love you all more than you will ever know.
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I would like to acknowledge how much my husband, Joe, for helping me to grow as a person. Your continued commitment to justice, honesty, and honor has helped shape me into the person I am today. I acknowledge my children who are the driving impetus behind this research. I want to thank you all from the bottom of my heart for all that you endured during the six years that I spent of your childhoods finishing my education. I know that I will never get those years back, but I did it out of love for you. You will never know how much I love you but I hope that this gives you an idea.

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Abstract

Increasing the number of people who choose science is of national importance for both the economy and scientific dominance (Wang, 2013). Women and girls are underrepresented in science, technology, engineering, and math, or STEM, fields their numbers are increasing, however, they are doing so disproportionately. Women are a minority in fields such as engineering and computer science, but are well-represented in the biological sciences. This mixed methods study investigated the intersection of gender and science identity and how girls formed science identities. This study used Mann-Whitney U tests to analyze the Likert scale data and both a priori and inductive coding to analyze the focus group discussion data. Two differences were identified between boys and girls. The first was that girls rated themselves as less able to get good science grades than boys and they were less comfortable talking to people who worked in science careers. The focus group data showed that girls stated approachable teachers and friendly classmates with a common interest were valued by girls in science classes. Emphasizing a growth mindset can offset girls’ self-assessment of achieving less satisfactory grades than boys. Girls mentioned that they enjoyed learning about the world through science. Intentionally developing teachers’ and students’ worldview may help create more inclusive climates. More inclusive and collaborative educational climates can better model the larger scientific community where sharing and communication are encouraged.
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Chapter I: Introduction

Increasing the number of people who choose science is of national importance (Wang, 2013). As President Obama (2009) announced in his "Educate to Innovate" Campaign for Excellence in Science, Technology, Engineering and Math (STEM) Education, “Reaffirming and strengthening America’s role as the world’s engine of scientific discovery and technological innovation is essential to meeting the challenges of this century” (para. 3). Women and girls are underrepresented in science, technology, engineering, and math, or STEM, but are making strides in certain areas of science, such as biology and healthcare fields. Other areas of science, such as physics, have consistently low numbers of women and girls in advanced courses and related jobs. Understanding the intersection of a student’s identity and the culture of science may provide insight into why some people choose science and some do not. Learning why women and girls choose STEM fields may reveal what factors enabled them to persist and bolster the persistence of this demographic. Currently, there is a short supply of people qualified to fill the increased demand for STEM workers in the future in physics, engineering and computer sciences and more women are needed to fill these positions and provide fresh insight on today’s problems (Wang, 2013).

STEM jobs are not only beneficial for women, they are also good for the country. The United States’ competitiveness in STEM is a matter of economic and national security because STEM fields provide economic growth, technological advances, cyber-security innovation and maintenance, and improved healthcare (Denney, 2011). One important area of the job market is research and development (R&D). R&D in all areas of science, from healthcare to cyber-security, develops new and improved goods and services that provide economic growth as well
as improved quality of living for women (Science and Engineering Indicators, 2021). Denney (2011) stated that more scientists and engineers are needed to increase our R&D capacity because other countries are surpassing the U.S. in scientific capability.

Occupations in STEM require people with education in life sciences, health sciences, physical sciences, engineering, mathematics and computer sciences. The scientists that work in these fields provide an improved standard of living, technological advances, economic growth, and improved healthcare. Having recently emerged from the COVID-19 pandemic, the United States has seen the importance of advances and scientific innovation in healthcare (Science and Engineering Indicators, 2021). The National Science Foundation (NSF) (2019) stated that the U.S.’s competitiveness is important to power the nation's science and engineering enterprises through R & D, technological advances, and economic growth.

National Significance

The United States has slipped to third place in international high school science competitions but awards for high school students are not the biggest problem that the United States faces (Forbes, 2022). According to Denney (2011), the reason that the United States needs more diverse STEM innovators in the workforce for research and development, technological innovation, and healthcare. Women, a currently under-represented population, bring missing perspectives and problem-solving abilities to the STEM workforce. STEM fields provide a high standard of living for employees and society benefits from improved technologies, cybersecurity, and healthcare (Wang, 2013). High salaries and job security make them attractive career choices; however, rigorous education is required to obtain these careers. The high salaries that STEM jobs provide can contribute to closing the gender-wage gap if more women attain these positions. While demanding education is required, access to quality science education is inequitable as both
socioeconomic status and achievement predict access to high-quality science education (Smith et al., 2013; Whitcomb et al., 2021). As a result, the population of underrepresented STEM workers is similar to the population of underrepresented STEM students (Allen-Ramdial, 2014). Women and other demographics of the population are under-represented in both STEM education and workplaces. Smith et al. (2013) found that lack of access and low achievement are two key factors that cause certain populations to be underrepresented in STEM.

A combination of factors such as low socioeconomic status, fewer resources, and low science achievement not only restrict access to advanced science education, but also have an impact on future science achievement. The personal inputs that students bring to science may interact in a positive or negative way with science culture. If the students personal inputs conflict with science, identity confusion may result. This can result in reduced achievement. Students with lower achievement, for example, are often given inexperienced teachers and inadequate resources (Smith et al., 2013). Students that live in lower socioeconomic school districts are less likely to choose science if they do not have access to the high-quality science education, resources, and the AP classes that they need. Access to advanced science classes can be restricted by identity confusion of limited resources. This reduces the probability of forming a science identity because these students simply do not have access to AP or advanced science classes. Lack of access and low achievement are two factors that can prevent science identity development.

In essence, science identity is the idea that a person has about their belonging in science. Sfard (2019) defined identity as a “set of stories about a person that are reifying (saying what a person is and has rather than what he/she does), significant (believed to be the person’s defining features) and endorsable by the author” (p. 1). Since science identity is a specific facet of a
person’s overall identity, science identity is a student’s stories that are both reifying and relevant to their sense of belonging in science classes and careers. It is influential in science education because it can help students persist through difficult science concepts and courses. Since identity formation undergoes a period of heightened awareness during high school, this is a critical time to study in order to ensure that these factors are known and addressed. Feeling like a science person, or that they belong in science, can help a student feel confident enough to ask for help from their teacher, raise their hand in class, endure challenges, and persist in science education.

Many scholars, politicians, and academics, including Pinder and Blackwell (2014), have called for more research to collect data about girls’ educational experiences in science. They suggest collecting discursive data from girls to uncover the reasons that they do or do not choose science in school and the job market. For example, Keenan & Gupta (2019) noted that in a comparison to math classes, 39% of students in advanced math classes were girls while only 23% of students in advanced physics classes were girls. This study shows that more girls self-select advanced math but do not choose to take physics. Girls’ math ability is often blamed for the reason they do not choose disciplines such as physics or engineering (Hazari et al., 2010). The reason for the discrepancy may be the result of the clash of girls’ identities and the culture of physics classes.

Women are represented in science but are more predominantly represented in health sciences and less well represented in the physical and computer sciences (Kantrowitz, 2022). The difference in numbers may be related to the culture of these particular disciplines. Carlone and Johnson (2007) suggested that girls have difficulty in science because it has a culture that values White-male norms, such as competitiveness, innate ability, and self-sufficiency (Carlone & Johnson, 2007). Science education, at times, reinforces these norms and creates a culture viewed
as White and male which may cause identity confusion for students who are not White and male (Pinder, 2013). Students’ identities fit with (identity synthesis) or conflict with (identity confusion) the culture of specific disciplines in science (Wenger, 2000). Remediating the culture and climate in science can increase the retention of girls in advanced high school science classes and help them succeed in college science. Science identity varies between disciplines of science as students interact with different coursework and communities of practice. Math-based science classes, such as physics, traditionally have lower numbers of girls than boys. If educators knew the factors that help girls to persist in the face of challenging classes and form a science identity, their students would benefit and be better situated to persist in STEM.

**Purpose of Study**

The underrepresentation of girls in STEM is an issue related to the intersectionality of their gender and possibly racial identities and the culture of science (Collins et al., 2020). Women and girls are not universally underrepresented in science, but are underrepresented in specific disciplines. Science has many disciplines, some of which interact with girls’ identities in different ways due to the norms and cultures in each discipline. The purpose of this study is to examine how girls identify with science disciplines and careers.

Studying the retention of women in STEM may help to increase the number of well-qualified candidates for the growing number of STEM jobs. The U.S. Bureau of Labor Statistics, (2020) predicted an 8% increase in STEM occupations and only a 3.4% increase in non-STEM occupations until 2029. This growth provides an opportunity for women to gain access to secure jobs with high salaries and provide fresh perspectives to solve tomorrow’s problems. According to the National Science Foundation, NSF, (2021) STEM workers enjoyed a lower unemployment rate than non-STEM workers in 2019, which continued even through the COVID-19 pandemic.
When investigating science identity, intersectionality is an important concept because multiple factors can combine to promote or prevent the formation of a science identity. This intersectionality either produces identity synthesis or identity confusion (Erikson, 1968). Griffin (2017) said that intersectionality is “best understood as unique ways in which the confluence of an individual’s identities exposes them to unique forms of privilege and marginalization” (p. 469). Privilege or marginalization in science may make the difference between forming a science identity and not forming one (Kantrowitz, 2022).

Rationale for Study

This study sought to investigate science identity to improve equitable access for women to STEM education and jobs. There is a demand for well-educated people to fill the rising number of high-paying STEM jobs. Well-qualified people from all demographics are needed to fill these positions to restore America’s international STEM dominance. The demographics of people in an area should be represented in that area’s STEM students, teachers, and workers to provide the diverse perspectives missing from the current STEM community. Yet, this is currently not the case since as of 2019, women constituted only 27% of the STEM workforce (Kantrowitz, 2022). These numbers suggest that something about STEM jobs themselves deter women from entering the field.

The culture of STEM jobs may conflict with women’s identity even when they are interested in a STEM field (Carlone & Johnson, 2007). Forming a science identity may mitigate the culture of science that conflicts with women’s identity and help these women persist. This study will explore the identity forming factors that allow high school-aged girls to form science identities. Since middle school science is the direct precursor to high school science, the focus group discussion questions were phrased in such a way as to inquire about middle school science
experience as well. The Science Career Interest and Preparation Survey identified the students with a science identity (see Appendix A). The girls who agreed to participate in the focus groups provided the qualitative identity data that supported the survey data. The theoretical framework for this data combined elements from Identity Theory, Intersectionality, and Social Cognitive Career Theory, SCCT.

**Problem Statement**

The dominance of the U.S. in international STEM excellence, as well as our economy, depends on American students persisting and excelling in STEM education (Denney, 2011). The absence of people needed to fill the workforce and the low quality of the candidates who do apply is drawing not only national attention, but also federal funding (Wang, 2013). Specifically, Talafian et al. (2019) noted that despite an increase in available STEM jobs, students in the U.S. are often underqualified to fill them due to low achievement and reduced access to high-quality STEM education. The number of American students studying STEM is disturbingly low (Forbes, 2022). Of the Americans studying for a STEM career, Mattern et al. (2015) stated that research indicates a disconnect between the academic skills required for college and students’ actual levels of preparation. Science education needs to address the issues of not only retaining women in STEM, but also providing more access to rigorous education that will prepare students for STEM jobs.

The reasons for the low number of people particularly women in science fields warrant investigation, and the lens of the intersectionality of gender and science identity using Social Cognitive Career Theory may provide some insight. Specifically, the intersectionality of bias and discrimination that students’ have experienced in science classes may be part of the reason for the underrepresentation of women in certain STEM fields. If these biases and discrimination are
made known they can be remediated and perhaps more women will experience identity synthesis and realize that they belong in science.

Often, society perceives science as a masculine discipline because the norms of science are the same as norms attributed to people who identify as a man (Francis et al., 2017). Attributes such as competitiveness, speed, and natural aptitude are some of the masculine traits attributed to science (Boaler, 2002). Carlone and Johnson (2007) found that students who pursued science majors in college had to navigate disciplines that were based on “white, masculine values and behavioral norms, hidden within an ideology of meritocracy” (p. 1187). Tandrayen-Ragoobur (2021) found that women are less likely to choose STEM education and careers perhaps because these hidden norms cause identity confusion. These hidden norms are not only difficult to address because they are hidden but also because they reinforce the current culture of science. Iaccarino (2003) stated that the culture of science recognized by the scientific community is also largely Eurocentric. Not only does science have White masculine values but the empirical way in which main-stream science collects data are Eurocentric. This Eurocentric science may conflict with students’ identities if they are not of European ancestry (Iccarino, 2003). Carlone and Johnson’s idea that these norms are hidden may be the reason that they have persisted for so long.

Predictors of students’ choice to pursue a STEM degree are students’ self-efficacy and academic performance in high school (Tandrayen-Ragoobur, 2021). These factors are also influential in the formation of a science identity and need to be encouraged in school, especially encouraging self-efficacy for underrepresented populations. The missing perspectives, problem solving insight, and talent brought by women in STEM may be recovered if more women are retained in STEM (Gonzalez & Kuenzi, 2012; Ong et al., 2017). Science identity formation
enables students to see themselves as scientists. How students’ identity and the culture of science intersect with other facets of students’ identities, such as gender, during high school is the purpose of this study.

**Research Questions**

The overarching research question addressed in this mixed methods study was:

*How do high school students form a science identity?*

This question was addressed via two sub-questions:

1. What factors are most critical for science identity formation in women and girls?
2. How does the intersectionality of gender identity interact with science identity formation?

**Rationale for Methods**

This mixed methods study utilized a survey design mixed with a Yinian case study approach to examine the science identity of high schoolers. Mixed methods are used to provide data that gives a richer perspective than one singular method about the phenomena being studied. The quantitative data came from the Science Career Interest and Preparation Survey. The survey reached a larger number of students and identified students who had a science identity and recruited students for the focus groups. The survey generated a larger data source that included boys and girls to identify the most important factors for both groups as well as possible differences between the groups. The focus group, treated a case for the case study, was composed of girls selected from the survey data who had a science interest and agreed to participate in a focus group discussion to collect qualitative data. Focus groups allow students to tell their own stories or identities. The focus group served as a community of practice in this study and because the girls had interest and identities in different disciplines, it also served as an interaction between the boundaries of different communities of practice. The girls came from
different backgrounds and had different science identities. Identity and the intersectionality of identities in the community of practice of science and at boundary interactions may be revealed through these stories. Focus groups were chosen because the girls all share a common trait and the discussion took place in a social setting. Since identity is a social construct, this method seemed appropriate. The data collected were gathered using mixed methods to allow the quantitative data to identify factors important to all students and the focus groups highlighted the voices and lived experiences of girls. The mixing of the data provided deeper insight into science identity formation than either one alone.

**Survey Design**

Surveys allow researchers access to a large sample size in order to get robust data and ask questions about the extent to which people agree or disagree (Creswell & Guetterman, 2019). The Science Career Interest and Preparation Survey asked high school students how they managed their science classes and if they were interested in a science career. The purpose of this survey was to get the opinions of girls and boys about the variables that impact their science education and desire to pursue a science career. These opinions will be compared by gender to see how they differ between the two groups. This survey, adapted from the STEM-CIS survey (Kier et al., 2014) was a convenience sample because the students included in this group were enrolled in a science class. A paper survey was used to administer this cross-sectional survey and a 5-point Likert scale was employed to identify the degree to which students agree or disagree with questions related to science career interest and preparedness. This survey identified the participants for focus group discussions and generated data for the comparison of the two groups who all share a common characteristic, science identity.
Case Study

The survey data generated the participants for the focus group discussions and supported the findings of the case study. The focus group was treated as a separate Yinian case study. Yin (2002) defined a case as “a contemporary phenomenon within its real-life context, especially when the boundaries between a phenomenon and context are not clear and the researcher has little control over the phenomenon and context” (p. 13). Science identity in high school students is both contemporary and within its real-life context. Yin (2017) said case study is an appropriate method when the question being asked is a why question or a process question. Since this case study seeks to understand the process of science identity formation and why only certain girls identify with science, case study is an appropriate method to use for this study.

The girls whose survey score indicated that they had a science identity, a nine out of fifteen or greater, were asked to participate in focus group discussions that were treated as a case. Marshall & Rossman (2016) stated that focus groups can range from 4-12 participants that have been selected because they share a specific characteristic. In this case, all participants identified as science people. The reason that a focus group was chosen as a method was to hear students’ stories. Focus groups promote discussion among the participants to express their ideas and beliefs (Creswell & Guetterman 2019). This focus group allowed students to discuss science identity in a group of other science people because identity is socially constructed and not created in isolation. The social environment is more relaxed for students than an individual interview (Marshall & Rossman, 2016). The focus group was treated as an individual case study using Yin’s protocol.
Significance of Study

This study is unique in that it addresses a gap in the literature of science identity. Most studies address the college or middle-school-aged population. Very few researchers have describe the unique time of high school science identity formation. This study investigated how the intersection of identities impacts science identity by hearing the voices of girls who have formed a science identity. Every person, no matter their background or life choices, should have the opportunity to feel that they can be a “science person.” The culture of science may need to shift to become more inclusive. This study identified some of the factors that may help underrepresented students persist in science and answer President Obama’s call for a return to America’s scientific greatness.

Limitations

The limitations of this study are related to the population studied, the survey methodology, and the limitations of the case studies of the focus groups. The major limitations of the sample are the size and location of the study due to the limited number of participants in a suburban, upper-middle class school district. Low response rates are statistically problematic. The teaching staff is predominantly White and upper-middle class as are the majority of students. This is a limitation because this study will not capture the intersection of many different identities interacting with science identity. This study may only be transferable to similar schools with similar socioeconomic status and population.

A common limitation of surveys is that the population is difficult to describe. This study has a population of middle to upper middle-class students enrolled in a science class. Andrade (2020) said that another limitation is that participants in a survey may be biased. This study sought to minimize these limitations by asking questions that determine whether the student has
a science identity, however, respondents would not be representative of the larger population. The case study was composed of girls from the survey with a science identity who assented to participate in the focus group discussion.

Case study also has some limitations. Some researchers do not view it as its own method but as a type of ethnography (Moss, 2020). Using Yin’s protocol reduces this criticism and promotes case study as a legitimate research method. The use of a protocol differentiates case study from ethnography. Yin lays out how to formulate questions, the type of questions to ask, a decision tool to decide whether case study can answer these questions, how to conduct a literature review, how to define the cases, how to decide if one or multiple cases are needed, how to decide how to collect data, how to create case study databases, how to provide chains of evidence, and how to collect and analyze the data. These types of data are subject to other limitations as a result of faulty recollections and the desire to appear favorably in a social group.

**Definition of Terms**

*Gender*- “refers to the attitudes, feelings, and behaviors that a given culture associates with a person’s biological sex. Behavior that is compatible with cultural expectations is referred to as gender-normative; behaviors that are viewed as incompatible with these expectations constitute gender nonconformity” (American Psychological Association, 2015).

*Identity*- Sfard (2019) defined identity as a “set of stories about a person that are reifying (saying what a person is and has rather than what he/she does), significant (believed to be the person’s defining features) and endorsable by the author” (p. 1).

*Intersectionality*- the interconnected nature of social categorizations such as race, class, and gender as they apply to a given individual or group, regarded as creating overlapping and interdependent systems of discrimination or disadvantage (Crenshaw, 1989).
SCCT-Social Cognitive Career Theory is an extension of Albert Bandura’s (1986) Social Cognitive Theory. SCCT utilizes several variables to make sense of students’ academic and career choices.
Chapter II: Literature Review

Science, technology, engineering, and math (STEM) jobs offer job security and high salaries. The growth rate in the job market is considerably greater than for non-STEM jobs (U.S. Bureau of Labor Statistics, 2020). Talafian (2019) reported that despite an increase in STEM jobs, students in the U.S. are not qualified to fill them due to lack of motivation and lack of access to high-quality STEM education.

More people from all demographics are needed to fill the increasing number of jobs and equitable access should be the right of every U.S. citizen. Women comprise only 28% of that workforce because they have historically been excluded from STEM education until 1972 when Title IX of the Education Amendments and the Higher Education Affirmative Action Guide gave women access to science higher education (Conefrey, 2001; NSB, 2018). The United States needs fresh insight to solve the problems of the future and attracting women to STEM may provide missing perspectives that can help to restore the U.S. to its number one international ranking (Gonzalez & Kuenzi, 2012) (Ong et al., 2017). This review of the literature seeks to understand why in today’s society when women are no longer excluded from STEM education, they do not choose to pursue it.

Underrepresentation of Women in Science

Attracting and retaining women in STEM is of national importance to reclaim the United States dominance in STEM and to provide equitable access to high-paying jobs but the reasons that women are not choosing STEM are more complicated than they appear (Obama, 2009) (Ong et al., 2017). The following literature review looks at the reasons why women are underrepresented.
The United States is in a race with China for dominance in technological fields (Forbes, 2022). In order for the U.S. to maintain international dominance, many highly-skilled workers are needed for the future. The demand for workers is only increasing but the question remains of whether will there be enough future workers to meet the rising demand (U.S. Bureau of Labor Statistics, 2020). These future workers are still in school and there is time to cultivate this workforce. In 2021, the U.S. placed third in international high school science competitions, while China took first and Russia took second (Forbes, 2022). Of the Americans studying for a STEM career, Mattern et al. (2015), stated the research indicates a disconnect between the academic skills required for college and students’ actual levels of preparation. This disconnect and the low number of graduates is the reason that STEM education is an area of national concern and importance because our future workforce is not as competitive as other countries (Forbes, 2022).

Camilli and Hira (2019) found that 45% of the U.S. STEM jobs in Information Technology (IT), or 1.7 million jobs, have been outsourced to India. In 2015, President Obama issued his final update of a strategy for American innovation, noting that the U.S. economy and international presence in STEM depends upon our ingenuity and the education of our children in STEM (Obama, 2015). In order to fill the rising demand for STEM workers, recruitment of historically underrepresented people can help fill the vacancies (Stets, 2017). Not only will these people fill vacancies, their fresh insight will bring new knowledge and invigorate the existing community of practice. STEM would benefit from people of all demographics to fill these positions and provide diverse perspectives on today’s problems (Wang, 2013). The U.S. competitiveness can come from our diversity because the United States is more diverse than China or Russia who are currently in first place (Morin, 2013). Diversity is an advantage in scientific inquiry because people with different lived experience pose new questions, provide
fresh insight and unique methods of solving problems (Bernard & Cooperdock, 2018). President Obama said, “Reaffirming and strengthening America’s role as the world’s engine of scientific discovery and technological innovation is essential to meeting the challenges of this century” (Obama, 2009).

STEM is not only important for the scientific dominance of the United States but also for the individuals working in these fields and the population at large. STEM innovators brought the world out of the COVID-19 pandemic and put people in the International Space Station. Many other challenges lie ahead, such as climate change, environmentally responsible energy, clean water, and engineering the things that we use on a daily basis. When perspectives are missing from these challenges, the solutions to these problems reflect only the needs of the people solving them. For example, the people who designed the first airbags were a group of predominantly male engineers and they designed a product to protect adult male bodies resulting in avoidable deaths of women and children (Fisher & Margolis, 2002). Careers in STEM offer exciting challenges that advance human civilization and offer high paying careers with job security that boost America’s economic strength. These jobs require rigorous education for equitable access to these jobs. The difference in average salary is an important factor for retention of women students considering STEM majors in college. STEM jobs offer high salaries that can help narrow the gender-wage gap. In 2019, the median annual wage in STEM occupations was $86,980 and in non-STEM occupations, it was only $38,160 (U.S. Bureau of Labor Statistics, 2020).

High-paying STEM jobs require rigorous education. The United States education system does not provide high-quality STEM education to everyone (Reimann, 2020). President Obama was calling for improved STEM education for all people for the good of the country and for the
individuals who choose STEM. Equitable access to STEM education is the right of all Americans through free and public education. However, even when high-quality education is provided, certain groups of people tend to stay away from science.

Upper-level science classes are often filled with a skewed demographic. In a study of advanced STEM classes in high school, NSB found that 72.3% of the students in calculus or higher math were Asian and White boys (NSB, 2018). In advanced AP Physics B, girls comprise 41% of the classes and in AP Physics C or Mechanics, girls made up only 32% of the class (Chodos, 2011). Low numbers of girls in advanced physics classes is not a new phenomenon but with a great demand for STEM employees, the missing population needs to be recruited for these jobs. Reexamining science education may be beneficial and if classroom climates are changed, a more diverse population may pursue STEM. Hazari found that even when girls get good grades in science classes, they often do not choose advanced science classes or related careers (Hazari et al., 2010). Science identity may hold some answers as to why girls don’t pursue science careers even when they are successful in science classes.

Pinder and Blackwell (2014) called for more research to collect discursive data about girls' educational experiences in science to elucidate the reasons that they do not choose science in school and the job market. Science teachers can have a major impact in helping girls see themselves as scientists and aid identity synthesis. Science identity is an important concept that may inform science teachers, curriculum, and classroom climate to promote girls' self-selection of advanced science classes and careers. Identity is the set of important stories a person has about themselves that define who they are; science identity are those stories that allow that person to know they belong in the scientific community (Sfard, 2019). This study seeks to understand
science identity and how it is formed in high school-aged girls to promote equitable access to advanced science classes and STEM careers.

Women and girls may not self-select science because they do not identify with the culture of science. Science has white-male norms that may discourage students whose identities do not align with them, these norms also persist in the job market today (Carlone & Johnson, 2007). Cech (2022) found that white, heterosexual, nondisabled, men earn $7,831 more a year than their coworkers and have more opportunities at work (Watson, 2022). White male norms are part of the unspoken culture of science because the scientific community recognizes Eurocentric, Western science. Hecht (2021) described the discipline of science as Eurocentric because it centers on European thoughts, values, and culture. Kojève & Navarrete (2020) pointed out that modern science, particularly physics, has its roots in Christian theology originating in the sixteenth century. Eurocentric science may conflict with other gender, racial, and possibly religious identities and cause identity confusion (Iaccarino, 2003).

Eurocentric science is empirical in nature and not as holistic or inclusive as non-European science (Iaccarino, 2003). Other cultures have their own ways of studying the natural world that are more holistic and less empirical in nature and may be useful to inform the future scientific community (Iaccarino, 2003). This method of conducting science creates a contrast between European and non-European scientific inquiry of the natural world. Science education reinforces Western norms and creates a culture that is White and masculine (Pinder, 2013). Science education may benefit from non-European science and create a culture of science that is less empirical and more holistic. Because of the male, Eurocentric, unspoken culture, people who are not European and male, may find it difficult to see themselves as scientists.
Identity

Identity is a useful construct for exploring why students behave the way they do in specific settings. The stories that students tell about their experiences in science are their science identity (Sfard, 2019). The decision to persist or not in the face of challenges depends upon how strongly they identify with the subject. Domain specific identity is a complex concept that is strongly linked to stories of achievement and recognition from others (Carlone & Johnson, 2007).

Defining Identity

Only a few centuries ago, people were born into specific identities. Since current trends in society allow people to choose their own identity (Sfard & Prusak, 2005). People have control over much of their own identities whether they are conscious of it or not. There are different definitions of identity that have overlapping themes and highlight different aspects of what Sfard, Gee, and Wenger discussed when defining identity.

Sfard. Sfard’s definition focuses on the predominant stories that a person internalizes about experiences in different communities. Sfard (2019) defined identity as a collection of significant stories or narratives about an individual which the person deems important. This definition is unique in that identity is not explained by the stories, it is the stories. Since stories are the way a person makes sense of things, the ones that they accept as important are their identity. Sfard and Prusak (2005) stated that the narratives are reified by the person, if the individual does not acknowledge part of their identity, then it will have a minimal impact on identity. Additionally, what a person maintains about their own identity may be different than what others see enacted. The stories not only describe who the person is, they indicate future behavior. Identity is self-made and remodeled as new stories are incorporated (Sfard & Prusak,
The narratives that constitute a person’s identity are the outcome of collective storytelling even if the individual is telling their story because identities are not produced in isolation but by the product of social interaction (Sfard & Prusak, 2005).

A major component of identity is inclusion or exclusion from specific communities. In school, learning takes place as the student is able to tell stories and explain some aspect of reality relevant to that community. The success or failure of a student to accomplish this goal results in a story that can contribute to either identity synthesis or confusion. The stories about a student in a particular class become part of that student's identity. The more stories in a class that occur concomitantly with the student’s identity, the more likely they form an identity that aligns with that academic domain. The stories that a student accumulates in a class can either confirm or negate the students designated identity. Social interactions and the learning occurring from them translates designated identity into actual identity over time. For example, a student may believe that they are more of a history person than a math person but the stories in those classes may change the person’s identity over time. This process results in the person “closing the gap” between their sets of stories about their identity (Sfard & Prusak, 2005, p. 1).

Sfard and Prusak’s (2005) definition of identity closely aligns with educational research to understand why people behave differently in similar situations and why these behaviors are familial in nature, in other words, similar people behave similarly. It is also a construct that lends itself to discursive research and highlights that people are agents of change. People have the power to influence “the dynamics of social life and in shaping individual activities" (Sfard & Prusak, p.4). This is a powerful notion when applying identity to educational research. Since students have agency over their own identity, classrooms are akin to small-scale social experiments that have the potential to shape future generations.
Identity research has the potential to change future generations. Identity as a construct controlled by individuals is helpful in looking at power and power imbalances. Identity is influential in determining who is responsible for individual lives. For example, a person born into a situation where education is substandard is not responsible for that fact. Identity helps researchers explore the ways that personal responsibility and collective responsibility impact people's lives. The collective responsibility is to provide free, high-quality education to which all people have equal access. The individual's responsibility is to make good use of that education. The idea that people control their own identity brings to light the great responsibility for individuals to use this power.

Sfard and Gee both discussed parts of an individual’s identity and how those parts interact with each other. Sfard and Prusak (2005) called this actual identity or designated identity. The person’s actual identity is the stories that represent the “actual state of affairs” (Sfard & Prusak, 2005, p. 45). Student's designated identity is the, “narratives presenting a state of affairs which, for one reason or another, is expected to be the case, if not now then in the future” (Sfard & Prusak, 2005, p. 45). Gee separated identity into four regions and recognized that these regions are accessed or denied in different communities of practice and situations.

**Gee.** Gee (2000) outlined the multiple facets of individuals’ identities, their Nature, Institution, Discourse, and Affinity identities. People recognize and prioritize these four different facets in different circumstances. The four aspects of identity interact and influence each other as the person defines and redefines their own identity (Gee, 2000). These four areas of identity all contribute to identity but this study is focused on how gender identity impacts students’ science identity.
Historically, people in the United States and other Western countries have emphasized one aspect of identity over others. At certain early points in history, the United States viewed Nature identity as the most important and defining aspect of identity (Gee, 2000). Race, gender, and, dis/ability are some aspects of Nature Identity often determined by genetics or nature, visible to others, and are part of a person’s designated identity. In the past, biological sex defined a person, dictated gender norms, and greatly impacted their Nature Identity (Gee, 2000). Biological sex and other aspects of Nature Identity are associated with many stereotypes that traditionally excluded women from science (Conefrey, 2001). Until recently, people assumed men were naturally more intelligent because the male brain was different due to testosterone (Brush, 1991) (Shields, 1982); while women were presumed to be less intelligent, more suited for language-based fields, and to have inferior math skills (Hill et al., 2010). Similar norms and stereotypes persist to this day in both education and industry (Hill et al., 2010).

Conefrey (2001) noted that women were excluded from science education until 1972 when Title IX of the Education Amendments and the Higher Education Affirmative Action Guidelines allowed them to be included. Sexual discrimination from the pre-1972 period has had a lingering effect on the science identity of girls. In 1980, the National Science Foundation (NSF) began collecting data about the status of women and minorities in science and engineering (Conefrey, 2001). The results of the study indicated a “chilly climate” for women in science (Conefrey, 2001).

Later, in the U.S., people’s position in society defined their Institution Identity (Gee, 2000). This definition of identity is still prevalent today because many people define themselves by their jobs (Ashforth, 2016). Nature Identity influences the Institutional Identity because of the biases and stereotypes associated with a person’s nature. Since stereotypes about careers are
often gender-based, a person’s gender identity can influence job choice. Next, Discourse Identity defined people based on the way other people acknowledged their achievements. Recognition by others is a powerful component of identity synthesis. When students are recognized by teachers and peers as a science person, it confirms that they belong in science.

Lastly, Affinity Identity defines people by the experiences the person has in the affinity groups to which they belong. Affinity Identity is the stories that a person gains about themselves as they interact with communities of practice. If the stories are reifying, the person experiences identity synthesis, if not, they may develop identity confusion (Erikson, 1968). Depending upon the situation, any and all of these identities and their intersection are the person’s identity. Most importantly, identity is the way the person sees themselves in all of the situations that they find themselves in life.

All facets of a person’s identity, their performance in communities, and the relevant stories of the person’s narrative contribute to overall or core identity. Nature itself provides human beings with features that impact the person’s identity. The chromosomes that a person inherits determines some of their physical features which affect that person’s identity. The degree to which they impact the person’s identity depends on the degree to which they are acknowledged by others and the person themselves (Gee, 2000).

Sfard and Gee have different approaches to defining identity. Wenger’s definition helps to bring together the ideas that both Sfard and Gee have established. Wenger ties together the building of identity in a community of practice and how people can create bridges between communities and how school can serve as a home base for students but also provide them with a trajectory into the future.
Wenger. Since identity is a socially defined concept, identity is formed as the result of multi-membership in different communities of practice based on the person’s lived experience. A community of practice is a group of individuals working toward a common goal and is the basic building block of social learning. Inclusion in the community is based on knowledge, competence, and lived experiences. Once a person is included, they participate in belonging to that community. There are three modes of belonging to a community of practice: engagement, imagination, and alignment. Specifically, people belong by engaging in activities together, having an image of themselves, their community, and how they relate to the larger world, and aligning themselves not only with each other but their local community and the larger world.

Individual communities define what it is to be a competent member and hold each other accountable to their standards. The person defines how they belong to the community by the way they contribute to it. Wenger said, “If knowing is an act of belonging [to a community], then our identities are a key structure of how we know” (Wenger, 2000, p. 238). Identity allows the individual to know that they fit with the community. A person will identify with the community if they know the community’s common goal well enough to contribute to it. Competence and knowledge are essential for inclusion. Members interact with each other in order to produce a shared repertoire of resources including common language, routines, sensibilities, artifacts, tools, and stories.

Communities of practice have defined, but fluid, boundaries. These boundaries are created by engaging in shared practices and from engaging in projects that are different from other communities' practices. The people in the community need a safe, judgment-free place to engage in a common practice. Learning is maximized when members’ experience and competence are in close tension with each other. New members can expand not only their own
identity but also the identities of existing members by bringing in new experience and competence. Learning is also maximized at boundary interactions between communities, especially when the communities are close enough to discuss things and not too far apart that they do not understand one another.

People belong to multiple communities and define themselves by what they know as well as what they don’t know, who they are and who they are not. Communities have boundaries that are a result of shared practice. The intersection of their membership in multiple communities is important in defining identity. Multiple membership cultivates different facets of the person's identity and creates opportunities for growth. Growth often takes place at the boundaries of the communities. People have multiple identities within themselves which intersect and converge as the person’s singular identity. Boundary interactions that occur among communities help people navigate these same boundaries in themselves. They are not distinct from each other and can change over time.

There are three ways that Wenger says identity is crucial to our existence in the world. First, identities combine experience and competence to create a way of knowing. Identity is crucial to making decisions about what matters and what does not and with whom knowledge is shared. Second, identity is crucial to navigating boundary interactions productively. Boundary interactions may require certain identities to be suspended and others to be engaged. Learning at boundary interactions opens up a person’s identity to other ways of being in the world and expands identity. Lastly, identity is a living vessel through which a person experiences communities and boundaries, and becomes realized. Multi-membership in different communities allows people to experience boundaries and build bridges between communities. In doing this, people develop their own identities and deal with boundary conflicts within themselves.
**Science Identity**

Identity allows students to personify certain ideas and experiences that enable them to see themselves in certain communities (Vincent-Ruz & Schunn, 2018). Identity is a unique concept because the person actively creates and maintains it (Sfard & Prusak, 2005). According to Abbasi (2016), the process of identity formation is a lifelong narrative that undergoes heightened periods of formation, one of which is during high school. Carlone and Johnson (2007) defined science identity as other people recognizing you as a science person. Sfard (2019) defined identity as the stories that a person deems important and are reifying are their identity. By extension, students’ science identity are the stories that they tell about themselves relating to science. When teachers, parents, and peers, confirm the self-efficacy, interest, and personal goal to pursue science, it facilitates identity synthesis. Science achievement is also key in science identity formation. High science achievements are linked to high levels of identity synthesis or commitment to science, and low achievement leads students to reconsider their commitment to science and creates identity confusion (Pop et al., 2016). Identity confusion also predicts low academic achievement (Pop et al., 2016).

Hill et al. (2010) claimed that when young women enter college is a point in time when they decide not to choose STEM majors and careers. Forming a science identity in high school may help them choose science majors in college. High school science achievement is crucial for the formation of a domain specific science identity. High achievement in a specific branch of science creates the knowledge and experience that makes someone a community member. High achievement increases a student’s commitment to the domain and causes identity synthesis (Pop et al., 2016). If students have low achievement in a class, poor grades cause them to reconsider their commitment, and creates identity confusion (Pop et al., 2016). For example, if girls do not
excel in high school physics, they are not likely to pursue STEM subjects in college or the job market (Hazari et al. 2010). Physics is often a weed-out or gateway course because science majors are required to pass it in order to graduate. If students fail physics they are unable to continue in their major and may experience identity confusion.

Middle school is another very important time for identity formation, and the time during which students become aware of marginalization from communities and academic domains. When a community or academic domain marginalizes students, the likelihood of them identifying with it decreases. By the time students reach middle school, boys are more confident and have a greater sense of self-efficacy than girls in math-based activities (Bandura, 1994). Building self-efficacy in science and math is important to retaining girls or they are not likely to form a science identity.

**Gender Identity**

Gender identity is one of the multi-membership identities that can converge or conflict with other identities. Not only are students gendered, academic domains have gendered stereotypes associated with them. Whitehead (1996) found that children view science as masculine and language and art as feminine subjects. When academic domains have gendered stereotypes, the students' gender will interact with those gender stereotypes to produce either identity synthesis or confusion. Ong (2011) noted that using a particular facet of identity, for example a girl being good at science, can ignite the fire to succeed, but it can also sensitize girls to gender stereotypes. If gender identity conflicts with an academic domain or even specific gendered courses, identity confusion results. Hazari et al. (2007) found that physics, a perceived masculine science, is a required course for most science majors and can prevent them from completing their degree if they cannot complete the course. Science, especially physics, has
stereotypical White-male norms, such as competitiveness and natural aptitude and discourages students whose identities do not align with theirs (Carlone & Johnson, 2007) (Ong, 2005). If a woman’s gender identity conflicts with college physics, they may change their major.

Currently, a working definition of gender identity is a person’s “innermost concept of self as male, female, a blend of both or neither—how individuals perceive themselves and what they call themselves. One’s gender identity can be the same or different from their sex assigned at birth” (Human Rights Campaign.org, 2020). Butler (2006) clarified this definition by stating that gender is related to a person's sex and is not binary. Gender identity is fluid and may change during their lifetime; a person's gender performance can vary in different settings (West & Zimmerman, 1987). Oluwatelure (2015) stated that gender is taught and learned from the day a person is born and they continue to grow and have new experiences, their gender identity may change. Gender and gender identity exist on a spectrum that can vary as the person engages with different tasks and in communities of practice (Oluwatelure, 2015). Individuals perform their gender by the way they dress, arrange their hair, speak, and behave (Stone, 2013). The things that people consider most important to their gender identity vary among people (Vantieghem, et al., 2014). If gender identity is prioritized over other parts of a person’s identity, they are more sensitive to gender stereotypes (Godsil et al., 2016).

When students take courses that are gendered, such as physics or literature, their gender identity interacts with associated gender stereotypes. This can create identity confusion. Gender stereotypes activate stereotype threat to some degree, “Stereotype threat describes the situation in which there is a negative stereotype about a persons’ group, and he or she is concerned about being judged or treated negatively on the basis of this stereotype” (Spencer et al., 2016, p.416). While stereotype threat is usually associated with students from minority racial groups, it applies
to the target of any stereotype. When an individual is the target of a gender stereotype, they perceive stereotype threat more than others who are not the target (Block et al., 2019). For example, if the gender stereotype is that girls are not good at physics or math, girls are the target of this stereotype and experience stereotype threat. When the stereotype threatens girls, they feel added pressure to succeed. When girls have difficulty, they assume that the stereotype is accurate. Boys are not the target; therefore, they are not subject to feeling the added pressure to succeed that girls experience. The extent to which the person associates themselves with their gender, they are more sensitive to stereotype threat. If a particular girl identifies as a highly feminine girl, she will experience stereotype threat more than a girl who doesn’t consider femininity as an important part of her gender identity (Godsil et al., 2016). Gender perception compounds the issue of performance in stereotyped and gendered courses. Stereotype threat causes extra stress for the targets of the stereotype and diminished academic performance in these courses and domains (Godsil et al., 2016).

**Sex Versus Gender Language**

Much of the research on the underrepresentation of women in STEM addresses differences based on sex and not gender. Gender, like identity, is fluid and operates on a spectrum whereas sex is binary and assigned at birth. Binary sex categories use words such as the words masculine and masculinity or feminine and femininity to describe traits. Masculine or masculinity defines the qualities associated with the male sex and feminine or femininity describes those qualities associated with the female sex (Merriam-Webster.com, 2021). Women are people who identify as women and are over 18 years, and girls are under 18 years of age. Men will be defined as those individuals who identify as men and are over 18 and boys are under 18 years of age.
Since the late 1990s and early 2000s, when much identity research began, the definitions of gender have changed. While gender had historically been interchanged synonymously with sex, definitions of gender need to be explicit.

Many different definitions for gender exist and the terminology associated with gender continues to evolve. In this study gender:

refers to the attitudes, feelings, and behaviors that a given culture associates with a person’s biological sex. Behavior that is compatible with cultural expectations is referred to as gender-normative; behaviors that are viewed as incompatible with these expectations constitute gender nonconformity. (American Psychological Association, 2015)

This study used terms including: boy, girls, transgender boy, transgender girl, genderqueer, and cisgender.

**Identity in Practice**

Identity is a social construct, reinforced or conflicted as people engage in activities with communities of practice (Wenger, 2000). Wenger (2000) stated that the community of practice is the basic unit of social learning and these groups define membership and what it means to be competent. The members hold each other accountable and create norms within the group. The community reinforces itself by engaging in common practices, maintaining shared norms, using common language, sharing repertoires, establishing routines, sharing tools, creating artifacts and most importantly, creating stories. Shared stories are crucial in community development. Sfard (2019) said that identity is the stories that a person believes to be important based on inclusion or exclusion from specific communities. If students’ have positive experiences in science classes
they may strengthen their science identities by creating important stories, using common language and tools, establishing routines, and creating artifacts.

As people develop common stories through interaction, they strengthen their identity as well as the community. Shared stories of common practice have to be important and solidify the individual’s identity within themselves and also in the community. Gee (2000) stated that all parts of a person’s identity, their performance in communities, and their relevant stories, contribute to core identity which points to the fact that people have multiple identities from their multi-membership in different communities. Gee (2000) recognized that Nature identity influences other identities, especially gender and cultural identities. The identities that students bring to school, from their Nature and Affinity identities as well as those developed from the cultural and educational understanding of their families and communities, are as important as the factors experienced during school learning. The students' school identity is grounded in the students' natural, social and cultural identity (Srard & Prusak 2005).

Since, Sfard (2005) defined identity as a person’s stories that are both important and reifying, the common stories shared by a community of practice either reinforce the person's identity with the community or not. These science identity stories begin the first time a student interacts with science. During students' formal education, their success in and stories from science classes either makes them feel like they are part of that community or not. The ability to contribute to science practices in the classroom is important to students’ membership in the science community. Competence in the community is the first step to gaining access to membership. Gaining member status in the science community will contribute to the student’s science identity synthesis.
If students already feel marginalized from the science community in middle school, it can be difficult to engage them in high school. This research was specifically focused on high school students, however, students’ experiences during middle and elementary school are still very relevant to their identity. Sfard & Prusak (2005) noted that identities that were formed in childhood are especially difficult to change. Many ideas on how to address this feeling of marginalization have been discussed in the literature. Increasing girls’ knowledge and competence in science will improve their self-efficacy and help them gain member status within the scientific community. A common suggestion has been to segregate schools so that girls take science classes with girls. Studies have shown that girls’ self-efficacy and frequency of questions increases in learning environments with other girls (Baker, 2013). Girls taking classes with girls may improve self-efficacy in the short term but students need to be able to perform in mixed environments to prepare them for communities of practice and the job market.

Wenger (2000) said that communities of practice align local activities to the activities of the broader community which broadens the person’s identity and aligns it with a larger community. This larger community is diverse, not composed of women only. Research also suggests that quality of the education received by students is more important to self-efficacy and identity than a single-sex environment (Baker, 2013). The community, or school, defines what it means to be competent in science. This means that students need to understand science well enough to not only know science but contribute to it.

**Science Identity and Learning**

Sfard pointed out that students already belong to a community outside of school and that part of their identity interacts with academic domains. What students bring to school as part of their identity is as important as the identity formation that happens in-school. A student’s cultural
identity has the potential to be a very important part of their identity and either work concomitantly or in conflict with an academic domain. Educational research has the potential to uncover the ways that these different facets of identity interact with the school environment to produce domain specific identities and remove biases.

Improving the overall quality of science education and removing the White, male cultural norms are changes that have the potential to attract and retain girls in STEM. Since the community establishes its own norms, language, routines, sensibilities, and stories, all members should be involved in mutual engagement and contributing to the community or class. This mutual engagement builds the community, creates shared repertoires and norms, and generates the stories that students either find important or unimportant, reifying or exclusionary.

Being a successful science student depends on forming a functional domain specific learning identity that also aligns with the established norms of the science classroom (Solomon, 2011) (Boaler, 2002). Norms such as natural ability, speed, math ability, and competition are associated with being a science person and have historically been considered masculine (Boaler, 2002). Being aggressive, ambitious, analytical, assertive, athletic, dominant, independent, logical and self-sufficient are also considered masculine characteristics (Auster & Ohm, 2000). Some characteristics considered to be feminine are being caring, gentle, helpful, passive, sensitive, and shy (Auster & Ohm, 2000). Being helpful and gentle should be just as much a characteristic of a scientist as being analytical. This range of characteristics, at different positions on a spectrum, are seen in different people of all gender identities at different times in their lives and should not preclude anyone from forming a science identity.

Science educators are advised to make sure that the norms of the classroom do not favor masculine traits. Norms need to reflect the needs of everyone and not only those who adopt
Eurocentric views of science. The culture of science would benefit from a change, not only in how teachers teach and assess science but to improve the performance and self-efficacy of girls and marginalized groups. Teaching and learning styles that meet the needs of girls, such as real-world problems, as part of a robust curriculum, should be used in science education. The culture of the classroom needs to be intentionally created to make all students feel included. Being aware of the hidden culture of Eurocentric, White, and masculine norms is a good first step to creating a more inclusive science community.

Identity is an important concept in science education because while education is supposed to impact the identity of the student, the students’ identity can conflict with the science education and this can be difficult to observe (Sfard, 2019). Wenger (2000) called this a boundary interaction. He compared it to sitting at lunch with a group of high energy particle physicists. Most people would feel like they did not belong in this community because they would struggle to understand the conversation. Science education is in place so that all students can join the conversation. In that situation, parts of the person’s identity may be activated if they have stories about themselves in physics class that they could relate to what the scientists are talking about. Similarly, students sitting in a physics classroom may have important stories about themselves in past science classes that influence their experience in their current class.

Identity may have a major impact on whether the students' progress results in what they consider to be a success or a failure (Sfard & Prusak, 2005). Hill et al. (2010) found that girls hold themselves to a higher standard and consider equal grades to boys as unacceptable. Girls would benefit from science instruction and assessment that considers students’ narratives and build upon them in constructive ways that solidify students’ science identities. Real-world questions on tests could ask about shared lab experiences so that everyone understands the
experience. Test questions often ask students to solve problems about unfamiliar situations, like using a trebuchet, something most students have never done. Lab experiences create new stories for students and build competence in the community. These new stories that students add to ongoing narratives should be significant if they are going to contribute to science identity formation.

Students need healthy and robust science identities if they are to be maintained and expanded. Students can learn about their own multifaceted identity and how it engages with academic domains. Wenger (2000) said that having a home base allows people’s identity to evolve along with their home base’s community. School can be a student's home base. Schools can help shape students and mold their identities. A home base, such as school, allows students to try new things at the boundary of their identity and not feel uprooted by the experience. This helps students to form strong, healthy identities that they need to feel empowered and not marginalized. A strong identity is required to navigate between different communities.

High school is the last period in a person’s life before they leave home and are launched into the next phase of their life and into a new community. A strong identity comes from deep connections that are formed from meaningful experiences, reciprocity, affection, mutual commitments, and shared history. High school is a crucial period for students because it represents the last opportunity for free public education where their identity can be shaped and strengthened. It is important that this is done intentionally and with purpose. Wenger (2000) said schools create outbound identity trajectories because they project participation with the larger community. Schools produce the newcomers that will join existing communities.

A healthy identity is not singular but is defined by membership in multiple communities and extends across boundaries and through time (Wenger, 2000). These identities through
membership in multiple communities interact and influence each other. They can converge or conflict with each other. Komaraju and Dial (2014) said that when students’ identities align with an academic discipline they will put forth a greater effort and commit more time to challenging tasks. This is why academic domain identity helps the person to persist in the face of challenges and choose a STEM career (Stets et al., 2018). The ways in which a person manages all facets of their identity is how personal growth happens and has an impact on the social structure in which that person resides (Wenger, 2000). People influence others’ identities and expand their own by combining their memberships in multiple communities. People are also able to build bridges across communities because of their membership in each of them.

Students have alma maters that become part of their identities in positive or negative ways. They shape the person’s identity contributing to where the person has been and where they are going. Schools can purposefully help their students to create a strong, healthy identity that extends into the future and helps them to welcome newcomers in existing communities of practice in the world outside of their alma mater. With their strong and healthy identity, students can expand their own identity as well as the identities of the existing members of the community of practice that they enter and stimulate growth and change. Without this influx of new people with fresh perspectives and insight, communities of practice will stagnate. Schools should strive to produce graduates who will bring positive experiences, rich repertoires of resources, and important stories to the larger community.

**Interest in Science**

Interest in science is one of the first steps in science identity formation (Robinson et al., 2019). This needs to be intentionally cultivated in high school and middle school girls because while young girls show similar interest in STEM to boys this interest decreases with age (Baker,
The reason for this decrease in interest could be due to the education itself and the lack of identity synthesis with science. If the culture of early science classrooms is engaging to girls, their interest will be maintained and their self-efficacy will increase (Linnenbrink & Pintrich, 2003). The early years of education are especially important to maintaining interest and creating self-efficacy in science and they contribute to a strong, healthy science identity. Teachers need to be trained in effective methods of creating experiences that maintain girls’ interest in science. Another significant factor to both interest and identity is having a science role model. Many girls who do maintain an interest in science have a family role model who has a career in, or values, science (Guo et al., 2019). Creating a role model experience for girls in school may increase science identity formation in more girls that don’t have access to a science role model outside of school.

Family interest and influence is a key factor in many girls’ interest in science. This effect is stronger in countries with lower socioeconomic status (Guo et al., 2019). Lower socioeconomic status families may value hard work and high salaries and may encourage girls to pursue science. In the more affluent countries, such as the United States, gender-stereotypes and family influence have a greater impact on girls and STEM career choices (Guo et al., 2019). The more affluent the family, the more likely the girl is to follow gender stereotypes. The interplay of socioeconomic status and gender stereotypes is important to note since STEM jobs pay more, they may be more attractive to girls and women in lower socioeconomic status families. Socioeconomic status may be a mitigating factor in gender-science career choices but this study did not include this factor. Family influence can be augmented or adjusted by other influential factors such as informal science experiences and formal school-based science experiences.
Since not all families share an interest in science, opportunities to interact with science role models are important in the early years of girls’ science education (Guo et al., 2019). The current curriculum and culture of science do not pique the interest of many girls (Keane et al., 2022). Baker reports that exposing students to women role models, such as undergraduate science majors and having women science teachers, helps girls increase their interest in science (2013). Hazari et al. (2010) highlights the need for a science curriculum with conceptual framework. The Next Generation Science Standards or NGSS (NAS, 2022) propose such a framework. They are a framework that will unify K-12 science education, ensuring the curriculum has a uniform theoretical framework. Hazari et al. (2010) also finds that girls need realistic problems as opposed to abstract ones, especially in physics instruction, to maintain their interest.

Increasing both girls’ interest and self-efficacy is important because it is necessary for girls to feel confident and identify with science. They are both prerequisites to self-select advanced science classes and science identity synthesis. If a person has no interest in a subject or believes that they are bad at a subject, they will self-select as few of those subject matter courses as possible (Sturdevant, 2021). Self-efficacy is also one of the major factors involved in forming a science identity and choosing to follow a science career path.

**Self-efficacy in Science**

Self-efficacy is another, and arguably the most important, factor to forming a science identity for girls. Bandura (1994) defined “perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (p. 71). Science self-efficacy can be developed through experiences in science class. Middle school is an important time to build girls’ self-efficacy in science. Girls
often report that they do not want to take classes like chemistry and physics because they anticipate that they won’t do well (Guo et al., 2019). There are things that can be done to foster science self-efficacy in girls. Baker (2013) showed that design-based activities or hands-on projects improves the self-efficacy of elementary and middle school girls. Projects boost girls’ confidence in their own technical ability, which is essential to forming a science identity and persisting in advanced science classes. These projects and the experiences that go along with them also add stories to the student’s science narrative. Science self-efficacy is paramount for girls in perceived masculine areas of science like physics, because they tend to have less confidence in their own abilities (Usher & Pajares, 2008).

Physics can act as a weed-out class or roadblock to students trying to persist in science majors in college (Hazari et al., 2007). Most science majors need physics to complete their degree. Biology, a science field that has a higher percentage of women than other science fields, requires college physics (WCU, 2021). Yet, Whitcomb et al. (2021) found that even though girls and women have higher grades in high school physics than their male schoolmates, they do not get the same grades college physics.

Hazari et al. (2017) examined the time frame for girls’ interest in physics careers and found that it often begins in high school. High school is a critical time for science identity formation and science career interest. Hazari et al. (2017) discovered recognition from high school physics teachers had a statistically significant impact for girls on their desire to pursue physics as a career path. This is one example of the importance of having a role model in science. The type of recognition received in high school, not only by physics teachers and classmates, but also other science role models is significant for high school aged girls.
Education and the climate of science classrooms have the potential to increase the number of women and girls that will choose science. Teaching girls to be competent contributors to their science community of practice requires well planned instruction. An effective pedagogical method used to increase girls’ self-efficacy in the use of a learning cycle. The learning cycle, or 5 E cycle, is a student-centered method of teaching. The 5 Es are to engage, explore, explain, elaborate, and most importantly, evaluate (Putra et al., 2018). A learning cycle has routine and discursive elements and students working in groups. They are expected to solve investigations and develop concepts for themselves under the guidance of an experienced teacher. These learning cycles, like communities of practice, encourage self-efficacy and have been found to be effective in decreasing the failure rate of underrepresented groups, especially undergraduate women in physics (Bybee, 2006).

Pedagogical methods can contribute to the climate and culture of the classroom. The success of the pedagogical methods mentioned earlier, like hands-on projects, strong curricular conceptual framework, learning cycles, and interacting with role models is evident in project SCALE-UP. The letters can vary in meaning depending upon the university, but at North Carolina State University, Beichner & Saul (2003) defines it as Student-Centered Activities for Large Enrollment Undergraduate Programs. The active ingredient of SCALE-UP is the social interactions between the students and with the teacher (Beichner, 2008). This teaching design encourages collaboration and diversity to solve complex problems. It has been so successful at the college level that many other academic domain courses have adopted the design at many different universities. Its success in teaching introductory physics has reduced the failure rate of women fivefold (Beichner, 2008). When applied to an introductory physics class at Penn State Erie campus, the force concept inventory, a standardized measure of physics understanding,
scores went up by 46% (Beichner, 2008). This teaching design and classroom arrangement should be studied by educators and adapted for the high school level.

**Social Cognitive Career Theory (SCCT)**

Social cognitive career theory, SCCT, provides insight into why people make certain academic and career choices. SCCT originated from Albert Bandura’s Social Cognitive Theory (Lent et al., 2000). SCCT employs multiple variables to explain peoples’ academic and career decisions. There are both intrinsic and extrinsic variables that relate to students’ choices. Intrinsic variables that SCCT uses to study student choice relate to self-efficacy, outcome expectation, and personal goals. Extrinsic variables such as race, gender, and amount of support that a student receives are also considered. SCCT and students’ identities were used to explore how these factors intersect and lead to science educational and possibly career choices (Lent et al., 2000).

SCCT analyzes variables relating to the person’s environment, the person themselves and their outcome expectation to see how they impact each other (Lent et al., 2000). These variables impact not only each other, but they also influence the person’s behavior. The person’s behavior impacts the contextual support that they receive and also their academic and career outcomes. Human actions are the result of the sum total of the interaction between these factors (Bandura & Walters, 1977). SCCT extends Bandura’s theory to explain the factors that cause people to align themselves with academic domains and make career choices. The six variables pertaining to the three major areas that impact students’ choice self-efficacy beliefs, outcome expectations, and goals structured the survey and focus group instruments.
Figure 1

Triad of Reciprocal Variables in SCCT

Note. Three major areas and supporting variables that affect students’ academic and career decisions: self-efficacy, goals, and outcome expectations.

Person

The “person” aspects of SCCT are self-efficacy, personal goals, interest in science, and personal input. In SCCT, the person themselves is the most important variable. The way that a
student responds to their environment reflects the person’s identity. Student's responses to the environment can be hard to observe and would benefit from study to delineate how identity influences a person’s choices (Sfard & Prusak, 2005). Predispositions, gender, race/ethnicity, and disability/health status are all aspects of an individual person, when combined with the other variables of contextual support and personal outcomes expectation, they impact the academic and career choices that a person will make (Sheu & Phrasavath, 2018). These interactions are complex and the effects of the variables will depend upon the specific individual. The intersection of all of an individual’s identities has an overarching impact on their interests and goals because of the cumulative effect on the person during their lifetime (McAuliffe et al., 2022). These cumulative experiences impact the amount of interest and input that a student dedicates to science. The interaction of the person’s identity and their lived experience will also determine the personal goals and self-efficacy of the student.

Support

Contextual support is defined by Lent et al. (2000) as environmental support. For student’s in this study, the contextual support is the encouragement that student’s receive from teachers, role models and families. This is relevant because much of a student’s identity is influenced by their role models and families. Since the majority of this identity formation happens before high school, students will be asked to relate stories about how these people had an influence on the student’s academic and career identity. These people also influence other variables in SCCT. A student may develop an interest in science or a sense of self-efficacy as a result of these people in their lives.
**Outcome**

Outcome expectation directly precedes the generation of interest, goals, and actions that a student takes toward their science classes and career choices. Much farther removed are the person variables that are extrinsic to the student such as gender, race, predispositions or disability/health status. Outcome expectation is a direct result of learning experiences and self-efficacy. The learning experience comes not only from school and the academic choices that students make, but also from their role models and families.

A student’s identity along with environmental factors described by SCCT, interact and result in student choice. The choice to pursue STEM education and jobs is a result of the student's identity interacting with communities of practice and achieving identity synthesis. The variables included in SCCT were determined to impact student choice. Collecting numerical survey data and hearing the stories, or identities (Sfard, 2019), of girls who indicated a high degree of interest in science illustrated the importance that interest, input, self-efficacy, goals, support, and outcome expectation have on science identity formation. The level of support students receive is another crucial factor. The outcome that students expect is a result of their personal goals but is dependent on the amount of support they receive as well as their personal input. Many factors have to converge for students to pursue STEM but the culture and climate should not exclude certain segments of the population.

**Conclusion**

Students’ identities, or stories like the ones heard in the focus groups, are based on their lived experiences which influences their academic domain identities. The ways in which science identity clashes with the rest of students’ identity can be difficult to observe and measure (Sfard & Prusak, 2005). Since high school science is the direct precursor to college science, the factors
that can help increase the retention of girls in science can help increase the retention of girls in high school and college science classes. This is especially true for science classes that trigger gender-science stereotypes. Physics is a required class for most science majors and is perceived as the most masculine. Climate, culture, and method of teaching physics have the potential to change the number of students who choose science and help underrepresented students in science to be much more successful. The specific cultural, personal, and pedagogical methods that allow girls to persist in the face of challenging classes and form a science identity would benefit from additional research at the high school level. This deeper knowledge of the factors that aid girls’ science identity formation with a SCCT lens will be helpful for teachers at all levels of science education to increase the retention of girls in science and possibly choose a STEM career.
Chapter III - Methodology

Overview

This explanatory sequential mixed methods study utilized a survey design method mixed with a Yinian case study approach to examine the science identity of high schoolers. Yin (2006) stated that the data obtained by mixing methods provide more convincing evidence than a single method can provide. Mixed methods studies are often used to build a multi-faceted understanding of a phenomenon (Fielding, 2012). Triangulation, approaching an issue with more than one data stream, is a goal of mixed methods studies. The methods chosen provide data that link different vantage points together and provide a unique analytic perspective (Cameron, 2011). Quantitative survey and qualitative focus group discussion were used to study science identity. The “advantage of combining methods is the possibility of attaining a double perspective on social reality both examining patterns as they are available to the outside observer and the rationalities guiding practice from the perspective of the individual actor” (Monrad, 2013, p. 348).

Research Design

This quantitative survey and qualitative focus group discussion data to help elucidate the factors that aid in the formation of a science identity of girls. The study tools and the data mixed to provide better insight into science identity than one research method.

Survey

This study began with a cross-sectional survey designed to identify students with a science identity and compare the factors most important to girls and boys for formation of their science identity. Creswell & Guetterman (2019) noted that survey design is a useful tool to investigate individuals’ opinions or attitudinal trends in a community. Surveys have the power to
reach large populations and poll their opinions and beliefs. Additionally, Yin (2009) stated that surveys are appropriate methods to answer “what” and “who” questions as opposed to “how” questions.

According to Yin, the investigator should follow three steps to generate the research questions. First the researcher should skim a large number of papers on the topic of interest. Then they should read three to six of these papers thoroughly. Finally, integrate key insights from these papers into research questions (Moss, 2020). Survey questions should address the variables being researched but the designer limits the number of variables and therefore questions to keep the survey to a manageable amount (Yin, 2009). Many different types of survey design exist but investigators use cross sectional surveys to investigate current attitudes and beliefs of the sample population (Creswell & Guetterman, 2019). This study administered a cross-sectional survey to collect data about self-perception related to science identity (Creswell & Guetterman, 2019). Cross-sectional survey data can be used to compare the attitudes and beliefs among different groups. These survey data were divided into two groups (girls and boys) so that the variables can be compared by gender.

**Case Study**

A case study is an “empirical inquiry that investigates a contemporary phenomenon within its real-life context especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2003, p. 13). Yin (2009) argued that case study is an effective method to study “how” and “why” questions, especially when the investigator “has little or no control” (p. 9) over the phenomenon being studied.

Many types of case study methods exist to investigate different questions. The three major methodologists that define case study are Robert Yin, Sharan Merriam, Robert Stake
(Yazan, 2015). These methodologists differ in their definitions and styles of case study research. Yin (2003) specified that case studies can be exploratory, explanatory or descriptive. Explanatory case studies are used to answer how a phenomenon has occurred (Yin, 2003). In any case study, Yin (2003) stated that developing research questions is the first and most important step in the research project. The overarching question for this explanatory sequential mixed methods project was: How do high school students form a science identity? Case study was an appropriate method used to study science identity in girls because this study focused on a contemporary event in which the “behaviors cannot be manipulated” (Yin, 2003, p.7). Yin (2003) said case study adds sources of evidence useful for investigating how these students’ science identity formed because it included direct observations and interviews of the people with a high score on the Science Career Interest and Preparation Survey. Focus groups were chosen because the interview process was more relaxed compared to one-on-one interviews and they allowed multiple students to contribute data at the same time. Focus groups also provided a social context to discuss a social construct, science identity. This allowed for richer and more abundant data collection.

Case study design follows a linear process that includes: planning, designing, preparing, collecting, analyzing, and sharing (Yin, 2009). After deciding to use a case study, planning requires a thorough literature review to inform the design of the questions and to form propositions for the study (Moss, 2020; Yin, 2009). Propositions are possible explanations from the literature that may answer the question(s) being investigated (Moss, 2020). Binding the case is another crucial step in defining the case. When planning, the case should be bound to describe not only what the case is but also what it is not (Yin, 2003). The population and the specific
research questions are also considered when defining the case. The case was students with science identities and the population was high school-aged girls.

A criticism of case study is the argument that it is not a distinct method but a type of ethnography. Yin differentiates case study because it explores a few defined cases, such as, a few intriguing people with a common trait within a broader context whereas ethnography tends to explore the entire context or community (Moss, 2020). Using a well-planned case study with a defined protocol contradicts most criticisms of case study.

**Description of the Setting**

This study took place in a suburban high school with a majority of students coming from upper middle socioeconomic status homes. This school had a median household income of $56,175 and 3.3% of the population below the poverty line (Census Reporter, 2021). This district had a magnet school which pulls STEM students away from the general population and may have impacted the study results. The district draws students mainly from white households (80%), with the remaining population coming from Asian, Black, Hispanic, or families of two or more races (Census Reporter, 2021). In addition, 54% of the population identified as girls (Census Reporter, 2021).

**Participants**

The study included students enrolled in science classes (biology, chemistry, physics, or any of the advanced versions of these classes) at the time of the study. All of these students, girls and boys, were asked to complete the survey. The focus groups included girls who both agreed to participate and had a high science interest score on the survey. All participants both received parental consent and assented to participate.
**Instrumentation**

This mixed-methods study had two phases. Students who assented, received parental consent, and were currently enrolled in a science course completed the survey, in Phase 1. Phase 2 consisted of focus group discussions with girls who had a high science interest score.

**Survey**

The survey, adapted from the Science Technology Engineering and Math Career Interest Survey (STEM-CIS) (Kier et al., 2014), asked high school students how they managed their science learning and if they were interested in a science career. Adapted STEM-CIS questions structured the Science Career Interest and Preparation Survey and the focus group questions used in this study (Kier et al., 2014). SCCT grounded the questions for both survey and focus groups. The questions created the six composite variables interest, input, self-efficacy, goals, support, and outcome expectation (see Appendix B).

According to SCCT, students are both shaped by their environments and affect their environment and this two-way interaction influences career choice. The three core areas that directly impact career choice are learning experiences, self-efficacy and outcome expectations (Lent et al., 2000). SCCT ties together in one variable person inputs and includes attributes such as predispositions, racial and gender identities with environmental variables, financial and academic support, and quality of educational experiences within the intrinsic variables of interest, input, self-efficacy, outcome expectation, and goals (Lent et al. 2000). Three questions in the survey addressed personal inputs and focused on the influence that gender had on science interest. Since the masculine norms of science culture deter some students, the intersection of gender and science interest was a focal point.
Students' interests, goals, personal input, and self-efficacy in every situation are tied to their identity and interact with academic domain choice and career choice. If a student has no interest in science, for example, they will not choose to take extra or advanced placement science classes. Student learning experiences impact self-efficacy and outcome expectations in science. Self-efficacy is domain specific and comes from “personal performance, vicarious experiences, social persuasion, and physiological and emotional states” (Lent et al., 2002). Choosing upper-level science classes and being successful in required science classes leads to self-efficacy and persistence in science. Personal accomplishments are thought to be a major source of self-efficacy (Lent et al., 2002), but Carlone and Johnson (2007) argued that girls and women respond strongly to recognition by others as a source of self-efficacy.

A person’s environment is another key factor in career choice. The support and the educational opportunities that the student receives relative to the specific academic domain or career selection plays another crucial role in student choice. Factors such as parental and teacher support, availability of quality education, and even financial support are all incorporated into the contextual support that student receives. Students who have a role model in a science career are more likely to choose a science career (Quimby & De Santis, 2011). Quimby and De Santis (2011) also found that when students have a role model, it was a more influential factor than self-efficacy in women and girls’ career choice.

Lastly, outcome expectation from academic domain choice is an important driver in academic and career choice. This is tied to the person’s interest and expectation for their life. These six variables interest, input, self-efficacy, goals, contextual support, and outcome expectation are the composite variables addressed in the survey. Parallel questions structured the focus group discussion.

Figure 2
Conceptual and Theoretical Framework

Note: Self-efficacy, Outcome Expectation, Interest, and Personal Input contribute to Science Identity.

The Science Career Interest and Preparation Survey only targeted part of the community, which were students enrolled in science classes. Not all students take science classes and the purpose of the survey was to identify important factors in science interest and locate students who may have a science identity and would be willing to participate in focus group discussions. The survey design was well-suited for this purpose. This survey was a paper, self-administered, cross-sectional survey. A 5-point Likert scale was employed to identify the degree to which students agree or disagree with questions related to science career interest and preparedness.

The survey questions were structured around the key variables of SCCT and attempted to gather data about each variable and how it impacts student choice. There were three questions related to each of the six variables: self-efficacy, personal goals, outcome expectation, interest, support, and personal input to create a composite variable with a score range from 3-15. A
composite variable is made up of two or more measures that are conceptually related (Song et al., 2017). These questions created a larger scale relating to each of the six variables to provide more meaningful information.

The survey participants demographic data collected from the population of survey participants allowed for additional analysis that contributed to the understanding of the personal input variable. The survey also collected email addresses of possible focus group participants. This information may provide more meaningful analysis of the survey data as well as the focus group data. In order to generate data that mixed together, or inform each other, the survey and focus group discussion questions were both adapted from the STEM-CIS because the survey and discussion questions “connected to each of the aspects of the social cognitive career theory” (Kier et al., 2014, p. 467). This similarity allowed for streamlined analysis of the data and helped with data triangulation.

**Focus Groups**

Phase 2 was the focus group discussion to allow the girls with high science interest scores to share stories of their science identity. Since Sfard (2019) defined identity as stories, the focus group provided insight into these girls’ science identities. The focus group was conducted with girls who had a high science interest score that may indicate science identity. The discussion lasted approximately one hour in duration and was recorded via Zoom. Students were asked to use pseudonyms for themselves and turn off their cameras before the discussion began. The discussion was semi-structured to allow the girls to talk freely and build upon one another’s responses. The questions for the focus group discussions mimicked the survey questions and had the same six variables as their themes. There were three questions related to each of the six areas.
Marshall & Rossman (2016) stated that focus groups can range from 4-12 participants that have been selected because they share a specific characteristic. In this case, all six participants identified as both science people and girls in Phase 1. The reason that focus group was chosen as a method was to hear students’ stories. Focus groups promote discussion among the participants to express their ideas and beliefs (Creswell & Guetterman, 2019). The focus group allow students to discuss science identity in a group of other science people because identity is socially constructed and not created in isolation (See Appendix C).

**Procedures**

A high school administrator sent an email to parents early in November of 2022 requesting that their student participate in a survey. Parents responded to the primary investigator to give their consent to both phases of this research. The survey was administered to students after their parents consented and the students assented to participate. After parental consent was obtained, the students were given a pass to come to the auditorium to take the survey. The survey was self-administered and the data were collected on a paper copy in the Auditorium during the students’ lunch periods. The survey data was analyzed to determine which girls from the survey would be good candidates for the focus group. These girls were emailed a Google form to determine a time and date amenable to all participants. The date and time was arranged and a Zoom link was sent to all of the girls. The participants were asked to de-identify themselves and remove their names from the Zoom session and were reminded that they were free to leave at any time. The participants were also asked to keep all information gained in the focus group confidential. The focus group was semi-structured to allow free flow of conversation. The questions were asked so that the first question associate with each variable was posed before the second and third so that at least some of the data reflect each of the six variables from the survey.
At the end of the discussion, students were thanked for their participation. They were also reminded to keep any and all information gained from the discussion confidential. The data collected were analyzed separately and then mixed. The survey data was analyzed using the Mann-Whitney U test to compare girls’ and boys’ opinions. The results of the quantitative data were considered when analyzing the focus group data. The data informed each other and strengthened the conclusions that could be drawn. The mixed analysis both broadened, by comparing girls’ and boys’ opinions, and deepened, by considering girls’ identities, this study and perhaps provided fresh insight into girls’ science identity.

**Data Collection Schedule**

Data collection started November 9, 2022 when the informational email was sent by an administrator to parents of students currently enrolled in all science classes. One week later, a reminder email was sent. The survey did not get through the district filters and the IRB approved a paper survey. The survey data were collected on January 18th. The students who assented to the focus groups were contacted and a date for the focus group was discussed and confirmed. The focus group discussion took place on January 26th at 5:15 pm via Zoom.

**Threats to Validity and Reliability**

Mixed methods research, while time consuming, minimizes threats to validity and reliability by triangulating data because there is more than one data stream.

**Internal Validity**

According to Yin (2003) internal validity is a construct applicable to explanatory and causal studies. It is the degree of confidence that the relationship you were testing was not caused by other factors or variables (Bhandari, 2021). The survey questions that were identical to the STEM-CIS questions had good internal validity (Kier et al., 2014). The internal validity of
the focus groups depended upon the honesty of the students. Students may have wanted to look good in front of their peers or the investigator and may not be completely honest with their responses in the focus groups.

**External Validity**

External validity is the “domain to which a study’s findings can be generalized” (Yin, 2003, p.34). The survey data were largely valid because it was adapted from the STEM-CIS survey (Kier et al., 2014). The added questions detracted from the validity of the STEM-CIS survey questions but added to the analysis of the results by creating a composite variable. The results of the focus group data have “high face validity” (Marshall & Rossman, 2016, p. 154) because many people are familiar with this method of data collection. Yin (2003) stated that case study relies on analytical generalization by which the researcher is generalizing “a particular set of results to some broader theory” (p. 37). The generalizability of the cause and effect relationships studied are tied to a strong theoretical framework and should relate to other similar situations.

There are two types of external validity, population and ecological. The population validity indicates the degree to which results are generalizable to a larger group of people (Bhandari, 2021). The population that this study would compare to would have similar characteristics. The population would be students interested in science from an upper-middle class suburban high school. Because the survey includes both girls and boys, it compared to the larger school population who are also interested in science. However, the focus groups will not reflect the larger population of the school so the external validity of this group was compared to the larger population of girls interested in science.
Ecological validity is a measure of the degree to which the data collected is generalizable to the findings of studies conducted at other settings (Bhandari, 2021). This study took place in a suburban, upper-middle socioeconomic status, predominantly white high school. The survey sample reflected the interest of a similar broader population in comparable settings. The focus groups reflected a specific population of high school girls who demonstrated an interest in science. The insights provided by these girls are generalizable to the larger population of girls with an interest in science and other similar identity aspects such as socioeconomic status, gender, and racial identity.

**Reliability**

The goal of conducting a reliable study is to minimize error and biases (Yin, 2003). The reliability of a study relates to the items on the instrument, the procedures of the researcher, and the quality of the participants (Creswell & Guetterman, 2019). Reliability is related to the ability of other researchers to conduct the same study and conclude the same results (Yin, 2003). The reliability of the Science Career Interest and Preparation Survey did not match that of the STEM-CIS because the STEM-CIS involved more rigorous testing. The new questions added to the survey were piloted but may not test what they were designed to test. If another researcher replicated this study, these questions could be evaluated. Yin stressed that the reliability of a case study assumes that another researcher could conduct the same case study and not a replication. Since the focus groups occurred on Zoom, any irregularity in the location of the students may have impacted reliability. Additionally, if the students were nervous or knew one another, they may have responded in ways that did not reflect their actual thoughts and ideas.

**Researcher’s Bias**
Biases occur at all stages of research, especially during data collection, analysis, and interpretation (Bhandari, 2021). Validity and reliability of data are impacted by biases that remain unaddressed in research (Bhandari, 2021). When the researcher conducts a survey, however, there is less risk of bias in data collection. Nonetheless, the use of statistical analysis further minimized researcher bias. For focus groups, bias is more likely to occur. To counter bias in evidence interpretation and conclusions, Yin (2003) suggested following a systematic procedure. The researcher followed a script during the focus group discussion.

When the researcher is a science teacher at the school being studied, a power imbalance exists. Students viewed the researcher not only as a person studying science identity but also as a science teacher. Since the discussion revolved around science, the students were aware that the researcher hoped to hear that students like science and their science teachers. The focus group participants’ high scores on the career interest survey minimized the risk of this bias because the participants already indicated that they had an interest in science. However, the students’ responses may not reflect their true inner identity because they wanted to appear more favorably in front of their peers or be helpful to the researcher who is also a teacher.

Yin (2003) suggested pattern matching to compare findings to previous studies, which can minimize bias. Based on Yin’s findings, the researcher applied codes defined in the codebook related to the propositions from the research and the conceptual framework. Since SCCT literature guided the definitions of the variables investigated, the supposition is that the data will be consistent with the theory. There is a rival proposition that the data will not be consistent with literature but the hypothesis was that the data would match SCCT’s suppositions about career choice and interest.
The focus group transcript was checked while the researcher listened to the recording. The data were also analyzed for emergent codes from the stories of the girls. They represent the unique identity of the participants and quotes were used when possible. Interpretation of focus group data is the area of this study that had the biggest risk of researcher bias. Since the researcher is a science teacher investigating science interest, there was a possibility that any data contrasting the literature could be misinterpreted. To address researcher bias in the emergent coding process, inter-rater reliability was checked. The presence of another analyst reduced the researcher bias in the analysis process.

**Generalizability**

This study is generalizable to high school students from similar environments, similar demographics and socioeconomic status. The presence of a STEM magnet school may have skewed some of the data.

**Analysis and Coding Procedures**

Likert survey data are ordinal and had five choices. The choices were: 1: strongly disagree, 2: disagree, 3: neither agree or disagree, 4: agree, 5: strongly agree. The analysis of the survey data comparing girls’ opinions to boys’ can report scores higher or lower relative to another. The mean value is irrelevant because the 3 means neither agree or disagree. Because the data displayed a non-normal distribution, a Mann-Whitney U Test is appropriate because the data do not have to be normal and can be applied to ordinal data with more than two values. Each of the six variables addressed had three questions which gave an expanded scale ranging from 3-15 for each variable and an overall score range 18-90. The null hypothesis was that both boys and girls have the same central tendency in their opinion about science identity. The alternative hypothesis was that one of the groups has a different rank sum than the other.
The individual factors were also analyzed to determine which factors were ranked as most important to students. These factors are influential in forming science identity and relate to the SCCT variables. These variables informed the conclusions and insights gained from the data collected.

**Coding**

Coding is a process of dividing data into categories. Yin recommended using more than one analysis technique to interpret focus group data (Moss, 2020). Memoing, a priori coding, and inductive coding were the methods used to analyze the qualitative data. Memoing is a process of writing notes while the researcher observed the study (Creswell & Guetterman, 2019). The transcription of the Zoom recording was checked while the researcher listened to the recording. The first round of coding used a priori codes. A priori codes are codes that came from the research and theoretical framework and emergent codes came from the data collected. The a priori codes came from SCCT. A master list, or start list, of the codes, was compiled for the a priori coding before analyzing the focus group transcript (Basit, 2003). The a priori codes were taken from the SCCT variables interest, input, self-efficacy, goals, support, and outcome expectation established by Lent et al. (2002).

After coding the data with codes identified from the literature, the data were pattern matched and re-coded with emerging themes from the data itself. The inductive codes were established by counting the number of times the themes were discussed. Inductive codes were used when possible to highlight the identities of the girls in the focus groups. Since identity is the important stories that students tell about themselves, the participants themselves gave nuanced meaning to the data in their own words (Manning, 2017). This qualitative phase of the study
reflected data collected from a microculture, girls with high science interest scores science identities.

A priori and inductive coding methods were used to analyze the focus group data. Using both coding methods helped to reduce researcher bias and facilitated pattern matching. Patterns that emerged that did not match the SCCT variables were inductive codes. These codes came from the data but did not match the variables explicitly defined by SCCT.

**Content Analysis**

The questions for this study were adapted from the STEM-CIS. This survey was designed to find “out not only if students were interested in STEM subjects and careers but also what factors influenced this interest” (Kier et al., 2014, p. 477). SCCT has been “psychometrically evaluated in predicting interest with middle school students and now has been applied to this new STEM career interest survey” (Kier et al, 2014, p. 477). The survey was researched and found to be reliable for use to investigate science interests using the instrument as a whole or a subset as one instrument (Kier et al., 2014). Only the science portion of the survey was used. A Mann-Whitney U test was used to analyze the Likert data.

**Triangulation**

The data from the survey and the focus groups analyzed in tandem triangulated the themes that occurred from the research. The codes used from the focus groups were supported by the data gathered by the survey as well as generated new emergent codes.

**Informed Consent and Protection of Human Subjects**

Emails were sent to obtain parental consent for the study. Before the students took the survey, they assented to both the survey and the focus groups. To protect students’ identities, the students deidentified themselves before conducting the focus group discussions but because they
all attend the same school, they were also asked to keep anything discussed in the focus group confidential. The participants were also reminded that they were free to leave at any time and that their grades or treatment at school would not be impacted.

The data from this study were housed on a password protected laptop in a locked room. It was scheduled to be destroyed on May 31, 2026. This data contains the identities of children under the age of 18 years. As such, these minors’ rights needed to be protected. This research may advance educational practices and impact future generations of students. Any research conducted with children needs to consider their privacy. It was the responsibility of the researcher to ensure a safe environment for students. No educational time was impacted for students and the focus groups were conducted via Zoom for their convenience. The risk to students was minimal but real. High school is a time when students’ identities are forming and their self-image is fragile and the researcher tried to be respectful.

Summary

Mixing methods provided a more complete view of the research questions. Mixing quantitative and qualitative data based on the same instrument allowed the data to mix and inform each other. Phase 1, the survey, collected data compared by gender, and Phase 2 explored in more depth the stories of the target population. Using two data streams helped not only to triangulate the data, but also provided a more robust view of science identity.
Chapter IV: Results

Some demographics, especially women and girls, report experiencing “chilly” environments in science classes and workplaces (Smith & Gayles, 2018). Understanding what allows some girls to persist in science education and pursue science careers was the focus of this mixed methods study. This study had two phases: phase 1, a survey of 22 high school students, and phase 2, a focus group composed of 6 girls from the survey. The data collected to investigate this phenomenon were quantitative data from the Science Career Interest and Preparation Survey adapted from the STEM-CIS (Kier et al., 2014) survey and qualitative data collected from a focus group. This study was conducted at a suburban, upper-middle class high school. This high school provided a wide range of science classes including several AP and honors science courses. The students participating in this study ranged from grades 9-12, received parental consent, and assented in order to participate in the study.

Phase 1 of this study consisted of a survey adapted from the STEM-CIS (Kier et al., 2014) survey by adding questions to create composite variables for more robust data. Phase 2 collected data from girls, identified by the survey, who were interested in science and agreed to participate in a 45-minute focus group discussion. The focus group questions elaborated upon the survey questions, providing insight from these girls as to how they persist in science education. The overarching research question addressed in this mixed methods study was:

*How do high school students form a science identity?*

This question was addressed through the following two sub-questions:

1. What factors are most critical for science identity formation in women and girls?
2. How does the intersectionality of gender identity interact with science identity formation?
Phase 1: Quantitative Survey Data Results

The students who participated in the survey had qualities that will be discussed in the descriptive statistics that separate them from the general student population. The survey respondents were evenly divided: 11 girls and 11 boys. The survey, adapted from the STEM-CIS (Kier et al., 2014), included demographic information as well as three questions about each of the five aspects of science career interest and investigated students’ opinions about their self-efficacy, personal goals, outcome expectation, interest, support, and personal input. In order to better explore trends within the five categories of career interest, each of the three items in each subcategory were combined to create composite variables. In addition, a scaled composite variable that included all 15 career interest questions was also developed.

Demographics

This study was conducted at an upper-middle class, suburban high school. The students selected their race/ethnicity at the end of the survey. White students made up 95.50% of the sample and 4.5% of the respondents were Hispanic or Latino. Half of the respondents of the survey were girls and the other half were boys. Of the students who participated in this survey, only 50.00% agreed or strongly agreed that they plan to major in science in college. This finding was significant because the students who elected to participate in this Science Career Interest and Preparation Survey largely reported getting good grades in high school science but only half of them intend to pursue science.

Descriptive Information

The first type of analysis that I conducted on the quantitative survey data was to run descriptive statistics on the survey items. In SPSS, I calculated frequencies of occurrence and conducted the Mann-Whitney U test.
**Self-Efficacy.** According to Bandura (1994), “Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (p.71). In order to choose science, students need to feel that they are capable of performing science competencies to an acceptable level (see Table 4.1).

**Table 1**

*Self-Efficacy Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to get good grades in my science classes</td>
<td>22.70%</td>
<td>72.70%</td>
<td>4.50%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I am able to complete my science homework</td>
<td>50.00%</td>
<td>50.00%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I was able to get good grades in my middle school science classes</td>
<td>63.60%</td>
<td>31.80%</td>
<td>4.50%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*

When participants were asked if they were able to get good grades in their science classes, 21 out of 22, 95.40%, of the sample agreed or strongly agreed that they attained good grades in their science classes. In the case of the participants in this study, the ability to obtain good grades in science classes was a good indication of their self-efficacy in science because their cumulative grades include test, quiz, and lab grades. Grades are often perceived by students as a measure of their ability, however, when students have greater social support, they have improved attitudes about science and math (Rice et al., 2012). This shows that while students have interpretations about what their grades say about their ability, that self-perception can be altered by support from parents, teachers, and peers. According to Bandura (1994) self-efficacy
contributes to determining outcome expectations. Students who perceive themselves as being
good at science expect good grades in science (Bandura, 1994). The opposite is also true in that
students with low self-efficacy in science expect low grades in science (Bandura, 1994). Students
responded that their trend of earning good grades extended through middle school. The vast
majority, 95.4% agreed or strongly agreed to getting good grades in middle school with only
4.50% disagreeing. Middle school science was reported in the focus group data as being
considerably less challenging than high school science classes. In addition, 100% of participants
agreed or strongly agreed that they were able to complete their current science homework. The
ability to complete science homework is a demonstration of their self-efficacy in high school
science because they were able to perform the tasks assigned by their teacher to be proficient at
the required skills. Getting good grades in science classes provided a more complete picture of
science performance than homework completion ability.

The five areas of investigation were all evaluated with a composite variable for each. The
composite variable, the compilation of the three self-efficacy related questions, resulted in
50.00% of the students scoring a 14 or 15 out of 15. The majority of students who responded to
this survey felt that they could complete their science work and get good grades. According to
SCCT, their personal input and leaning experiences allowed 50.00% of students to feel self-
efficacious. The middle section, 40.90%, another large section of respondents, scored 12 or 13
out of a possible 15. The lowest portion of students, 9.00%, scored a 10 or 11 out of the
maximum 15. Students with a high degree of self-efficacy approach difficult tasks with
confidence whereas students with a low degree of self-efficacy interpret things to be more
difficult than they really are, making them less likely to continue to choose science.
**Personal goals.** Students' personal goals give direction to their behavior and achievement. Their satisfaction is based on their progress in achieving their valued goals (Bandura, 1994). The three questions were asked of students related to their personal goal to use science in their future career, willingness to work hard in science, and planning to major in science (see Table 4.2).

Table 2

*Personal Goals Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use science in my future career.</td>
<td>36.40%</td>
<td>22.70%</td>
<td>27.30%</td>
<td>9.10%</td>
<td>4.50%</td>
</tr>
<tr>
<td>I will work hard in my science classes.</td>
<td>72.70%</td>
<td>22.70%</td>
<td>4.50%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I plan to major in science in college.</td>
<td>27.30%</td>
<td>22.70%</td>
<td>27.30%</td>
<td>13.60%</td>
<td>9.10%</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*

While only 59.10% of the participants agreed or strongly agreed that they planned to use science in their future career, a little more than half of the survey population, the majority, 95.40% agreed or strongly agreed that they worked hard in their science classes. The question related to college majors provided varied results among the survey population: 50.00% of the students agreed to strongly agreed that they planned to major in science, 27.30% of this population neither agreed or disagreed that they would choose a science major in college, and 22.70% disagreed or strongly disagreed that they would choose a science major in college.

The composite variable of personal goals showed a larger spread in the range of results. Goals are direct result of interest and self-efficacy. The highest results, 15 or 14 out of a possible 15, was scored by 31.80% of the respondents. This shows that fewer students who feel
efficacious in science have the personal goal to choose science. Students scoring an 11 or 13 out of 15 made up 40.9% of the population. Students who fell in the 10 or 9 composite score made up 13.60% as did the students who scored a 7 or an 8. No one scored lower than 7 out of 15. The difference in the results from self-efficacy may be due to lack of interest.

**Outcome Expectation.** According to Bandura (1994), the outcomes that people anticipate depend upon their own assessment of what they think they can accomplish. Outcome expectation is related to students’ self-efficacy in science. The variables used to assess students' outcome expectations measured whether students thought that success in science would benefit their future, their education would help them achieve a science career, and level of parental approval from choosing science (see Table 4.3).

### Table 3

*Outcome Expectation Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>If I do well in science classes, it will help me in my future career.</td>
<td>31.80%</td>
<td>54.50%</td>
<td>9.10%</td>
<td>4.50%</td>
<td>-</td>
</tr>
<tr>
<td>My parents would approve (provide financial and emotional support) if I choose a science career.</td>
<td>59.10%</td>
<td>22.70%</td>
<td>13.60%</td>
<td>-</td>
<td>4.50%</td>
</tr>
<tr>
<td>I expect that my education will help me work in a science career.</td>
<td>27.30%</td>
<td>63.60%</td>
<td>4.50%</td>
<td>4.50%</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*
When asked whether doing well in science would help their future career, 86.30% of participants agreed or strongly agreed, 9.10% responded neutrally, and 4.50% disagreed. 86.30% of the respondents report that science is beneficial to their future. This distribution is noteworthy considering only 50.00% of students participating in this survey planned to choose a science major. These students saw an intrinsic value in learning science that they thought would help them in their future careers.

Participants were asked about the parental support available to them in choosing a science career, support included not only approval but also financial and emotional support. 81.80% of the students said that their parents would support their choice of a science career, 13.60% neither agreed or disagreed, and 4.50% of the respondents strongly disagreed that their parents would support their decision to choose a science career. While the vast majority of parents supported their child’s choice to pursue science, one participant reported that her parents strongly disagreed with her decision to major in science in college, further discussion of this girl’s focus group data will be explored in the focus group analysis portion of this chapter.

The final question related to outcome expectation asked students if they thought that their science education would help them work in a science career. Of the sample, 90.90% of participants agreed or strongly agreed, 4.50% neither agreed or disagreed, and 4.50% disagreed. While 9.00% did not agree that their high school science education would prepare them for a science career, 90.90% did report that their education would help them attain a career in science. These students expected that the education they received would help them secure a job in a science field. Only 4.50% of the students had outcome expectation composite scores that resulted in a 9 out of 15, 9.10% of students scored a 10, 13.60% scored an 11 or 12 for each, 27.30% scored a 13, 18.20% scored a 14, and 13.60% scored a 15. Few of these students expect that they
will ultimately major or work in science. Outcome expectation generally precedes student goals, interest, and actions which all contribute academic choice (Lent et al., 2000).

**Interest.** Science interest is a result of student self-efficacy and outcome expectation (Lent et al., 2000). Students who have an efficacious science viewpoint and expect to have positive outcomes have an intrinsic interest in science activities (Bandura, 1994). “Students' belief in their capabilities to master academic activities affects their aspirations, their level of interest in academic activities, and their academic accomplishments” (Bandura, 1994, p. 8). The three questions asked about science interest pertained to interest in a science career, liking science classes, and choosing to take science classes (see Table 4.4).

**Table 4**

*Interest Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am interested in careers that use science.</td>
<td>36.40%</td>
<td>40.90%</td>
<td>4.50%</td>
<td>18.20%</td>
<td>-</td>
</tr>
<tr>
<td>I like my science classes.</td>
<td>22.70%</td>
<td>59.10%</td>
<td>13.60%</td>
<td>4.50%</td>
<td>-</td>
</tr>
<tr>
<td>I choose to take science classes.</td>
<td>50.00%</td>
<td>40.90%</td>
<td>4.50%</td>
<td>-</td>
<td>4.50%</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*

When asked if they were interested in a science career, 77.30% agreed or strongly agreed, 18.20% of participants were disinterested in science careers and 4.50% neither agreed or disagreed. This result was surprising in that 22.70% of respondents to a science interest survey were not interested in a science career. These students may have had other motivations for responding to a science career survey. Students may have had an interest in science classes but not in pursuing a career since 81.80% of respondents said they liked science classes and 90.90%
of respondents chose to take science classes. Students' planned career choices may differ from their interests.

The results of the interest composite variable resulted in 18.20% of respondents scoring a 15 out of 15. Only 9.10% of respondents scored a 14 out of 15. The majority of students, 27.30%, scored a 13 out of 15. The students who scored a 12 out of 15, composed 13.60% of the sample while 18.20% scored an 11. Students who scored a 9, 8, or 7 each made up 4.50% of the sample. The majority of students reported a 13 out of 15 for overall science interest. This was a lower result than expected because these students responded to a science interest survey.

**Support.** Social Cognitive Career Theory, SCCT, states that objective factors such as the quality of education and family support, both emotional and financial, impact students’ academic decisions (Lent et al., 1999). The fifth area of investigation focused on students’ support in science from their teachers, role models, and families through three survey questions. Support in this study refers to things that actively promote science choice for the student, not simply the absence of barriers (Lent et al., 1999). The students were asked if they had supportive science teachers, role models, and family members (see Table 4.5).

**Table 5**

**Support Descriptive Statistics**

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>My science teachers help me learn.</td>
<td>31.80%</td>
<td>63.60%</td>
<td>4.50%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I have a role model in a science career.</td>
<td>22.70%</td>
<td>27.30%</td>
<td>22.70%</td>
<td>18.20%</td>
<td>9.10%</td>
</tr>
<tr>
<td>I know of someone in my family who uses science in their career.</td>
<td>22.70%</td>
<td>27.30%</td>
<td>13.60%</td>
<td>18.20%</td>
<td>18.20%</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*
Of the respondents, 95.50% agreed or strongly agreed that their science teachers help them learn, only 4.50% reported that they neither agreed or disagreed, and none reported that they disagreed or strongly disagreed. This reflected the specific school environment studied which may vary in other locations but was indicated to be an important factor for students interested in science (Lent, et al., 2000). Half of the students or, 50.00% of the respondents, reported that they had a role model who worked in a science career while 27.30% did not have a role model and 22.70% neither agreed or disagreed. This 22.75% of the population may not be aware of the careers of their role models or may be unsure whether they have role models with science careers. This question yielded similar results as the question asking about family members who use science in their careers.

The respondents who had family member who used science in their career represented 50.00% of this sample, 36.40% reported that they did not have a family member who used science in their career, and 13.60% neither agreed or disagreed. The majority of students had a family member or other role model in a science major or career. However, while only half of the sample had someone outside of school supporting them in science, a larger majority of students, 95.50%, had science teachers by whom they felt supported. While objective factors will impact students’ educational and career choices, SCCT also states that student responses to environmental factors partly determine the effect that the factors have on the students (Lent et al., 1999). These students who responded to this survey felt more support from their teachers than they did from other role models. The range of scores from this composite variable ranged from 15 down to 6. Only 4.50% scored a 15, 9.10% scored a 14, 18.20% scored a 13, 9.10% scored a 12, 13.60% scored an 11, 18.20% scored a 10, 4.50% scored a 9, 13.60% scored an 8, 4.50% scored a 7, and 4.50% scored a 6. The composite score of 6 out of 15 was the lowest for
any of the composite variables. While many students felt that their science teachers help them learn, having family members or role models may improve the chances that students persist in science education and careers. Support is a contributing factor for student perceived abilities and attitudes towards science and math (Rice et al., 2012). Increasing student support may help students feel more confident in science.

**Personal Input.** The final area investigated in this study was personal input. According to the creators of the STEM-CIS survey, “Personal inputs are socially constructed factors, such as gender, background, race, and socioeconomic status; and intrapersonal factors, such as personality, that contribute to one's feelings of high or low self-efficacy” (Kier et al., 2014). Since self-efficacy is the best predictor of student choice, personal input, which impacts self-efficacy, was another area investigated in this study (see Table 4.6).

**Table 6**

*Personal Input Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree or disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel comfortable in science classes.</td>
<td>27.30%</td>
<td>54.40%</td>
<td>13.60%</td>
<td>4.50%</td>
<td>-</td>
</tr>
<tr>
<td>I like learning about science.</td>
<td>40.90%</td>
<td>50.00%</td>
<td>9.10%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I feel comfortable talking to people who work in science careers.</td>
<td>36.40%</td>
<td>50.00%</td>
<td>4.50%</td>
<td>9.10%</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: The table above includes numeric data of survey participants*

The three questions in the survey asked about personal input, considering other demographic data. The questions were about students’ comfort level in science classes, how much they liked learning about science, and how comfortable they felt in talking to people with science careers. The majority of students, 81.80%, felt comfortable in science class, 13.60%
neither agreed or disagreed, and 4.50% of the students were uncomfortable in science class. These data were consistent with the other demographic data and confirmed that these students are already interested in and may pursue science in college or as a career. The question asking whether students were comfortable in science class was related to school but also outside learning opportunities. The vast majority, 90.90%, agreed or strongly agreed that they liked learning about science and only 9.10% of these students neither agreed or disagreed that they liked learning about science. These answers were consistent with the population who agreed to participate in a science survey.

Most students, 86.40%, agreed or strongly agreed that they were comfortable talking with scientists, 9.10% of students disagreed that they were comfortable talking with scientists and 4.50% neither agreed or disagreed that they were comfortable talking with scientists. The comfort that most of the students had will serve them well in advanced science classes as well as outside learning opportunities. Having the confidence to talk to experts comes from students’ self-efficacy and personal input. The range for the personal input composite variable ranged from 15-9 with only 18.20% of the respondents scoring a 15, 9.10% scored a 14, 18.2% scored a 13, the majority, 40.90% scored a 12, an13.90% scored a 9. According to SCCT, personal input is the first variables that contributes to career choice and interest. If the student themselves is has a predisposition, gender, racial, or disability (Lent et al., 2000) status that conflicts with the subject area, the student will most likely not have a high score in the personal input area.

**Mann-Whitney U test**

A Mann-Whitney U test was performed to analyze the both the composite variables and individual questions in the quantitative survey data to determine whether the results of the Science Career Interest and Preparation Survey differed between boys and girls. This test was
appropriate because the sample size was small, n=22, and because the data was not normally distributed. Likert survey data are ordinal because the numbers reflect self-selected opinions based on a scale from 1-5 in which 1 represents strongly agree and 5 represents strongly disagree. The Mann-Whitney U test is a non-parametric test that compares the data collected from two independent groups, in this study: girls and boys. It uses the rank sums assigned to the responses to compare the data. The null hypothesis for each question and the composite variables was that the groups are essentially the same.

**Girls and Boys Science Opinions: Differences.** Only two of the questions asked of the survey population showed any difference based on gender. Any p value of 0.05 or less was considered to be significant, and any p value greater than 0.05 was not considered to be significant.

**Good Grades in High School.** The ability to get good grades in high school was the first question investigated in this survey because it is related to students’ self-efficacy. This question showed a statistically significant difference in this sample population with more boys reporting that they were able get good grades in science ($U = 30.00$, $p = 0.01$). This difference will be further explored in the focus group analysis and appears to be related to student confidence and self-efficacy because girls in general view their own grades as less acceptable than boys do, even when they get the same grade. These numbers also show that this sample is representative of the population at large because, according to Rittmayer & Beier (2009), girls’ self-efficacy in science is usually lower than boys’ in the larger population in the United States. While the girls reported themselves as equally able to get good grades in middle school. This difference is an area that would benefit from further investigation.
**Comfort in Talking to Scientists.** The next area that showed a statistically significant difference was the last question on the survey, in which students were asked about their comfort level in talking with people who work in science careers. Students’ comfort in talking to scientists also showed a significant difference between boys and girls. The results indicated that boys were more comfortable talking to people who work in science careers than girls, (U = 27.50, p = .017). This difference will also be discussed in the focus group analysis as it relates to personal input, confidence, and self-efficacy. Personal input, which was the larger composite variable that this question was designed to measure, is an important foundational factor.

**Girls and Boys Science Opinions: Similarities.** All of the other composite variables and individual questions of the survey showed no statistically significant difference in the opinions of girls and boys.
**Self-Efficacy.** Bandura (1994) defined “perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (p. 71). Girls and boys reported similar opinions about their overall self-efficacy in the composite variable which contained three sub-questions. The results indicated that overall, girls had no statistically significant increased or decreased level of self-efficacy than boys, \((U = 49.50, p = 0.45)\). This is a point of interest because in the first sub-question related to self-efficacy, girls reported a lower ability to get good grades in high school than boys but the composite variable for self-efficacy showed no statistically significant difference between girls and boys. As for homework completion, the second sub-question, the results indicated that girls had no statistically significant greater ability to complete their science homework than boys, \((U = 55.00, p = 0.68)\). Ability to complete homework showed no difference and should contribute to overall self-efficacy. They also had no reduced ability to complete their homework which should increase their ability to get good grades. This brings up the question that other researchers have noticed and will be addressed later in this chapter: do girls get the same grades as boys but perceive them as worse? The third self-efficacy related question, achieving good grades in middle school, showed that girls had no statistically significant greater ability to get good grades in middle school than boys, \((U = 58.50, p = 0.88)\). This result was different from the question relating to high school grades. Girls reported that they were equally able to get good grades in middle school but not high school. The reasons for this will be discussed in the focus group data analysis. The only self-efficacy variable to differ was perceived ability to get good grades in high school.

**Personal Goals.** The composite variable for personal goals showed no statistically significant difference between girls and boys. Girls and boys reported similar goals to use
science in their future career. The three sub-questions related to students’ personal goals to measure their desire to use science in their future career, their drive to work hard in science classes, and their desire to major in science in college. The results of the first sub-question indicated that girls had no statistically significant difference in their personal goals of using science in their future career than boys, (U = 47.50, p = 0.39). This result indicated that this population had similar levels of desire to use science in their future which is consistent with a population willing to complete a science interest survey. Results for students’ goal to use science in the future showed no statistically significant difference in girls than boys, (U = 42.00, p = 0.21). This result is inconsistent with national averages and the findings of other studies; however, a larger sample size may have revealed different findings.

The second personal goal sub-question asked students about their perceived drive to work hard. The results indicated that drive to work hard did not differ between genders, (U = 38.00, p = 0.06). This was consistent with most of the findings of other studies. However, Kessels (2015) found that seeming natural ability is perceived as superior to hard work by American students. These students reported that they are willing to work hard but the p value was close to 0.05 and this will be discussed further in chapter 5. The third sub-question related to students desire to major in science in college. The goal of girls to major in science in college showed no significant difference than boys, (U = 43.50, p = 0.25). If this question was broken down to specific disciplines, the results may have shown differences based on gender and the specific scientific discipline.

**Outcome Expectation.** The students’ overall outcome expectation: their opinion that science will help their future career, parental opinion of science choice, their opinion that their education will help them work in a science career was similar. The composite variable for
outcome expectation showed no statically significant difference between girls and boys, \((U = 50.00, p = 0.48)\). Considering the sample population, students who responded to a Science Career Interest and Preparation Survey, this result shows that all of these students had similar outcome expectations for their future in science. The results of the first outcome expectation sub-question, showed that girls had no significant difference in their opinion that science will help with their future career than boys, \((U = 60.00, p = 0.97)\). This result indicated that among students interested in science, girls and boys equally reported that high school science classes will help their future career. The second sub-question showed that girls had no significant difference in their perception that their parents would approve of a science career choice than boys, \((U = 46.00, p = 0.28)\). Parental approval was equal for girls and boys. This finding is consistent with the support variable and showed that both girls and boys had equal outcome expectation that their parents would support them if they chose a career in science. The last sub-question related to students’ outcome expectation asked them if they thought that their education will help them work in a science career. Girls also showed no significant difference in their expectations that their education will help them work in a science career than boys, \((U = 60.00, p = 0.97)\). This result showed that the girls thought that their current education would prepare them for a science career.

**Interest.** These students’ overall interest in science were similar. Interest often follows self-efficacy and outcome expectation. Students were asked questions that pertained to their interest in a career that uses science, the degree to which they like their science classes, and their choices to take advanced or additional science classes. The composite variable for interest showed no statically significant difference between girls and boys, therefore no difference was observed in overall science interest as it pertains to gender for this sample, \((U = 56.00, p = 0.76)\).
As for the individual sub-questions, there was also no significant difference in girls’ interest in science careers than boys, \( (U = 49.50, p = 0.44) \). Gender was not a factor in the opinion that these students were interested in science careers. Since this population voluntarily responded to a science survey, this result is not surprising. The second sub-question asked students to report their opinion on whether or not they liked their science classes. Girls and boys did not differ in their opinion that they liked their science classes, \( (U = 56.00, p = 0.74) \). Of the population surveyed, the girls reported liking science classes as much as boys. The third sub-question asked students about their choices to take advanced or additional science classes. Girls showed no significant difference in their choices to take science classes than boys, \( (U = 50.00, p = 0.44) \). Girls in this study are as likely as boys to choose advanced or additional science classes. This Since this sample was a voluntary sample of students who elected to complete a science interest survey, these results are consistent with the population that they choose to take science classes and are interested in science.

**Support.** Support refers to the assistance given to students from teacher, role models, and family members. The composite variable for support showed no statistically significant difference in self-reported levels of support in science between girls and boys. The level of support reported by these students showed no significant difference based on gender, \( (U = 57.00, p = 0.82) \). They reported similar levels of support from science teachers, role models, and family members. The first sub-question asked students about their opinion that their science teachers help them to learn. Girls showed no difference in their opinion that their science teachers help them learn than boys, \( (U = 41.00, p = 0.13) \). This finding tied into the theoretical framework which indicated that support from others in science is a factor in the student seeing themselves as a science person. It also showed that the girls did not report that boys were helped more by
teachers than they were. The next sub-question asked students if they had a role model in science. There was no significant difference between boys and girls having a role model in a science career, (U = 42.00, p = 0.21). This may be significant because girls respond to recognition from positive role models to help them see themselves as scientists, therefore it may be more important for girls to have science role models (Carlone & Johnson, 2007). The final sub-question asked students if they had a family member who used science in their career. Girls showed no significant difference in having someone in their family who uses science in their career than boys did, (U = 42.00, p = 0.21). This again may be significant because girls may benefit more from having a family member who uses science in their career. Support is one of the peripheral variables that can help students to see themselves as a science person. Girls and boys reported feeling equally supported by teachers, role models, and family members in science.

**Personal Input.** The final area, personal input, showed mixed results. Personal inputs are things about the person such as race, gender, ethnicity, religion, or other unique factors pertaining to that person that may impact their decision to choose science. The composite variable for personal input showed no statically significant difference between girls and boys, (U = 35.50, p = 0.09). All of the participants felt equally comfortable in science class and liked learning about science. The first sub-question asked students’ opinions about their comfort level in science class. There was no significant difference between girls and boys in their comfort level in science class, (U = 43.50, p = 0.22). No personal inputs significantly interfered with girls and boys feeling the same level of comfort in science class. The next sub-question asked the participants liked learning science. There was also no significant difference in the level that girls and boys like learning science, (U = 55.50, p = 0.72). No personal input impacted these students
liking to learn science. While girls and boys showed similar opinions about their comfort in science classes and liking to learn about science, they showed a difference in their comfort level of talking to people who work in science careers. This will be discussed in the later portion of chapter four and in chapter five. The reduced comfort of girls to talk to people with science careers may stem from their confidence and their worldview. The personal inputs were similar in their comfort level in science class and the level to which they like learning science but the last area, comfort in talking to people with science careers, differed by gender. This will be discussed further in focus group analysis.

**Focus Group Data: Girls’ Science Identity**

Phase 2 of this mixed methods study consisted of a focus group discussion among six girls who responded to the survey and agreed to participate. These girls were similar enough to have a discussion because they all in high school and share an interest in science, but they were different enough to generate data that reflected their different lived experience. The questions posed in the discussion paralleled the survey questions (see appendix B). The focus group data provided some insight into these girls’ science identities and why they choose science and their stories provided insight into why they chose science. The data were analyzed in two rounds. The first round of coding using a priori codes generated from the literature, specifically the codes generated from SCCT (Lent et al., 2000) and the STEM-CIS (Kier, 2014) survey. The survey is designed to measure the variables of self-efficacy, personal goals, outcome expectation, interest, support, and personal input, used in SCCT. Several themes emerged during the first round of coding. New codes related to community, collaboration, worldview, desired future, and challenge were developed and the second round of coding used these themes from the focus group discussion that did not align with the a priori codes.
**Round 1: A priori**

The codes for the first round of analysis came from the literature. The main source was Social Cognitive Career Theory, SCCT. This theory is based on Bandura’s Social Cognitive Theory. The themes predict how students develop career interest. These themes were defined by Kier (2014) in the STEM-CIS survey.

**Self-Efficacy.** Self-efficacy was the first area investigated and the most influential. “Self-efficacy is assumed to help determine whether people will approach versus avoid a particular activity, how much effort they will exert, how persistent they will be when confronted by obstacles, and how well they will perform at the activity (Brown & Lent, 2019).” Three questions were asked of the girls that focused on different areas of self-efficacy, and each of the following areas investigated. The first question asked the girls to give examples of things that they did to help them get good grades in their science classes. The girls gave examples of things that they did to be successful in their science studies. All six girls said that they used their own as well as teacher-provided notes. Most of the girls, four of the six said that they also watched online videos and two of the girls, participant # 5 and 6 mentioned on multiple occasions that they used their textbooks to help her get good grades, especially in physics class. The girls in this case study were all good students who worked hard and not only took notes in class but studied them outside of class time as well as consulted other sources such as textbooks and online videos.

Next, the girls were asked about the type of things that they did to complete their science homework. These girls mentioned the usual things that good students do to be successful in school. The majority, participants #3, 4, 5, and 6 all reported that they reviewed their notes and two of the girls, #5 and 6, said that they used their textbook to help them complete their science homework. One reported that she referred to the teacher’s slides, or teacher provided notes. Two
of the girls mentioned general habits of staying organized and paying attention to due dates as helping her complete her science homework. The girls in the case study reported doing additional studying and organizational tasks to help them complete their science homework and stay organized. Organization and additional studying help girls get good grades in their science classes and contributes to their self-efficacy (Kier, 2014).

The next self-efficacy question referred to middle school science experiences. Middle school is a crucial time in identity development so this was asked in order to collect data from that time period in the girls’ development. The girls implied that middle school science was generally easier than high school science. They all reported getting good grades and doing similar things to what they currently did. Two reported reviewing notes, one remembered graphing to see trends visually, another remembered making diagrams and flash cards to help her memorize things, and one student outlined the chapters of study from her textbook. Participant #6 said, “I usually got like good grades in science but in eighth grade I would outline the chapters (#6, focus group, January 26, 2023).” These girls performed many additional activities to be successful in their science classes outside of teacher assigned homework to help them achieve their personal goals. The girls in this study demonstrated that they worked hard to be successful in their science classes. Emphasizing hard work instead of natural talent is beneficial to girls in supporting their self-efficacy (Carlone, 2004).

**Personal Goals.** The second area of study was personal goals. The participants in the case study discussed their personal goals regarding (a) future careers in science and (b) attributes that helped them succeed in reaching their personal goals. Kier (2014) stated that self-efficacy is involved in setting personal goals. Because these girls feel that they are able to complete the
activities and get good grades in science they have personal goals to study and work in science fields.

**Future Careers in Science.** All of the girls in the study said that it was their goal to major in science in higher education. An emergent code related to this a priori code will be discussed later in this chapter. A few of the participants were undecided as to their future direction but some of the girls had some specific ideas. These girls had very different ideas about the type of science that they want to pursue. Two of the girls in this study wanted to pursue careers and college majors in biology. Biology is actually one area of science where women are not underrepresented (Hill et al., 2010). Participant #3 wanted to “major in bio, so I think I'm going to go in (to college) and major in that, and just go into the health field (#3, focus group, January 26, 2023).” She thought that majoring in Biology would give her the foundation that she needed to achieve her goal of working in healthcare.

Participant #2 wanted to study Environmental Science. She was currently in an Honors Biology class and said I want to study, “environmental science.” She may also have an interest in chemistry because she said that she likes environmental science because “you have to be able to tell like pH and chemical balance (#2, focus group, January 26, 2023).” Since she hasn’t taken chemistry yet, she may have been unaware that her interest also extended into chemistry and biochemistry. The branches of science that these girls wanted to study were diverse. Two of the other girls in the group had interests that crossed over from areas traditionally thought of as science and have merged with engineering.

Two of the participants, #5 and #6, had similar personal goals and were both interested in chemical engineering. #5 said, “I think I want to be some sort of engineer (#5, focus group, January 26, 2023).” #6 said she was considering, “chemical engineering or biochemical
engineering.” These two friends were currently taking AP Physics 1 together. Their friendship has helped them excel in physics class.

The girls that said that they wanted careers in science because science offers “good jobs” (#4, #2, and #3, January, 26, 2023). They also mentioned that science offer job opportunities (#4, January, 26, 2023) and they wanted a job that offered the opportunity to earn “good money” (#4, January, 26, 2023). These jobs are competitive but persistence in science education can offer job security and high salaries (Wang, 2013).

**Attributes that Help Students Succeed in Future Goals.** The girls also discussed activities or behaviors that helped them learn and be successful in science. Most of the girls mentioned that individual activities such as memorization was a strategy that they used often while studying science. Some of them mentioned using traditional methods such as making flash cards and drawing stars in her notes near things that she needed to memorize. One girl said that she liked to use a digitized version of notecards, Quizlet. This same student, participant #5 said she liked to play study games. Two of the girls, participants #5 and 6, said that they did extra practice problems in chemistry and physics class. All of these activities are individual as opposed to the social activities that were mentioned. Individual and social learning opportunities are helpful for girls to succeed in science.

Many of the participants described social methods that they liked to use to study and achieve their personal goals in science class. The last girl to speak, participant #6, said that she liked to FaceTime with her friend and discuss things for better understanding. Participant #6 said:

I like studying, and like going over things with other people. Especially this year, in organic (chemistry), and my friend and I will like FaceTime and talk before the test and I
think it's helpful because I kind of kind of get like their understanding, too, and we can kind of help each other. (#6, focus group, January 26, 2023)

Social activities like these help girls learn science. Discussions and sharing knowledge are not part of the competitive environments seen in engineering and other masculine STEM fields (Ong, 2017). Participant #3 echoed the sentiments of participant #6 when she said, “I definitely enjoy working with like other people, because, like you get their like ideas (#3, focus group, January 26, 2023).” Interactive and social teaching methods are becoming more popular in classrooms like the ones that use the SCALE-UP method of teaching physics (Beichner, 2008). This type of classroom environment uses discussion and interactive lab and lecture with students arranged in groups. It has proven helpful for all students, not just women and girls, to improve learning especially in difficult classes.

Participants mentioned the importance of having a comfortable classroom climate. #1 said:

I like it when you can ask, questions, and you, and also same with like others, (have) classmates (and) like feeling comfortable, to ask questions in front of other people as well. And also, just having like a group of people you can like talk to is also makes you feel comfortable. (#1, focus group, January 26, 2023)

Creating a classroom climate in which students feel comfortable helps them feel safe enough to ask questions was valued by these girls.

Participant #4 provided additional evidence for girls learning in a non-judgmental environment in which they can talk openly with other like-minded people. Participant #4 said:
I definitely like working with other people and like bouncing on ideas off each other, and I feel like I always like, get a different perspective of something, and I think it really helps me learn in the class. (#4, focus group, January 26, 2023)

The social aspects of learning science were important to the girls in the focus group to achieve their personal goals. According to Leung (2020) discussion and an established framework for navigating boundary experiences such as Wenger (2000) described helps students learn and make connections in STEM. Wenger (2000) stated that learning is maximized at boundary interactions between communities, especially when the communities are close enough to discuss things and not too far apart that they don’t understand one another. Within a classroom, there can be multiple communities of practice. Students tend to group themselves into communities and the intersection of these communities is where learning can occur. Teachers can encourage this boundary interaction by requiring comparisons between small groups. Providing opportunities for interactions between communities within the classroom can maximize science learning. These girls understand that discussion and sharing help them solidify learning and build connections.

**Outcome Expectation.** The third area investigated was the outcome expectation that the girls had based on their interest in science. According to SCCT, “outcome expectations affect interest, when interacting with self-efficacy (Kier, 2014).” The girls were first asked how they thought doing well in their science classes would help in their future career. Four of the girls said that high science classes gave them a good foundation and basic knowledge about the world. The discussion about basic knowledge of the world and perspective of aspects of the world will be discussed later, as it relates to the students’ worldview. Participant #5 said, “I definitely think it would give me a good foundation and also it kind of like this doesn’t just apply to science class,
but it kind of helps me learn how to learn in high school.” Three of the girls mentioned that science classes helped them with their metacognition as well as developing their work ethic.

One of the girls said that science class helped her with her work ethic and her work ethic reciprocally helped her in science class. Similarly, participant #4 said she put in a lot of extra effort in her organic chemistry class. She said that she would, “do a lot of practice problems like last year in chemistry. I would just do like multiple problems over and over, just to get like the gist of like the test and stuff.” Emphasizing hard work instead of natural ability helps girls choose and stay in science (Wang & Degol, 2017) These girls recognized that not only is high school science is a challenging subject, a challenge which they accepted, but they were willing to work harder with the hopes that science will provide them with a unique insight into how the world works and a good career. Participant #3 said,

I definitely did a lot of flash cards for memorizing, and I remember, like freshman year. I like remember, like I got a really bad grade on the test, because I like didn't study for it. But then the next test I like made sure to like, put like, make a lot of flash cards and like diagrams, and I could definitely tell difference with like the grades. (#3, focus group, January 26, 2023)

The girls were also asked how they thought their parents would react if they chose a career in science. This question was about outcome expectation but was also related to support, the fifth area of investigation, that these students receive in science. Most of the students said that their parents would be happy with their choice to pursue a science career. They stated that they thought science offered good career opportunities. Two of the students said that their parents were proud of their choice and one said that her parents pushed her more in the direction of science because of her interest. Participant #3 said, “they were like really proud (of my
decision to choose a science career), like they seem to like, push me more and like help me with like where I want to go in life, and they know that, like when I'm done (with) school it, I like, have many opportunities for me (#3, focus group, January 26, 2023).” This positive outcome is reassuring and affirming to children when their parents approve of and support their choices. It encourages them to keep trying and working hard. Not all students have that support and encouragement from their parents.

Participant #6 had a very different situation. In fact, she was discouraged from pursuing a science degree. She said, “neither of my parents really want me to go to college (#3, focus group, January 26, 2023).” This girl, who was currently in AP Physics 1, said she wanted to be an engineering major in college. Her attitude during this part of the discussion felt defiant. She acted as though she wanted to prove her parents wrong and get an engineering degree in spite of what her parents thought. This unique occurrence in the focus group is not unique among women who persist in science, other women choose to stay in science in spite of what others think (Hanson, 2008).

The final outcome expectation question was, “What career/job do you want?” This generated more specific data about particular area of science that the girls want to pursue. One of the girls reported the same career choice, and the others gave more specific answers than they had for previous questions. The girl who wanted to study and works environmental science gave the same answer for every future and career related questions. The other girls, who were all older, gave more specific details about their chosen areas of interest. The participant who wanted to major in Biology and work in healthcare specified that the areas of her interest, “bone doctor” or “heart” doctor (#3, focus group, January 26, 2023). These areas of interest stemmed from health problems that she and her grandfather had, two areas of medicine to which she had been
exposed. One of the participants remained undecided, but said that she wanted a flexible work environment, even though so many women cite this as their reason for leaving science careers (Hunt, 2016). The last two participants said that they wanted careers in chemical engineering. This outcome will present more challenges to these girls than will the biology and environmental science outcome.

**Interest.** The fourth area studied was interest. In SCCT, self-efficacy and outcome expectation precede interest and interest leads to personal goals. All of the girls answered that they were interested in obtaining careers that use science for themselves. Participant #3 said, “The science field definitely like captured me (#3, focus group, January 26, 2023).” Participant #4 said that she liked the idea of a science career because it’s, “always changing” and you, “can learn something new (#4, focus group, January, 26, 2023).” When asked what they like about their science classes, the majority mentioned that they liked working and talking with people who also enjoy science and shared a common interest. One student also said that she enjoyed gaining different perspectives when working with others. Other areas of interest were in lab work, mentioned by two of the participants, and one student said she liked learning about, “DNA and genetics.” These girls enjoyed the challenging subject matter that science had to offer and leaning about the world around them from a scientific perspective.

The final interest-related question asked these students how they make decisions about taking advanced or additional science classes. Participants #1, 3, and 4 stated that they choose advanced science classes to figure out which area of science is most interesting to them that they may wish to pursue for their future and to push themselves in high school to advance themselves for their futures. Participant #2 said that she chose an honors class, the highest level available to her, because it is more interesting so it is easier for her to take a harder class. Interest in science
was a driving factor that led these girls to choose to study different branches of science and to challenge themselves to take higher level science classes.

**Support.** The fifth area of investigation was support. Having supportive teachers and classmates was mentioned previously by the focus group participants as being important to them. Parental support showed mixed results as one of the girls, participant #6, did not have any. The first support-related question asked the participants how their science teachers helped them learn. Real-world examples, demonstration, diagrams, visuals, labs, and worked examples were pedagogical methods mentioned by the girls as being helpful and interesting. Stadler et al. (2000) found that girls want to understand science, in particular physics, in a way that helps them understand a broader worldview while boys tend to value the internal coherence of science. Stadler et al. (2000) also found that girls’ learning outcomes are improved when physics concepts are embedded in broader contexts.

One participant mentioned the importance of the stories that her teachers told on two different occasions. This will be explored in the inductive analysis as well as in chapter 5. The stories that teachers tell, “regarding like their own science” ties into the identity piece of the theoretical framework for this study and showed that girls identify with science, at least in part, through their teachers. The other theme that was mentioned was that science teachers, “correct my thinking and like, see where I went wrong.” This quote will be discussed in future sections as it pertains to students’ worldview but it also showed that these girls appreciate the individual support that they need to solve problems correctly. This also relates to statement that the girls made about appreciating approachable, supportive teachers.

The second support-related question was about role models. The question was, do you have a role model in a science career and why are they your role model? One student had a sister
with a degree in chemical engineering and another had a girl cousin, a senior in college, with the same interest in healthcare. Participant #4 said:

   My sister is definitely one of my role models. She graduated with a chemical engineering degree and she has like a really good job now. So just like seeing how hard she worked (I) really like hope that I can do the same as her. (#4, focus group, January 26, 2023)

This quote is origin of the title of this study. Another girl said that Rosalind Franklin was her role model. Three, or half, of the participants did not have a role model in science. When asked if they had a family member who uses science in their career, all but one student said yes. Two students had female cousins that either had or were studying for science careers, one had a sister, another had a father with a science career, and the last one had a grandfather who was a physicist. Having family members with careers in science may influence these girls even if they don’t realize it. Having a grandfather who was a physicist may increase the value that the family places on science. Participant #5, who wants to be an engineer said, “and my cousin is in her…she's working to become an engineer (#5, focus group, January, 26, 2023).” Having female role models in science may have allowed these girls to see themselves in these careers as a result of seeing the women in their lives achieve aspirational goals.

   Personal Input. The final area of investigation about science identity was personal input. The girls were asked to discuss what makes them feel comfortable in science class. Five of the six girls said that having an approachable teacher made them feel comfortable. Participant #2 said, “like a teacher you can ask questions, to after class like you don’t have to raise your hand during the during class (#2, focus group, January 26, 2023).” This points to a general discomfort in class and with classmates but if the teacher is approachable, this girl felt comfortable in the class because of the teacher alone.
Four of the participants said that having classmates with whom they were comfortable and could rely on for help made them feel comfortable in science class. Participant #1 said, that having “classmates (and) like feeling comfortable, to ask questions in front of other people as well. And also, just having like a group of people you can like talk to also makes you feel comfortable (#4, focus group, January 26, 2023).” These girls were all interested in science and considered to be “science people” by themselves and others. Participant #2 said, “I wanted to go into science since I was like 8 (#2, focus group, January 26, 2023).” These girls all had science identities. The communities of practice in which they placed themselves reaffirmed their identities. The collaborative and social nature of some science classrooms allowed them to communicate with other students and teachers who share their interests and built their science identities. Participant #5 said that she enjoyed having “classmates that I can talk to and kind of bounce ideas off of (#5, focus group, January 26, 2023).” They all said that working collaboratively and having people to share ideas with made them feel as though they belonged in science.

When addressing the broader scientific community, these girls were less comfortable. Communicating with perceived experts can daunting and the survey data showed that these girls were less comfortable talking to scientists than boys. The girls said that they felt comfortable talking with scientists but usually after they got to know them and realized that they wanted to help them. The scientists were seen as well-meaning, altruistic people. Participant #3 shared a story,

I got surgery like a couple of years ago. At first it was like really scary for me to like, talk to the doctor and become like comfortable with them. But then you realize that they're
there to help you. So, you have to like just like get used to them and know that they're there for the right reasons. (#5, focus group, January 26, 2023)

Once this girl was able to see that the doctor was there to care for her and help her, she became comfortable enough to talk to them. This caring demeanor was important for these girls in talking to their teachers and to scientists. Once the girls felt comfortable, they were able to open up, share, and learn. Many science classrooms don’t have a climate that is perceived as caring and open by girls. Only when they are made to feel comfortable, can girls begin to build their science identity.

**Round 2: Inductive**

The second round of analysis used codes generated from several themes that emerged from the first round of coding of the data that did not fall into the SCCT themes. The themes that emerged from the data were community, collaboration, world view, desired future, effort, challenge, and confidence.
Community. Community was defined as having people that you feel comfortable talking with who share a common interest. The girls often mentioned the importance of having classmates and teachers with whom they feel comfortable. Participant #4 said “having a good relationship with your teachers and your classmates” (focus group, January 26, 2023) is important for learning in a science class. All of the girls mentioned that they needed an approachable teacher to feel comfortable in science class. Five out of the six mentioned the importance of having classmates who shared their common interest on whom they could rely. Participant #5 said, “classmates that I can talk to and kind of bounce ideas off of (focus group, January 26, 2023)” makes her feel comfortable in science class.

Participant #3 said that she had a few family members who have been involved in her science identity formation but one in particular was especially influential in her life. She said:

My cousin, Victoria, she's like one person like so far out of my older cousins that have like gone through like this field (Biology) in college, and she's like really helped me with like understanding, like the topics and things that I'm going to have to like experience later, so she like helps with like the things that I'm going to need to know later in life.

Participant #3 talked about her cousin many times during the focus group discussion. She felt very close to her and was very influenced by her lived experiences. This cousin paved the way for participant #3 to see herself in a science major in college and possibly a career. Having someone that she felt comfortable with who shared her common interest was influential in her progression in science. Without this person, her choices may have been different.

Participant #4 had a similar story. She said:
My sister is definitely one of my role models. She graduated with a chemical engineering degree and she has like a really good job now. So just like seeing how hard she worked really like (I) hope that I can do the same as her. (focus group, January 26, 2023)

This excerpt from this girl’s story provides additional evidence of the importance of community in girls’ decisions to pursue science education and careers. Without these family members examples, these girls would have had a more difficult time persisting in a challenging discipline. It also shows that girls need to see women in challenging careers and education to help them survive. Girls need other girls in the science, technology, engineering, and math classes to share experiences and be a community on which they can rely.

**Collaboration.** Collaboration was defined as working with others as opposed to independently. The culture of science values independent work in certain disciplines. The girls in the focus group had fairly strong science identities but these girls all mentioned in some way that they liked having collaborative environments with friendly classmates. Participant #1 said, “I also really like working with other people, and like bouncing other ideas off of people like in groups, and like I said in labs (focus group, January 26, 2023).” These sentiments were reiterated many times in other areas of the discussion. This is in direct contrast to how many science classes operate.

Many classes foster a competitive work environment where grades are based on a curve and one person is the “curve wrecker.” Ong et al. (2017) said that “the prevailing culture and structural manifestations in STEM have traditionally privileged norms of success that favor competitive, individualistic, and solitary practices—norms associated with White male scientists (p. 206).” These girls enjoyed approachable teachers and friendly classmates with whom they could collaborate.
**Worldview.** Students worldview is their philosophy of the world. Students’ worldviews are comprised of a set of belief systems. Bandura (2001) said that “belief systems are a working model of the world that enables people to achieve desired outcomes and avoid untoward ones (p.3).” Many of the girls in the focus group had a limited worldview but thought that science provided insight into the larger world. Participant #3 said that science provided, “more information about like the world and like how everything runs” #4 said, that science gave her a “different perspective” on “aspects of the world (focus group, January 26, 2023).” These girls saw science as a way to learn about the world and expand their worldview.

These girls saw science as a way to lean about the world and their teachers as an expert to guide them along their journey. These students gave examples of the way that their teachers helped to expand their worldview. Participant #4 said that science gave her “more information about the world and how everything runs” and #1 said she liked it when teachers, “apply it to real world examples and their own examples and stories that they have (focus group, January 26, 2023).” This powerful statement provided insight into both the teacher’s identity but also how it impacts the students learning and their own identity. These girls placed a large amount of trust in their teachers. Participant #1 revealed that she found talking to people in science career as “intimidating (focus group, January 26, 2023).” The girls talked as if teachers have all of the answers and are the source of all knowing. Participant #1 also said she relied on the teacher for learning materials “they give you PowerPoint notes or their own outlines (focus group, January 26, 2023).”

Science is a way to explore the world. These girls should realize that curiosity and exploration are also ways to learn about the way the world works. The science taught in American classrooms is one part of a much larger picture of the natural world. Different cultures
have more wholistic ways of studying the natural world that often differs from Western science and these girls do not see that. They see their teachers as experts and science as having the, “right or wrong answer (#5, focus group, January 26, 2023).”

Desired Future. While all the girls had personal goals to obtain a career in science, what these girls want for their future and how they think science can get them there was a theme that emerged from this focus group discussion. The future that they desire may or may not be possible in the science career of their choice. Women, at times, leave STEM careers because their professional lives interfere with their personal lives, especially after they have children (Sassler et al., 2017). These girls had an interest in science and ideas that science would provide them with job security and opportunities for success. Participant #2 said, “There’s lots of jobs and opportunities in it (science) (focus group, January 26, 2023).” These girls had a broad view of science. Some of them wanted to study biology in order to pursue a career in healthcare, others wanted to study engineering, and another wanted to study environmental science. All of them saw science as a way to secure a future that would provide them with a good quality of life and a job that they found interesting.

Participant #4 said that she wanted a job where she could “work with people and have a work environment that is “flexible (focus group, January 26, 2023).” This same girl said that she wanted a career in science because it is “always changing” and “you can learn something new (focus group, January 26, 2023).” Her job description could be met my many different career choices, hopefully, a career in science offers her the career that she has envisioned.

Effort. Effort was defined as the extra work that the girls had done to succeed in science. All of these girls put in considerable effort into their science classes. Specifically, they did both independent and collaborative activities to study and learn. They mentioned things like making
flashcards, reviewing notes, outlining textbooks, and staying organized. They used technology to study as well by making Quizlets, and watching YouTube videos. Some of the girls used technology to collaborate and FaceTime with classmates. Their efforts were both individual and collaborative using traditional and more technologically advanced ways to study and learn.

These girls measured the success of their efforts by the grades that they got. Participant #3 said:

I definitely did a lot of flash cards for memorizing, and I remember, freshman year. I like remember, I got a really bad grade on the test, because I like didn't study for it. But then the next test I like made sure to like make a lot of flash cards and diagrams, and I could definitely tell difference with like the grades. (focus group, January 26, 2023)

This girl realized that she needed to put in more effort as a result of a low test grade. The problem with measuring effort by grades is that girls tend to interpret the same letter grade as a worse score. Rittmayer and Beier (2009) stated that girls have less confidence and are more modest about their grades thereby lowering their self-efficacy as compared with boys. The concern is that girls do as well as boys in STEM classes but they perceive their own performance to be worse and do not persist.

**Challenge.** Students attitudes in the face of difficult material in their classes is a demonstration of their resolve to face challenges. How these girls approach the challenges that science presents them will determine if they are willing and able to get a degree or a job in science. When asked what she liked about science classes, participant #4 said that she liked science because you can always “learn something new (focus group, January 26, 2023).” A positive attitude can make the difference between success and failure. The unspoken culture of science is that students should possess a natural ability in terms of science learning (Ong, 2011).
Having a growth mindset is one way that these girls can approach science learning in the face of challenges.

Participant #5 said that she would “push myself” by “taking advanced science classes” in high school (focus group, January 26, 2023). This girl was challenging herself in high school by taking as many advanced science classes as she could to get an idea of what each science discipline entailed. She said that taking advanced science classes helped her to push and challenge herself. Since she wanted to be an engineer and was unsure of which type of engineering she wanted, exploring the many offerings in her high school was a great way to help her make this decision.

Science can be daunting but effort helped these girls overcome many challenges. Participant #6 said science “definitely like pushes me because a lot of it I find like challenging at first (focus group, January 26, 2023).” Participant 6 gave many examples of how she worked hard to fight through the classes that were challenging at first. She is the same girl who outlines textbook chapters in her spare time and FaceTimed with her friends to study. These girls all enjoyed the challenges that science classes offered them. They are smart, motivated, and capable young women. Hopefully their growth mindset and willingness to face challenges will be enough to help them endure the challenging environment of higher education and science careers.

**Confidence.** Confidence is the beliefs that a student holds about their own ability to complete a task to a proficient level, often but not always, based on test scores and other performance evaluations. Many girls lack the confidence to persist in a male-dominated field because boys are generally more confident than girls in science. Confidence is related to self-efficacy which was found to be the same for boys and girls in this study, however, girls are more modest about their own performance than boys (Rittmayer & Beiet, 2009). This study echoed
this finding in the survey data when girls reported that they were less able to get good grades in high school science than boys did. The boys are more confident in their ability.

Confidence helps students talk with people who they perceive are experts in science. The girls in the focus group and the girls from the survey all reported that they were less comfortable talking to people with careers in science than boys were. Participant #5 said, “I just sound kind of stupid talking to them (focus group, January 26, 2023).” The boys in this study felt more comfortable talking to people who worked in science careers and had more confidence. Participant #1 said, “it can be very intimidating” talking to scientists. I would feel that way with my doctor.” This showed that she viewed her doctor as the expert and she lacked the confidence to feel comfortable talking with them.

One of the reasons for this lack of confidence is lack of practice talking with scientists. Students often have very little exposure to scientists unless they have a family member or a role model with a career in science. Participant #1 also said that she didn’t “really interact…with many people in the science field (focus group, January 26, 2023).” Not only do these girls feel intimidated but they don’t have many opportunities to practice talking to scientists. Increase exposure and more lived experience would help girls feel more comfortable and gain confidence when talking to scientists.

Summary

This study provided insight into girls’ science identity formation in high school. The survey data showed that girls have significantly lower self-reported ability to get good grades in high school science and have less confidence than do boys in talking to perceived experts. The focus group discussion provided context for these observation as well as providing some insight into girl’s science identity.
Community and Collaboration

The first insight gained was opposed to traditional science culture. Science culture has been said to reflect the norm of success for White male scientists. These White-male norms are practices such as competition, individualistic activities, and solitary work (Ong et al., 2017). Instead of working alone, girls prefer learning in social environments in which there is collaboration within a friendly community. The culture of the community should reflect the culture of the members of the community of practice, and not white-male norms. This collaboration within a community works in combination with individual work to provide optimal leaning opportunities. The girls appreciated approachable teachers and collaboration with friendly classmates to work collaboratively as well as independently.

As an extension to the collaborative work being done within groups, communication should also occur between groups and among different classes taught by different teachers. This level of communication simulates boundary interactions which promote additional learning. When groups collaborate with each other, especially about the same lab activity, boundary interactions occur and learning is maximized. Teachers can promote this by conducting shared laboratory investigations which create common experiences and encourage their students to talk to other lab groups and other students in different classes. Google documents can be used to share and collaborate as well as other methods of communication such as group chats.

Effort not Natural Ability

Girls are willing to work hard but often showed a lack of confidence in their natural ability. In order to encourage girls to persist in science education, stressing the importance of hard work is more important than stressing natural ability. Very few people possess the raw natural ability to just do science (Ong eta al., 2017). Emphasizing a growth mindset approach,
can help girls feel less intimidated in the face of a challenging coursework. Girls are willing to put in hard work, even if they feel intimidated, but they need to know that hard work will help them gain the ability that they need.

**Future Careers**

These girls understood that science offers good careers with job stability and high salaries. They also wanted flexible work environments that offered new challenges and new things to learn. The current STEM environment does not usually offer flexible work environments but certain careers do. Increasing the number of student internships and research opportunities would help these girls get a better idea of the work environments associated with different areas of science. Increasing girls’ exposure to people who work in science may help to address some of these concerns.

**Worldview**

High schoolers, in general, have a limited worldview because of their age and lack of experience. Presenting a more wholistic representation of different cultures scientific inquiries may help expand students’ worldviews. Having guest speakers talk to students would help display other ways in which science is conducted. Showing areas of science, for example the geocentric model of the universe, that were once accepted as doctrine and have since been proven incorrect may also help students to see that science is not infallible. Many of the students mentioned that they like science because there is a *right* answer. This may reflect the limited worldview that they have or be reflective of some of the math-based problems that are solved in chemistry and physics which do have a *correct* mathematical answer.
Identity

Identity was a major focus of this study and this girl showed how powerful stories can be. This girl was a junior in high school and was impacted by a documentary that she was shown during the pandemic her freshman year. The story of Rosalind Franklin was able to help shape this girl’s science identity. The stories that girls have about science education impact their science identities. Sharing the stories of scientist may be a first step to encouraging science identity development. Participant #5 said:

I remember watching a documentary about this woman named Rosalind Franklin who helped discover, like the DNA. Helping make advancements in that field, and I don't want to do anything in biology, but I still thought her story was really inspiring. (focus group, January 26, 2023)

Sharing the stories of scientists from all walks of life may be a first step to encouraging people from diverse backgrounds to see themselves in science. Allowing students to create their own stories in science is another way to nurture science identity development.
Chapter V – Discussion

Introduction

Science has the potential to transform lives by developing new treatments for disease, creating technologies that save lives, allowing people to explore uncharted territories, and saving humanity from the COVID-19 pandemic. While the education required to work in a science field is rigorous and expensive, the reward for succeeding in science education can be a high-paying job with job security. Women and girls are historically underrepresented in most science fields. Women and girls have reported negative experiences in male-dominated science education and work environments. This mixed methods explanatory sequential study sought to gather girls’ stories and perceptions as to why they choose science in spite of all of the challenges associated with the male-dominated classes and environments. The following section will include a summary and discussion of the study’s theoretical framework, results, limitations, and implications.

Summary of Study

This mixed-methods study sought to investigate how high school students, particularly girls, form a science identity. This question included two sub-questions:

1. What factors are most critical for science identity formation in women and girls?
2. How does the intersectionality of gender identity interact with science identity formation?

This study included two phases. Phase 1 consisted of a Likert scale survey adapted from the STEM-CIS survey (Kier et al., 2014). Phase 2 was a case study comprised of a focus group discussion with six high school aged girls using questions that paralleled the STEM-CIS survey questions. The STEM-CIS (Kier, 2014) survey collects data about students’ opinions in science, technology, engineering, and math in order to determine career interest. This study used only the
science portion of that survey and adapted it to create composite variables of interest, input, self-efficacy, goals, support, and outcome expectation, all of which are good predictors of career interest. Additionally, the stories of the girls from the focus group discussion captured their identity and provided insight into their experiences. The methodology is discussed in greater detail in Chapter 3 of this dissertation. The pairing of survey questions and focus group questions allowed for better triangulation of the data.

**Application of Theoretical Framework to Findings**

This study implemented Identity Theory and Social Cognitive Career Theory (SCCT) to investigate why some girls choose to pursue science education and careers. Chapter II of this document provides greater detail about the theoretical framework. Phase 1 of this study, the Science Career Interest and Preparation Survey, focused on the variables presented in SCCT. Phase 2, employed identity theory to understand the intersectionality the lived experience of a case study of girls with a science identity. Phase 2 utilized a focus group discussion which allowed these girls to share their stories of their lived experience. These stories provided insight into their identities in science. Together, Identity Theory and SCCT contribute to a richer understanding of why, in spite of all of the challenges that girls face in science education, some choose to persist in science.

**Application of Identity Theory**

Identity encompasses other personal input or contextual factors, such as support as well as self-efficacy. All the girls’ stories accessed or denied parts of their identity. They are all members in multiple communities of practice with pieces of their identities rooted in each of them (Wenger, 2000). The intersection of contextual identities becomes increasingly complex and creates “overlapping and interdependent systems of discrimination or disadvantage”
(Crenshaw, 1989). SCCT considers many of the other complicating factors and looks at how they impact each other. Social cognitive career theory helps to explain why students make the academic and career choices that they do (Lent et al., 2000).

SCCT is an extension of Albert Bandura’s Social Cognitive Theory that utilizes several variables to make sense of students’ academic and career choices. SCCT juxtaposes intrinsic variables such as self-efficacy, outcome expectation, and personal goals with extrinsic variables in the students’ lives such as race, gender, and the amount of support that a student receives. While these girls were all White, they were from families with varied socioeconomic statuses and received very different kinds and amounts of support from teachers and parents for their pursuit of science. SCCT and the intersectionality of the lived experiences and identities of these girls was used to investigate how these factors lead to science academic and career choices (Lent et al., 2000).

**Application of SCCT Theory**

Identity encompasses other personal input and background, or contextual factors, such as socioeconomic status, as well as self-efficacy influences. All the girls’ stories accessed or denied parts of their identity. They are all members in multiple communities of practice with pieces of their identities rooted in each of them (Wenger, 2000). The intersection of gender, science, and other contextual identities becomes increasingly complex and the “interconnected nature of social categorizations such as race, class, and gender as they apply to a given individual or group, regarded as creating overlapping and interdependent systems of discrimination or disadvantage” (Crenshaw, 1989). SCCT considers many of the other complicating factors and looks at how the impact each other. Social cognitive career theory helps to explain why students make the academic and career choices that they do (Lent et al., 2000).
SCCT is an extension of Albert Bandura’s Social Cognitive Theory (Lent et al., 2000). SCCT utilizes several variables to make sense of students’ academic and career choices such as intrinsic variables related to the student such as self-efficacy, outcome expectation, and personal goals and juxtaposes them with the other extrinsic variables in the students' lives such as race, gender, and amount of support that a student receives. While these girls were all White, they were from families with varied socioeconomic statuses and received very different kinds and amounts of support from teachers and parents for their pursuit of science. SCCT and the intersectionality of the lived experiences and identities of these girls was used to investigate how these factors lead to science academic and career choices (Lent et al., 2000).

**Summary and Discussion of Results**

Girls have historically been underrepresented in advanced science education and careers, especially in areas such as physics (Lock & Hazari, 2016). The number of women and girls in science has increased over the years but in many areas, there is still disparity. This explanatory sequential mixed methods study sought to understand how high school aged girls form a science identity by both hearing their stories and applying SCCT tenets to understand the data collected. The survey collected quantitative data to gather opinions about science interest. The results allowed for a comparison of girls’ opinions to boys. Girls who participated in the survey and were willing to participate in a focus group provided qualitative data. The qualitative data collected represented the lived experiences and identities of the six girls who all scored very high on the survey indicating that they had science identities. The mix of quantitative survey data and qualitative focus group discussion data approaches this issue from different angles and provides a deeper insight into this issue.
**Survey and Focus Group Results**

Survey data is useful for getting the opinions of a larger group of people at a specific point in time. The survey in this study asked students to give their opinions about their interest in a science career using variables that SCCT deems important to career choice. The sample size for the quantitative survey data was small, n=22, with an equal number of girls and boys. 46 parents consented and only 22 students volunteered to participate. The students completed the survey during their lunch periods which indicates that these participants may be dedicated students who were willing to give up their free time to complete a science interest survey and may not be representative of the larger population. Since the data was from a small sample and not normally distributed, the researcher used a non-parametric test, the Mann-Whitney U test, to analyze the data. The Mann-Whitney U test yielded very similar results for girls and boys. The survey included three questions that related to each of the composite variables for a total of 18 questions. All of the composite variables – self-efficacy, personal goals, outcome expectation, interest, support, and personal input – showed that overall, girls rate themselves similarly to boys in terms of science career interest. Two differences arose during analysis of the individual questions that made up the composite variables related to getting good grades in high school and their comfort level in talking to people who work in science careers.

The first difference related to the self-efficacy composite variable. Girls rated themselves significantly lower than boys in their ability to get good grades in their science classes. This finding is important because self-efficacy, the belief in one’s ability to perform a specific task, is one of the main reasons that girls leave STEM (Rittmayer & Beier, 2009). Girls often have lower self-efficacy in science than boys even when they perform as well as boys. As an example:
In a science class, a girl might view a B on an exam as a poor grade, indicative of her lack of science ability. A boy receiving a C on this same exam might view the grade as passing and therefore indicative of his strong science ability. (Rittmayer & Beier, 2009, p.1)

When girls perform as well as boys, they do not perceive their grades as good enough (Rittmayer & Beier, 2009). This demonstrates why girls showed a statistically significant difference in the survey question about their beliefs that they were able to get good science grades in high school. Their perception of that grade, not their actual ability, constitutes the real difference. This perception is why many girls leave science.

The next difference related to the composite variable of students’ personal input. The girls rated themselves lower than boys in their comfort in talking to people who work in science careers. While this is a personal input variable, both of the differences found in this study are related to self-confidence. Similar to their perceived inability to get good grades, girls lacked self-confidence when talking to people who work in science careers. The girls perceived these people as experts and shared that they did not want to appear “stupid” when talking to them (focus group, January 26, 2023). The girls told stories in the focus group about being intimidated by doctors until they realized the doctors only wanted to help them. The girls also told stories about how they feel as though they have limited exposure to people who work in science careers and therefore were less comfortable talking with them. Boys stated that they got better grades and were more comfortable talking to people who work in science because of their self-confidence and ultimately their overall self-efficacy. Schwarzer and Warner (2012) said that self-efficacy:
…reflects a sense of control over one’s environment and an optimistic belief of being able to alter challenging environmental demands by means of one’s own behavior. Hence, it represents a self-confident view of one’s capability to deal with certain stressors in life. (p. 139)

Having an optimistic outlook about one’s own ability to meet specific demands comes from having confidence in one’s own abilities (Schwarzer & Warner, 2012). Confidence is a key component of self-efficacy (Van Der Roest et al., 2017). Without self-confidence, girls will not be able to develop self-efficacy in science or other areas of their lives.

Heaverlo et al. (2013) found that middle and high school girls’ confidence in science was solely based on their science teachers’ influences. A theme that emerged from the focus group data was that the girls in this study were very reliant on teacher-provided resources. A teacher’s worldview is influential to their students’ learning and worldviews (Schraw et al., 2017). Schraw et al. (2017) noted that “teacher education programs should aim to reinforce the development of sophisticated epistemological beliefs and worldviews” (p. 294). They also found that teachers who are aware of and have developed their worldviews are generally more effective science teachers (Schraw et al., 2017). Traditional science education does not address student worldview development. Both teachers and students would benefit from developing a worldview in terms of science education. Cobern and Cobern (2000) found that education can augment and broaden student worldview and suggests using non-western science studies on teaching science to better understand how to carry out this process.

Some of the findings in this study may come from differences in student worldview. Student worldview is especially important as it relates to identity. Identity compounded with student worldview may account for the differences in the data. Male-dominated branches of
science may conflict with not only identity but also world view. Stadler et al. (2000) found boys’ worldview to be different than girls, particularly in terms of how they perceive learning physics. Boys were more interested in physics for internal coherence whereas girls looked for external coherence (Stadler et al., 2000). The girls in this study expressed that liked science because it helped them understand the world and how it works. They indicated that they wanted external coherence between science class and the broader world. The girls in the focus group often mentioned that they liked it when teachers used of real-world applications and examples to teach science. Girls believe that they understand a concept only if they can put it into a broader world view whereas boys are satisfied with learning for the sake of learning (Stadler et al., 2000).

Overall, the differences between boys’ and girls’ opinions about science were subtle. The focus group discussion provided additional insight into the identities of girls who choose science. The girls rated themselves equally with boys for all of the broad categories of science career interest and only rated themselves differently in their lower ability to get good grades in high school and lower comfort level talking to scientists. However, this study found that having approachable teachers and friendly classmates with a common interest were valued by girls in science classes. Emphasizing a growth mindset can offset girls’ self-assessment of achieving less satisfactory grades than boys. Girls mentioned that they enjoyed learning about the world through science. Intentionally developing teachers’ and students’ worldview may help create more inclusive climates. More inclusive and collaborative educational climates can better model the larger scientific community where sharing and communication are encouraged.

Limitations of the Study

The limitations of this study are due to the location and sample size. The location was an upper-middle class high school, predominantly populated by white teachers and students. The
researcher was a teacher at the research site. This may have influenced some of the responses of the students. These students may have wanted to be helpful and have reported their opinions and experiences in science more favorably because of the relationship of the researcher to the research site. The girls in the focus group may have been the most biased because they were answering science education questions to a science teacher.

**Limitations in Methodology**

This mixed methods study was implemented in two phases, Phase 1: a quantitative Likert-scale survey, and Phase 2: a qualitative case study using a focus group discussion. Survey data are useful because the tool is easy to administer and analyze but can be problematic especially with a small sample size. High school students are reluctant to give up their personal time during lunch periods to complete a survey which resulted in a small sample size, n=22, but the sample size was sufficient to generate usable data for this explanatory sequential design. Nonparametrically distributed survey data with less than 30 participants required a specific type of analysis, a Mann-Whitney U test. This test is less sensitive than a parametric test, therefore, larger differences are required to reject the null hypothesis. Of the participants who completed the survey, some respondents may not have given accurate or honest answers. Teenage participants may not have felt comfortable responding honestly to questions which present themselves in an unflattering manner. To counteract this, all survey responses were confidential.

Phase 2 of this study collected data in a focus group discussion because the girls all shared a common trait, and the discussion took place in a social setting. Since identity is a social construct, this method is appropriate. The researcher used mixed methods to allow the quantitative data to identify factors important for all students in order to compare the opinions of boys to girls, and the focus groups highlighted the stories of girls. According to Sfard (2019),
identity is a person’s stories, so focus group discussion allowed girls to share their stories. The limitations, however, of conducting a focus group discussion with teenagers who all attend the same high school can be divided into two categories: problematic silence and problematic speech.

The girls in this study knew each and may not have been completely honest with their feedback. Hollander (2004) points to problematic speech and problematic silences which created limitations in this study both of which are intensified when participants attend the same school. The girls in this focus group may not have shared relevant information in front of their peers for fear of appearing inferior to their peers. This problematic silence resulted in a loss of relevant data that would have contributed to the richness of the qualitative data. If the girls had been interviewed individually, the data may have provided more detail and a complete picture of the girls’ identities. However, the benefit of using a social setting to learn about a social construct outweighed the possible lack of data.

Another issue with focus group discussions is problematic speech. Hollander (2004) said that both groupthink and withholding true beliefs can also reduce the quality of focus group data. Groupthink is a common phenomenon in a group discussion especially when one person dominates the conversation (Hollander, 2004). Since one person can commandeer the discussion, all participants were asked to respond one at a time to counteract groupthink. This study asked the participants to speak in a specific order, individually, to reduce this phenomenon (Shaffer, 2020). The girls often reiterated what others had already stated. Getting teenagers to share their true belief is a difficult task. The participants were asked at the beginning to keep the discussion confidential in order to promote honesty and minimize the fear of sharing. Another safety put in place was conducting a focus group of girls only in order to increase their comfort level.
This study may not be transferrable to other schools that differ from this site. Factors such as religion, values, race, socioeconomic status, quality of education, and region of the population may alter the results of a similar replica investigation. These areas were not included in the scope of this study.

The sample size for this study’s survey was small and produced non-parametric data. Small sample size can reduce the probability of obtaining usable findings and makes the differences in opinions between boys and girls undetectable because of the limited pool of respondents. The case study using focus group data, generated by six girls, was an acceptable size. Marshall & Rossman (2016) stated that focus groups can range from 4-12 participants selected based on a shared characteristic. In this case, all participants identified as science people. If more participants had been willing to discuss science career interest, additional focus groups could have generated more abundant data.

Limitations in Analysis

The explanatory sequential design of this study was chosen to maximize data validity. The survey questions that were identical to the STEM-CIS questions had good internal validity (Kier et al., 2014). New questions were added to the survey to create composite variables that may not have the same reliability as the original STEM-CIS questions. The degree of confidence for the new questions may not have been as high as the vetted questions from the original survey (Bhandari, 2021). The sample size was not large enough to conduct factor analysis but most of the questions showed consistent findings with each other and the composite variables. Only two questions showed a statistically significant difference from the composite variable but these were supported by the literature. Since the data set was small and non-parametric, the Mann-Whitney U test allowed for a comparison of girls’ and boys’ opinions. Because the survey data met all
requirements for the statistical test, the analysis was reliable. The p value was set to 0.05 or 5%.
For the two questions whose value was below the 0.05 value, the null hypothesis (that there was no difference in opinion between girls and boys) was rejected.

Qualitative analysis has larger margin of error in interpretation. The first round of coding was a priori coding using codes generated from the areas utilized in Social Cognitive Career Theory, SCCT. Themes emerged from the data during the first round of coding that did not fit into the a priori codes. New codes were developed, defined, and then the data were coded a second time. The themes that emerged from the data are susceptible to misinterpretation. Braun and Clarke (2013) stated that thematic analysis is often “poorly demarcated” (p. 5). It is therefore important to define codes and be transparent about the coding process. To reduce these limitations in this study, a codebook was produced to limit misinterpretation and increase coder neutrality. Whenever possible, quotes were used to increase the validity of the interpretation.

**Limitations in Generalizability**

While all studies have limitations, this particularly study was small and was therefore susceptible to greater limitations. The views of the participants, if they were being honest and sharing their actual opinions, may not be reflective of a larger population even at this setting because the population in this study is not representative of the general student body. This sample was composed of students who chose to give up part of their lunch period to participate in science interest research. This study is also limited because it is only generalizable to similar socioeconomic status settings with similar racial demographics in similar regions of the country. This is a study of students with a science identity and may be relevant to other similar students with a science identity.
Implications of Future Educational Research

Future educational research could investigate new ways to interest and retain women in STEM fields that have low retention of women and girls. Areas such as engineering, physics, and computer science have especially low numbers of women and girls in these college majors and employed in these fields. Creating more collaborative classrooms with approachable professors who are accessible to students would help to retain more students in general but especially girls. The girls in this study repeatedly mentioned the importance of having approachable teachers and classmates with whom they could collaborate. Reducing competitive, weed-out practices would also help increase retention. Most of the practices that would help retain more women in STEM would also help retain all students. Expanding and researching pedagogical methods, such as specific real-world applications and training in spatial reasoning, would help girls learn and create welcoming classroom climates. Improving the overall climate may help to produce the number of people needed to meet the rising demand for STEM workers.

Talking with people who work in science careers was an area in which girls could benefit from some intervention. The girls in this study were statistically less comfortable talking with scientists than boys. Exposing students to scientists through career fairs and guest speakers might increase girls’ comfort level in talking with them. One girl in this study mentioned that Rosalind Franklin was her role model as a result of watching a documentary about her life in her freshman year of high school. Bringing women scientists and college-aged science majors into the classroom would be even more beneficial for improving girls comfort level in talking with them and resolve to stay in science. Kalender et al. (2019) found that “perceived recognition by others played a major role in students’ endorsement of physics identity” (p. 1). Giving girls the opportunity to interact with scientists and feel like a science person may encourage girls to
choose science. Studying the specific impact of such interactions may benefit pedagogical methods as well as educational motivation.

Real world connections were mentioned many times by the girls in the focus group when discussing identity. Future investigations could determine which specific real-world application are most beneficial to girls. The girls from the focus group specifically mentioned enjoying conducting laboratory investigations. Increasing the number of labs that are applicable to the real world may improve girls’ comprehension. The topics and methods that would provide the most benefit for girls could be studied. Areas of science where women are noticeably underrepresented, such as physics and engineering, would benefit the most from this type of future research. In addition to real-world applications, girls would benefit from the development of specific skills that increase their achievement in STEM.

Motivation to work hard and persist is another area that would benefit from future educational research. One of the areas investigated in this study, within the composite variable of personal goals, willingness to work hard, had a p value of 0.06. The survey question said, I will work hard in my science classes. The results from this question showed that girls’ drive to work hard did not differ from boys but its proximity to the significance threshold warrants further investigation in future studies. This area may be related to the questions asking about getting good grades in high school and middle school. Girls reported that they were equally able to get good grades in middle school as boys, but reported themselves as less able to get good grades in high school. These phenomena may be related in that high school science may require harder work and girls are less willing to put the time and effort into science. Investigating whether girls may be less willing to work hard in their science classes bears further investigation.
Implications for Educational Practice

The educational practice that best serve girls in STEM help all students perform better in STEM, however, specific pedagogical methods have been shown to help girls perform better. Attitudinal issues are more difficult to change and may be the real reason why many people do not choose science. Self-efficacy beliefs about getting good grades have been shown to differ in girls and boys even when the get the same grades (Rittmayer & Beier, 2009). Student beliefs about what constitutes a good grade would help students understand the expectations. The girls in this study rated themselves as being less able to get good grades than boys. Discussing with students what really constitutes a good grade in a class should be explicitly communicated. Getting a C in an organic chemistry class or second semester calculus-based physics class should not be a reason to drop a science major. Studies have shown that girls view their own grades as worse than they are in reality. One way to address the issue of grades is to encourage a growth mindset. Hill et al. (2010) found that encouraging a growth as opposed to a fixed mindset encourages all students but in particular girls to focus on how much they have learned and not focus on natural ability. A growth mindset encourages “greater persistence in the face of adversity” (Hill et al., 2010, p. 30)

Real-world examples and labs are helpful for girls to learn in science classes. The girls in this study mentioned real-world examples, labs, and also teachers’ own stories about their experience in science helped them to learn and identify with science. Helping these girls develop their own science identities by allowing them to connect with science, teachers, and create their own stories in science can contribute the retention of girls in science and STEM fields.

Allowing the opportunity for girls to interact with guest speakers, collaborate with scientists, and be recognized as a science person may also build girls’ confidence. Being
recognized as a science person by others is important for girls to see themselves in that way. Avraamidou (2020) stressed that recognition is “how individuals are recognized by others as certain kinds of people, is an ineradicable part of our social world” (p. 323). Since identity is a social construct based on a person’s stories, recognition by others is an integral part of identity formation (Sfard, 2019). Not only would the opportunity to talk to scientists help to build girls confidence and identity, it would help them understand what is involved in science education and how to achieve a career in science. Showing girls that the scientific community is collaborative and not isolating may impact their academic and career choices. There are simple things that can be done to make science education more accessible to all.

**Summary**

This mixed methods explanatory sequential study investigated science identity as it pertains to science interest and career choice. The growing demand for STEM workers in the United States is not being met by a growing number of candidates for these jobs. This study particularly looked at how girls form a science identity. This study consisted of two phases: Phase 1, a science career interest survey of twenty-two students and Phase 2, a case study of six girls who participated in a focus group discussion. The survey and the focus group data informed each other and revealed several findings. Girls are as capable as boys as boys in science but they view their own performance more critically that boys do. When faced with talking to people who work in science careers, these girls were less comfortable in talking to scientists than boys.

The climate of many science classes, with perhaps the exception of biology classes, is often competitive and deters girls from these branches of science (Miller et al., 2006). The girls in this study said that they prefer learning environments with approachable teachers and friendly classmates who share their interest in science. They shared that they prefer real-world problems
and situations to help them learn about science and the world. They also mentioned that they think that science is a way to learn about the world and how it works. In conclusion, girls do identify as science people, but the climate of the classroom and work environment are influential in retention. When the climate is competitive and isolating, girls can persist, but they often choose to leave. Unfortunately, when they leave, they take with them their unique perspectives and problem-solving insights.

The community that is created within the academic classroom is reflective of the teacher’s influence and the personalities of the students in the class. The structure of some classrooms is structured in a way that encourages competition. The scientific community relies on open communication and collaboration among members. This is the environment that girls are asking for in science education and the scientific community at large provides. The worldview of the girls in this study was limited science education that they had received. The community of science classrooms can be managed to encourage collaboration instead of competition and teachers’ worldviews can be deliberately developed in teacher education classes so that they are more aware of the importance of concepts of tolerance, inclusion, and scientific collaboration.
Jan 4, 2023 8:42:12 AM EST

To: Patricia Butler
Col of Education & Social Work, Literacy

Re: Modification - IRB-FY2022-396 Science Identity in High School Girls

Dear Patricia Butler:

Thank you for your submitted modification to your West Chester University Institutional Review Board approved project Science Identity in High School Girls. We have had the opportunity to review your modification and have rendered the decision below effective January 4, 2023.

Decision: Approved

Sincerely,
West Chester University Human Subjects Review Board

IORG#: IORG0004242
IRB#: IRB00005030
FWA#: FWA00014155
Appendix B

Phase 1: Science Career Interest and Preparation Survey
This survey will use a Likert scale from 1-5.

1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree

Questions:

1. (self-efficacy) I am able to get good grades in my science classes.
2. (self-efficacy) I am able to complete my science homework.
3. (self-efficacy) I was able to get good grades in my middle school science classes.
4. (personal goal) I plan to use science in my future career.
5. (personal goal) I will work hard in my science classes.
6. (personal goal) I plan to major in science in college.
7. (outcome expectation) If I do well in science classes, it will help me in my future career.
8. (outcome expectation) My parents would approve (provide financial and emotional support) if I choose a science career.
9. (outcome expectation) I expect that my education will help me work in a science career.
10. (Interest) I am interested in careers that use science.
11. (Interest) I like my science classes.
12. (Interest) I choose to take science classes.
13. (Support) My science teachers help me learn.
14. (Support) I have a role model in a science career.
15. (Support) I know of someone in my family who uses science in their career.
16. (Personal input) I feel comfortable in science classes.
17. (Personal input) I like learning about science.
18. (Personal input) I feel comfortable talking to people who work in science careers.
These questions are adapted from the STEM-CIS survey (Kier et al., 2014)

**Demographic Data Questions**


14. If you would be interested in a discussion about science identity, please provide your email below.
Appendix C

Phase 2: Science Identity Focus Group Questions

Students will be instructed to remove their names or use pseudonyms before the focus group discussion.

1. (self-efficacy) Give examples of things (reading the textbook, watching videos, studying) you do to get good grades in your science classes.

2. (self-efficacy) What things do you do to help yourself complete your science homework?

3. (self-efficacy) With hard work, were you able to get good grades in your middle school science classes?

4. (personal goal) How do you plan to use science in your future career?

5. (personal goal) Give examples of how your effort helped you learn in your science classes.

6. (personal goal) What do you plan to major in during college?

7. (outcome expectation) How do you think doing well in science classes will help in your future career?

8. (outcome expectation) How will your parents react if you choose a science career?

9. (outcome expectation) What career/job do you want?

10. (Interest) Are you interested in careers that use science?

11. (Interest) What do you like about your science classes?

12. (Interest) How do you make decisions about taking advanced or additional science classes?

13. (Support) How do your science teachers help you learn?

14. (Support) Do you have a role model in a science career? Why are they your role model?

15. (Support) Do you know of someone in your family who uses science in their career? What do they do and does it make you want to choose a similar career?

16. (Personal input) What makes you feel comfortable in science class?

17. (Personal input) What makes you like learning about science?

18. (Personal input) Do you feel comfortable talking to people who work in science careers? Why or why not?
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