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A Case Study of a School-Supported Extracurricular Activity's Influence on STEM Identity and Interest for Females

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A CASE STUDY OF A SCHOOL-SUPPORTED EXTRACURRICULAR ACTIVITY'S INFLUENCE ON STEM IDENTITY AND INTEREST FOR FEMALES

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ABSTRACT

A Case Study of a School-Supported Extracurricular Activity's Influence on STEM Identity and Interest for Females

Even though there has been a narrowing of the gender gap in STEM, there is still a pronounced gap in the physical sciences, engineering, and computer science. Females who persist in these fields have a strong STEM identity, including developing specific STEM interests. Females can develop STEM identity through long-term, active involvement in extracurricular STEM programs. Extracurricular STEM programs significantly impact the persistence of females in the STEM pipeline. This case study examined the effect of Science Olympiad, an extracurricular STEM program, on current high school students and alumnae's perceptions of their STEM identity and personal specific STEM interest. Potential participants were recruited from a Bay Area High School Science Olympiad program, both current students and alums. After completing an online survey, 17 participants were selected to participate. In individual interviews or a focus group, the participants reflected on their experiences in Science Olympiad and how those experiences influenced their STEM identity and personal specific STEM interests. The participants shared that a collaborative, team-focused atmosphere was most critical in developing their STEM identity. Additionally, exposure to and deep exploration of various STEM topics were essential components of developing personal specific STEM interests. The participants shared the features of the studied Science Olympiad program, which were most influential in encouraging their long-term, active participation and their frustrations. The program's key component was the program's team and partner-focused nature, which has led to the development of a strong community of practice.

Additionally, the participants described attributes of STEM people. While they related the traditional characteristics of ambition, smartness, and problem solvers, the participants also described the charitable nature of STEM. While the participants acknowledged that those who work in STEM fields might not be there for the sole reason of helping others, they felt STEM, in its very nature, is a humanitarian field. A strong STEM identity is crucial for females to stay in the STEM pipeline. Participating in a program, such as Science Olympiad, that is more collaborative than competitive allows the females a safe space to develop STEM identity and personal specific STEM interests.

This dissertation, written under the direction of the candidate's dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

Letta S. Meyer — May 24, 2023

Candidate — Date

Dissertation Committee

Chairperson — May 24, 2023

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STATEMENT OF THE PROBLEM

Since the 1990s, there has been a concerted effort to increase the involvement of females in science, technology, engineering, and math (STEM) fields due to the underrepresentation of females within those fields. There have been increases in female involvement in STEM careers since 2010, but there is still a disparity. According to the National Science Foundation (NSF), in 2019, only 29.4% of STEM jobs were held by women overall (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). However, according to NSF's data, certain areas of STEM have seen more significant gains than other areas. For instance, in 2018, 62.8% of bachelor's degrees in biology were earned by females, but females earned only 22.2 % of bachelor's degrees in engineering fields. There has been an overall trend in the positive direction of equal female representation; however, this trend has not increased steadily. (Adams et al., 2014).

Females introduce a different perspective to these fields (Milgram, 2011). Milgram describes females as more subjective and looking for ways to benefit others. Females appear to look for ways to collaborate and include multiple ideas to solve problems (Riegle-Crumb et al., 2019). As science and engineering fields develop solutions for different challenges, female perspectives can help analyze the benefits of each solution and introduce new ideas that have not been seriously explored before. With different perspectives, problems can be analyzed from different angles, and innovative solutions are explored and utilized.

Even though there have been gains in the representation of females in STEM careers, there is still a disparity between males and females, especially in physical sciences and engineering (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). Females are not entering the STEM fields, specifically the physical sciences, at a pace equal to males or at a rate sufficient to decrease the gap of needed STEM workers for our growing technical society (*Sizing Up the Gap in Our Supply of STEM Workers*, 2017).

To increase female participation in STEM careers, females must reach the professional field through preparation and schooling. The idea of young females leaving the STEM trajectory throughout their schooling is described using the term leaky pipeline (LaCosse et al., 2020; Linnenbrink-Garcia et al., 2018). The problem studied was the influences that strengthen females' will to stay in the pipeline even through difficult and often competitive foundational classes, which are referred to as weeder courses within the STEM culture through the development of solid STEM identity and well-developed specific STEM interest (Carlone, 2012; Kim et al., 2018; Linnenbrink-Garcia et al., 2018). When students enter high school, the focus of the science classes shifts from a general science curriculum with basic principles applied and discussed to a more foundational science curriculum in the three core-specific science areas: biology, chemistry, and physics, where math and science integrate (Papadimitriou, 2004). These foundational courses are essential to building a solid foundation to allow students to delve deeper into more specialized areas of science such as microbiology, virology, electrochemistry, protein synthesis, string theory, etc. However, the foundational courses are not generally presented in application-based settings and are not engaging for most students because the foundational theories and processes are not easily recognizable in everyday life (C. A. Shapiro & Sax, 2011). Shapiro and Sax further explained these foundational courses present theories in isolation and leave the connections between topics and real-life examples to be discovered by the students on their own. The extent to which students can correctly make these connections is seen as a way of measuring ability and competence in STEM.

Furthermore, Shapiro and Sax (2011) describe the majority of the introductory courses as being taught in a way that makes students compete for grades instead of experiencing the collaborative nature of STEM. While the construction of a solid foundation of STEM principles is crucial for future development in STEM, the challenge is developing systems where students, particularly females, are not driven away from STEM. They do not believe they belong because their identity does not match the perceived STEM characteristics.

Many different areas of STEM are not explored in the traditional kindergarten through twelfth grade (K-12) curriculum. These unexplored areas are where many females find their specific STEM interest. According to Adams et al., a critical aspect of developing a personal specific STEM interest is a long-term engagement with "sub-disciplines and interrelated disciplines" (Adams et al., 2014, p. 18). Combining Adams et al.'s idea of specific STEM interest with Hidi and Renninger's Four-Phase Model of Interest develop, I define a personal specific STEM interest as a well-developed personal interest in a particular area of science, not in science as a whole (Hidi & Renninger,

2006) Additionally because specific science interest applies across the domains of science, it is fair to say it applies across the various areas of STEM creating personal specific STEM interest. For instance, a young female may become intrigued with black holes, which may be mentioned for a day or two in a high school physics class and are not covered in any Advanced Placement curriculums (College Board, 2021). Females need to experience the detailed options in the STEM fields, what they explore, and how these fields are examined instead of just the dry theories presented in the classrooms.

The focus of many of the STEM interventions for developing a STEM identity and increasing interest and participation in STEM have been on extracurricular programs outside of the K-12 school system to supplement what is taught in the traditional high school classroom. The intervention and supplemental programs are typically sponsored and hosted by museums, universities, or colleges, often times during the summer months. For example, Adams et al. (2014) explored the effects of long-term participation in the Lang Science program at the American Museum of Natural History. Carlone et al. (2015) studied identity boundary work in the HERP Program funded by the National Science Foundation and supported by the University of North Carolina, Greensboro, which serves "academically promising high school students with significant financial need or no family history of college" (p. 1529). COSMOS is a University of California summer research opportunity for high school students located at four university campuses (*About COSMOS | Jacobs School of Engineering*, 2021). While these STEM interventions and programs are made available to many, even more students do not have the opportunity to participate in these programs due to either cost or location (Papadimitriou, 2004). Many programs target low-income students and provide methods for them to attend. For instance, Techbridge Girls in Oakland, CA, targets low-income females (Techbridge Girls, 2021). COSMOS, previously mentioned, has financial aid packages available for those who qualify (*About COSMOS | Jacobs School of Engineering*, 2021). Students from high-income households have a vast array of programs available because there is sufficient disposable income to pay for and transport students to the programs. However, students from low-middle income families may be left out because the families do not qualify for financial aid and do not have the disposable income to foot the bill for these types of extracurricular programs. Additionally, to participate in such a program may require a family to travel and stay near the program, which may make it difficult for many families due to time and cost.

We must keep females in the pipeline by providing opportunities to develop STEM identity and a well-developed specific interest in a STEM field. Developing a STEM identity, a crucial part of which is developing a personal specific STEM interest and seeing oneself as a scientist or engineer is a key predictor of females persisting through the STEM pipeline and entering STEM careers (Blank et al., 2016; Carlone & Johnson, 2007a; Kim et al., 2018). In addition, by exploring STEM identity, the types of questions that can be explored are modified to focus more on belonging in the STEM fields instead of purely on the ability and interest in STEM (Carlone, 2012; Carlone & Johnson, 2007a; Fraser & Ward, 2009).

While museum and university outreach programs have been found to increase STEM identity (Adams et al., 2014; Carlone et al., 2015) and serve many females, many students (male and female) do not have the opportunity to participate. There need to be opportunities presented within the school system that are easily accessible to students, such as Science Olympiad. Science Olympiad is an extracurricular program where students learn about a variety of areas of STEM and compete in teams of 15 students in 23 different events against other teams. According to the National Science Olympiad organization, all Science Olympiad teams must be associated with and approved by a K-12 school (Science Olympiad, Inc, 2021). Although coaches do not have to be teachers within the school, they must be authorized by the school district and administration according to the Science Olympiad policies. While multiple studies have been conducted to analyze STEM outreach programs provided by universities and museum organizations (Adams et al., 2014; Levine et al., 2015; Levine & DiScenza, 2018), there have been few which have analyzed programs offered by the K-12 school system (Koenig & Hanson, 2008). The studies that have been conducted around K-12 school system extracurricular programs have also not been applications of a larger national program in a specific arena.

Purpose of the Study

Therefore, the purpose of this case study was to explore the role of Science Olympiad in providing a safe place for the development of science identity and personal specific STEM interest in females. This case study will examine several females' experiences in Science Olympiad during their high school years. In addition, the study will investigate how Science Olympiad assists females in their college education and beyond by including alumni of Science Olympiad.

It has been suggested that there are many ways females are encouraged to stay in the STEM fields. For example, good role models that represent the same kind of person they are has been examined and found to be a key factor to combat stereotype threats and provide vision for many females who are currently in the STEM field (Boston &

Cimpian, 2018; Farland-Smith, 2015; Grunert & Bodner, 2011; Levine et al., 2015; Milgram, 2011; J. R. Shapiro & Williams, 2012). Additionally, family dynamics can encourage females to stay in the STEM fields through both examples and expectations (Baram-Tsabari & Yarden, 2008; Boston & Cimpian, 2018). While there are many different influences on why a female continues in STEM fields, there were two main foci investigated, STEM identity and personal specific STEM interest. STEM identity has been shown to encompass the majority of the other influences (Carlone, 2012; Carlone & Johnson, 2007a; Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; Kim et al., 2018). Kim et al. included interest into their model of STEM identity, but developing a personal specific STEM interest also plays an important role in persisting in the STEM fields (Baram-Tsabari & Yarden, 2008; A. Steegh et al., 2021b, 2021a; Stringer et al., 2020; Vincent-Ruz & Schunn, 2018; Wilcox & Lewandowski, 2016). Therefore, this study will explore both STEM identity and personal specific STEM interest.

However, it must be recognized that gender studies are challenging because there are many more factors that influence identity than gender (Carlone, 2012; Fraser & Ward, 2009; Krogh & Andersen, 2013). In fact, one of the greatest critiques of gender gap research is that gender is treated as an all-encompassing quality (Wilcox & Lewandowski, 2016). However, it must be acknowledged that all people are different and one female will have different views and experiences than another female (Holland & Lave, 2009). For these reasons, the study will be using qualitative methods to allow for the individuality of the participants to be presented and it must be kept in the forefront of the discussion that there is significant variance within females as a group.

This qualitative study explored how females developed their STEM identity through a competition-based, extracurricular program run by a public K-12 high school. This case study surveyed and interviewed students who currently participate or who actively participated in Science Olympiad at a Bay Area high school to accomplish this purpose. Participants shared experiences and thoughts on their perceptions of how Science Olympiad influenced their STEM identity and specific STEM interests.

Significance of the Study

This study is important for three reasons. First, Science Olympiad is a growing national organization that is not well studied in the literature. According to its website, Science Olympiad is a national program found in every state in the US. Over 7800 secondary schools have teams registered with the national organization, and most states are divided into several regions (Science Olympiad, Inc, 2021). In addition, the Science Olympiad organization claims to have a higher representation of girls in a national co-ed STEM organization than is typically seen. However, little research has been conducted specifically around Science Olympiad (Sahin et al., 2015). Science Olympiad is a positive experience for students when studied in conjunction with other science competitions (Abernathy & Vineyard, 2001).

Second, finding ways to introduce females to different areas of STEM in conjunction with formal science education can increase female participation in the areas where there is a disparity in female involvement, such as physics, engineering, and computer science. Work must be done to help females interested in these fields continue through the leaky STEM pipeline (Linnenbrink-Garcia et al., 2018). This study explored how a program can encourage girls to enter these underrepresented fields.

Lastly, the competitive nature of STEM is a deterrent to many females, and exploration of how to make competition less intimidating to females in STEM is important (Reuben et al., 2014). The competitive nature of STEM, while it may only be a perception, hinders many females in pursuing STEM (Boston & Cimpian, 2018; Carlone & Johnson, 2007a; Riegle-Crumb, 2017; A. Steegh et al., 2021b). By exploring a program with a competitive element and a higher number of females involved, I aimed to find what aspects of a Bay Area High School's Science Olympiad program were supporting females to build the resilience needed to persist through the most competitive course work on their way through the STEM pipeline.

Theoretical Framework

Researchers have termed the departure of females from STEM-focused majors in college and therefore careers in science as a leaky pipeline (Linnenbrink-Garcia et al., 2018). Multiple constructs have been identified as influencing females staying in the STEM pipeline. The two constructs that weave together to have the most significant influence on females remaining in the STEM pipeline are the development of STEM identity and personal specific STEM interest. By exploring females' perceptions of developing STEM identity and personal specific STEM interests in Science Olympiad, we can continue to deepen our understanding of the characteristics of programs that encourage the development of STEM identity and personal specific STEM interests for females.

Identity

Merriam-Webster defines identity as "the distinguishing character or personality of an individual" (*Definition of IDENTITY*, 1828). While the definition implies that identity is stagnant and has been referred to in the literature as core identity, I will address and refer to the type of person someone is (Gee, 2000). This type of identity must be constructed and is not built in a silo. Others participate in constructing a person's identity (Carlone & Johnson, 2007a). Identity is not one-dimensional, nor is it automatic. According to Gee (2000), identity can be viewed from four different angles. *Nature identity* is developed based on where you are and what you experience in the world around you, such as race. *Institutional identity* is what you are permitted to do and where you exist within social strata such as a university student. *Discourse identity* is how a person is recognized by peers, such as a smart person. *Affinity identity* is based on your groups, such as a Disney fan because you belong to a Disney fan club. While it appears that these identities would each exist in isolation, these four identities intermingle and overlap.

As the idea of science identity has been developed, Gee has taken the idea of the four angles of identity and described and refined them to one specific type: Science Identity or, as I will refer to it, STEM Identity. STEM identity is defined using a threefold model: competence, performance, and recognition (Carlone & Johnson, 2007a) (See Figure 1). Carlone and Johnson suggest competence is looked at in terms of knowledge and applying scientific principles to situations or the brain. According to Carlone and Johnson, competence is not purely learning the basic scientific principles but includes understanding how the principles interrelate and can be used in conjunction with one another to explain phenomena. Carlone and Johnson describe the action part of science identity as performance. When students do actions where they apply principles to solve problems and use scientific tools to predict and explain phenomena, they enact the performance area of science identity (Carlone & Johnson, 2007a). The last component of science identity described by Carlone and Johnson is recognition. Recognition helps students advance in STEM and become more deeply involved in science practices. Carlone and Johnson explain that recognition can come in many external and internal forms and needs to happen repeatedly. Kim, Sinatra, and Seyranian (2018) expanded Carlone and Johnson's three components of science identity to include two more: perceptions of scientists and interest in science careers. With the addition of the two

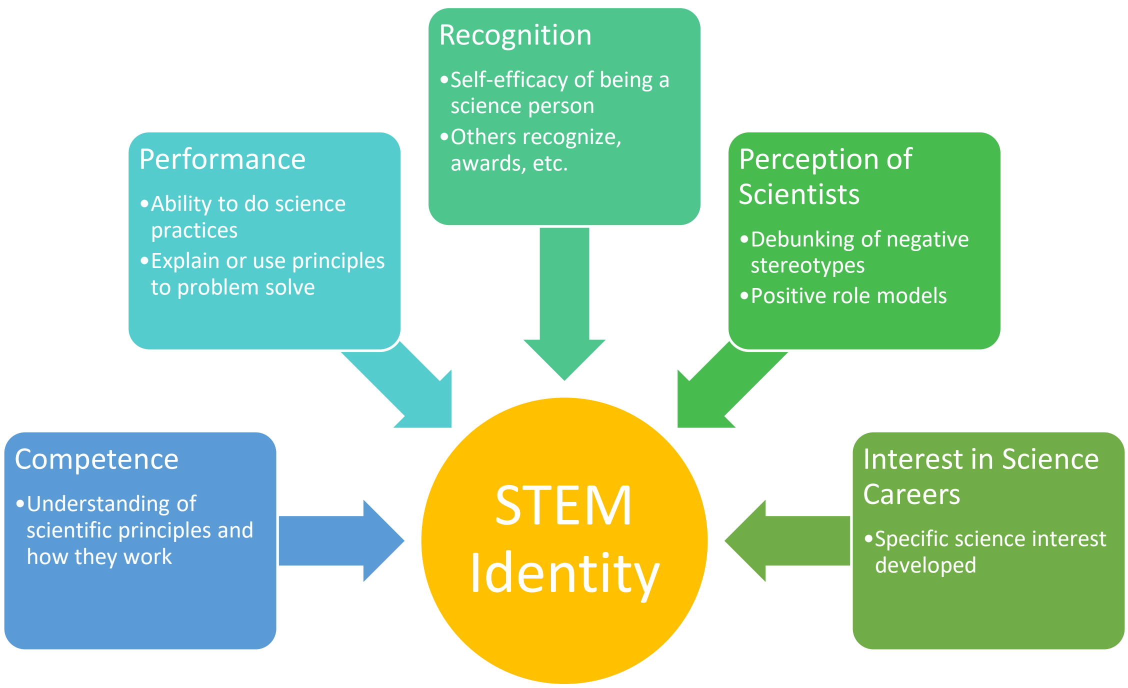

Figure 1. Components of STEM identity based on Carlone & Johnson (2007a) and Kim et al. (2018).

components, Kim et al. (2018) incorporate the need to address females' negative perceptions in STEM and the development of interest in specific areas of STEM.

Interest Theory

Interest theory has not been the main focus of research in female involvement in STEM recently because it has been folded into the model of STEM identity by both

Carlone and Johnson (2007a) and Kim et al. (2018). However, the Four-Phase Model developed by Hidi and Renninger (2006) supports these aspects of STEM identity. Figure 2 shows Hidi and Renninger's Four-Phase Model of Interest theory as it applies to STEM.

Hidi and Renninger (2006) propose that interest goes through four phases of development. Most interest starts in the Triggered Situational Interest Phase. According to Hidi and Renninger, interest is peaked for a moment and then forgotten in this phase. Triggered Situation Interest would be like seeing a picture of a scientific phenomenon as a student flips through a textbook. The student stops and looks at it but then continues to something else and never really goes back to it. When a person reaches phase two, termed Maintained Situational Interest by Hidi and Renninger, the picture referenced above may be part of an assignment in a science classroom. The student spends more time studying the picture or may reference it multiple times throughout a unit. The teacher would be providing questions or information that the student finds engaging. However, this interest does not stick or grow for the student, according to Hidi and Renninger. Once the class or assignment is done, the student no longer returns to the phenomenon. In Phase Three, Emerging Individual Interest, the student returns to the phenomenon independently. Based on Hidi and Renninger's ideas, a student begins to investigate deeper, not just finding what is required for the assignment but also other information they want to know. This phase is where the ideas start to grow and take more root in the mind and become part of the student's identity. The last phase, or Phase Four, called Well-Developed Situational Interest by Hidi and Renninger, is where the competence part of science identity starts to emerge and the area where I will focus my

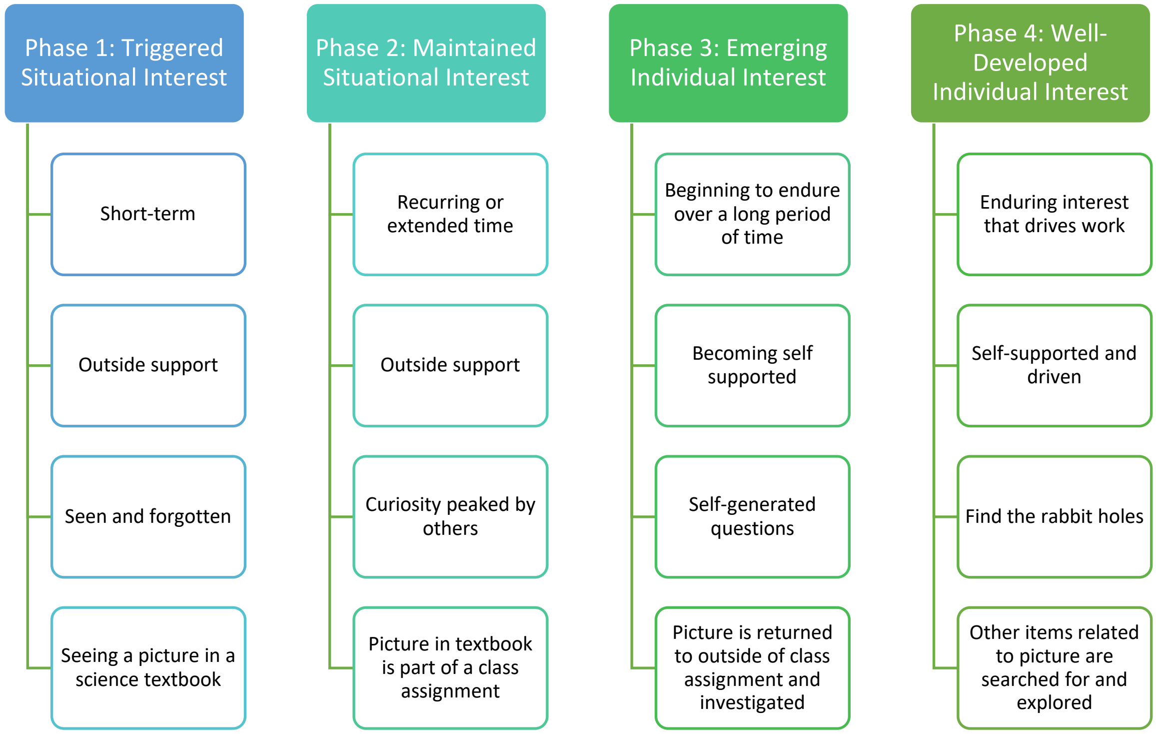

Figure 2. *Four-phase model of interest theory with a STEM focus. Developed based on Hidi & Renninger's (2006) model.*

interest discussion. During this phase, the student would take the phenomenon and begin to investigate how it relates to other parts of science. The student may also see how different laws, theories, and principles apply to this phenomenon. According to the ideas posed by Hidi and Renninger, the student needs no encouragement from others to continue to learn and discover. I will refer to this type of interest as a personal specific STEM interest. The key to this type of interest is the specific nature of the interest. Personal specific science interest is narrower than just STEM in general. It will focus on one area where the student will become engrossed in one STEM area.

Background and Need

As previously stated, there is still a gap in the number of females in STEM careers. However, when STEM achievement is measured, no statistically significant difference has been found between males and females as recently as in the 2018 survey done by the Programme for International Student Assessment (PISA) (Cooper & Heaverlo, 2013; OECD, 2019). When comparing science achievement data by country, only six countries, all located in the Middle East, had males performing at higher levels than females. While in 35 countries, females outperformed males (OECD, 2019). The same PISA survey found that the female students who outperformed males were still less likely to pursue STEM degrees and careers by 12% (OECD, 2019). In fact, in studies where only the highest achieving and brightest children are surveyed, it has been found that there is no gender disparity in who is considered gifted and high achieving (Boston & Cimpian, 2018). But when STEM participation is measured for the same group, the gender gap emerges again (Boston & Cimpian, 2018).

When STEM fields are delineated, an even more pronounced difference in genders is seen. The National Science Foundation data collected in 2019 saw the number of degrees awarded in the United States in all fields slightly favoring women. Also, degrees awarded in Science and Engineering (S&E) overall were very close to even, see Figure 3.

However, when the individual fields within Science and Engineering were examined, a significant disparity emerged (see Figure 4.) While the life science fields, biological and agricultural, had an equitable representation of degrees awarded for females, the physical science, computer science, and engineering fields showed significant discrepancies in equity. Engineering and computer science fields were the most pronounced, with only 22.2% and 19.9% of degrees earned by women, respectively (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021).

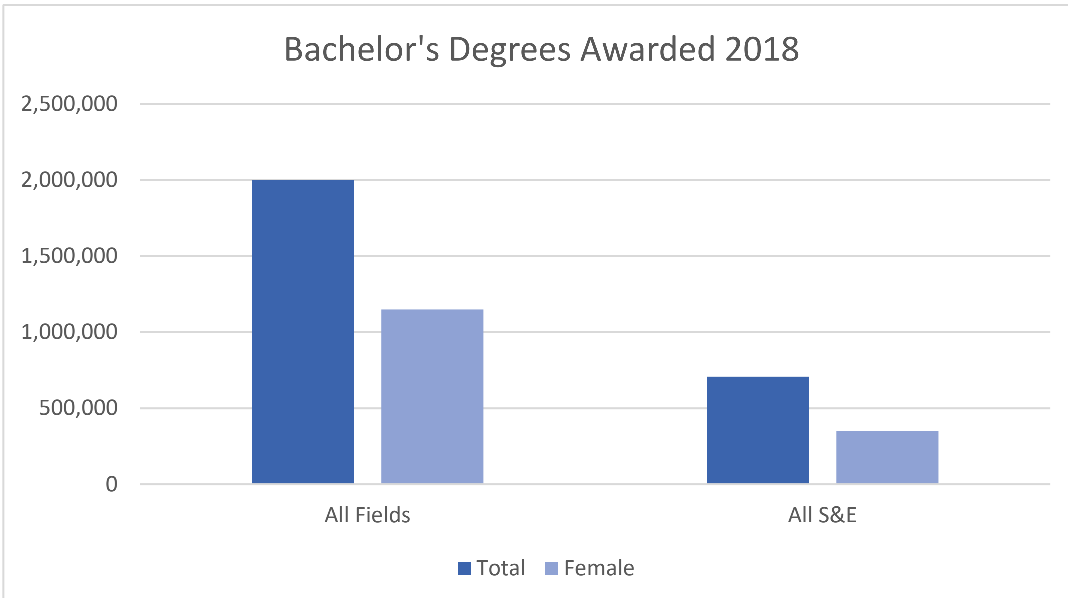

Figure 3. The total number of bachelor's degrees awarded by gender in 2019 in all fields compared to science and engineering.

(Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation, 2021)

This phenomenon is not just seen in the United States or with Bachelor's Degrees awarded. According to the PISA 2018 data, 30% of boys expect to work in engineering or a similar field when examining the highest science achievers, while only 10% of girls have the same expectation (OECD, 2019). When computer science fields are examined in the same group, the same trend is seen and even exacerbated: only one percent of girls compared to seven percent of boys plan to work in information communications technology, including computer science.   However, when looking at the health care

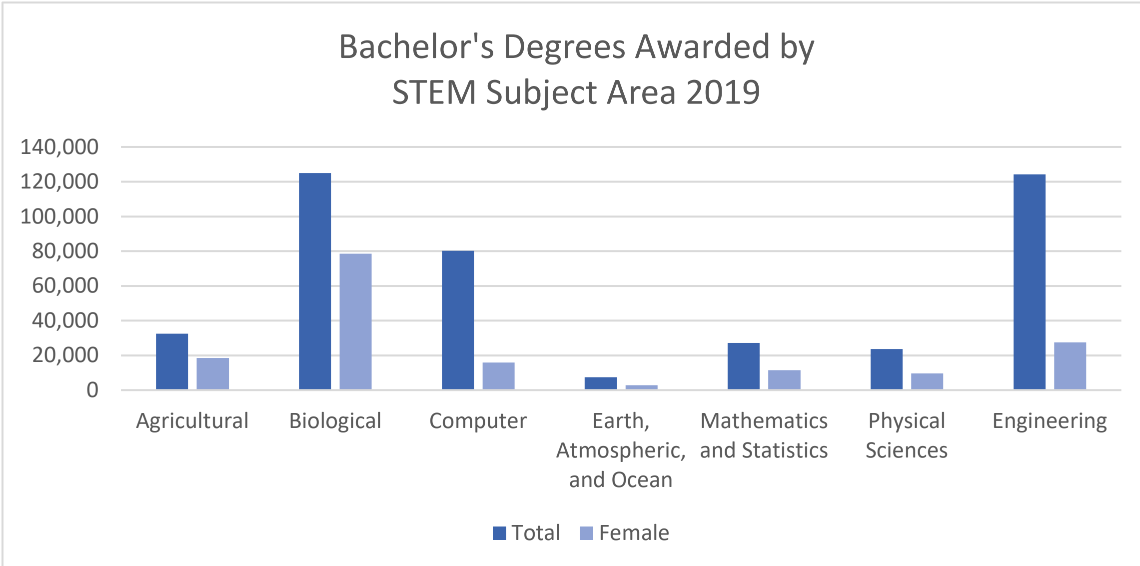

Figure 4. Bachelor's Degrees awarded in STEM in the United States by field in 2019 (Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation, 2021).

fields, 14.2% of boys plan to work in the health care industry while 40.0% of girls plan to work in the same field (OECD, 2019). This trend is possibly due to the altruistic nature of health care professionals, which is more in line with what females typically expressed as an essential aspect of their future professions (Stringer et al., 2020).

While the data presented was for degrees awarded and intentions of international secondary students, similarities are seen throughout every sampled group. Overall, there is a pronounced gender gap in the physical sciences, computer science, and engineering (C. A. Shapiro & Sax, 2011). Fox and Cater project that if there is a continued decrease in the number of STEM prepared graduates and the gender gap in STEM continues to persist, the position of the United States and other countries as STEM leaders will be put in jeopardy (Fox & Cater, 2015).

When females are given opportunities in challenging environments, such as STEM, it has been shown that females do well (Sparks, 2018). They innovate and bring a more diverse perspective to STEM's challenges and problems. While the gender gap is persistent, there is a definite need for females in STEM due to females' assets to each field. As previously mentioned, females' perspectives on STEM fields are different and desirable (Milgram, 2011). Generally, females express more empathy and understanding of social challenges and other situations, while males are more systems-oriented (Baram-Tsabari & Yarden, 2008). Therefore, when a system requires change, males tend to resist that change because of their affinity toward building systems that they perceive as working. However, with only one gender's perspective, these social and physical systems become biased and often less efficient than they could be with other perspectives being included. STEM, science, in particular, is not just a random set of theories that are memorized. Instead, it is a way of critically thinking about problems to explain them and then developing solutions to solve those challenges. Females are more inclined to see how science can help society, therefore, can bring the perspective that can introduce different innovative ways to solve the challenges and possibly even reduce social inequalities (Carlone et al., 2015; Carlone & Johnson, 2007a; Hill et al., 2018; Milgram, 2011). Because females tend to look for the ways that STEM can help society and further progressive development, many females choose to go into science education (Stringer et al., 2020).

Leaky STEM Pipeline

The path students take to arrive at a STEM career is referred to as the STEM pipeline (Linnenbrink-Garcia et al., 2018). Entrance into the STEM pipeline happens at a very early age. As young as nine years old, students begin to assess what they like and do not like and what they are good at in terms of career choices (A. Steegh et al., 2021b). Multiple factors such as media, family, culture, and peers drive much of who belongs in STEM and fits the STEM persona (Carlone et al., 2011). The media more readily portrays STEM people as socially awkward males with a few odd females mixed in, such as in the popular TV show Big Bang Theory (Kim et al., 2018). Seldom are females portrayed in STEM in a more socially promoted light. When females enter STEM fields, the majority choose to work in education and health care instead of the traditional STEM job (Stringer et al., 2020). Females are commonly found in all areas of STEM education, including private and public K-12 schools and corporate training, but not as typically in academia or the university levels (Levine & DiScenza, 2018; Stringer et al., 2020).

When females tend to leave the STEM pipeline

Gender differences in STEM engagement emerge in middle school and widen during high school and the first years of college (Papadimitriou, 2004; Stringer et al., 2020). While in elementary grades, an even number of males and females express interest and intrigue in STEM topics (Papadimitriou, 2004). In addition, multiple studies have not found differences in ability or interest between males and females at any age (Fox & Cater, 2015; Potvin & Hasni, 2014; Riegle-Crumb, 2017; Xie & Shauman, 2003). The lack of difference between genders begs the questions: What begins to happen in middle school and then continues through high school and college? And what can be done to narrow the gender gap?

Middle school, high school, and college are when students begin to examine themselves and decide who they are and what type of person they want to become as an adult (Hill et al., 2018). During this time, peer groups are essential in providing validation for what students are choosing to do with their time and at times see a conflict between STEM perceptions and the perceived social norms, so students turn away from STEM (Archer et al., 2017; Hill et al., 2018). As students enter middle school, they are given a choice in elective courses, and their choices are influenced by their peers and looking for social acceptance (A. Steegh et al., 2021b). In addition to more choice in elective courses, Steegh et al. point to the increase in variety and availability of extracurricular activities for students as a possible source of the gap between males and females in STEM programs and classes emerging and then widening through secondary and post-secondary schooling (Riegle-Crumb, 2017).

When females are interviewed and their trajectory through STEM is examined, high school appears to be a pivotal point in choosing to follow the path toward STEM majors and careers (Hennessy Elliott, 2020; Papadimitriou, 2004; Sparks, 2018). When students are in high school, students are given more course choices to fulfill graduation requirements, and with these choices, students tend to migrate toward courses where they have peer groups where they feel accepted (Riegle-Crumb, 2017; C. A. Shapiro & Sax, 2011). In addition to peer groups, students become more aware of their strengths and weaknesses during high school, equate those to potential abilities, and make course selections based on those perceived potentials (A. M. Steegh et al., 2019). The course selection in high school is imperative for preparation for further course work and major selection in college (Papadimitriou, 2004; Sahin et al., 2015). In fact, according to Shapiro and Sax (2011), the lack of preparation in high school is cited by many as the main reason students do not pursue STEM majors. The lack of preparation is a more significant obstacle for females because they tend to be more hesitant than males to pursue a major where they perceive a lack of preparedness. In addition to feeling underprepared, to begin with, the difficulty of the introductory STEM courses is a major deterrent for females because they feel unable to catch up (Sahin et al., 2015).

While traditional school science classes do not tend to be the primary motivator to stay in the STEM pipeline, school science classes are a source of leaks in the STEM pipeline (Covert et al., 2019; Krogh & Andersen, 2013). While the earlier exposure and promotion of STEM is critical and has shown to be a critical entry point into the STEM pipeline, high school courses can be a central exit point for females because of the integration of science and more advanced mathematics (Fox & Cater, 2015; Papadimitriou, 2004; Tai et al., 2006). Courses in high school are more content-driven and increase intrigue for some females. However, many females leave the STEM pipeline after taking high school biology and chemistry, even though the more STEM courses females take, the more likely a personal specific STEM interest is developed (Gokhale et al., 2015; Papadimitriou, 2004). Physics is a central sticking point because more females leave STEM or avoid physics by specializing in a biology focused area of STEM that does not require physics, so physics teachers and high school counselors must reach out and recruit females to those courses (Archer et al., 2017; Milgram, 2011). The most successful physics programs in maintaining females in their programs are the ones that realize that gender equity does not mean just giving the same classes and opportunities to both males and females. Instead, these programs examine the curriculum and find more inclusive examples of females (Baram-Tsabari & Yarden, 2008; Papadimitriou, 2004).

When females stay in the STEM pipeline through high school, introductory STEM courses in college are another hurdle immediately met. Introductory STEM college courses are commonly referred to as weeder courses because the design and difficulty of the courses discourage students from continuing on the path through STEM majors in college if they do not have an acceptable performance (Nelson Laird et al., 2007; C. A. Shapiro & Sax, 2011). These introductory courses are commonly graded on a strict curve which encourages competition and discourages collaboration, a hallmark trait of STEM work (C. A. Shapiro & Sax, 2011).

Why females leave the STEM pipeline

While there has been positive movement in the STEM pipeline for females, such as more female children representing their gender when asked to draw a scientist (Boston & Cimpian, 2018), the pipeline still leaks females more readily than it should. The factors that help females stay in the STEM pipeline are not well understood (Carlone & Johnson, 2007a). Many attitudes and experiences are said to contribute to the exit of females from the STEM pipeline.

As previously stated, researchers have explored many causes for the disparity between genders in the STEM fields. First, there is a lack of role models for females currently in the field (Levine et al., 2015). Without various role models, it is tough to break into a field that appears one-dimensional in terms of gender. In addition, this leads to a feeling for many females that they cannot break in and do not have the ability or knowledge to do so (Baram-Tsabari & Yarden, 2008; Levine et al., 2015). Then there are the perceptions of what a scientist does and looks like (Archer et al., 2017; Baram-Tsabari & Yarden, 2008; Boston & Cimpian, 2018). Parent belief systems add to females questioning whether they can enter the fields, leading to lower self-efficacy (Baram-Tsabari & Yarden, 2008). In addition, the atmosphere of the STEM fields has been commonly described as chilly (Dabney & Tai, 2014). Not only does the STEM field feel unwelcoming to many females, but the perception of a low life-work balance is also disheartening. Females are generally the ones responsible for the primary care of dependents, both children and the elderly, in a family. With the feeling that work must be the focus, females in STEM are torn between the rigors of scientific discovery and family obligations (Grunert & Bodner, 2011). Not one cause has been settled upon as a root cause, but instead, the many reasons are seen in combination.

Stereotypes of STEM. A stereotype is defined as a widely held view that has been simplified by others (J. R. Shapiro & Williams, 2012). Stereotypes exist in positive and negative forms and, in general, are very difficult to alter, especially at a large scale (A. M. Steegh et al., 2019).

Many negative stereotypes of people who pursue STEM fields do not promote a positive female environment. Society has commonly labeled people in STEM fields as "nerds" who have very little social EQ (Farrell & McHugh, 2017). Popular TV shows like "The Big Bang Theory" and movies dating back to the 1960s like "The Absent-Minded Professor" have portrayed scientists and engineers as masculine and socially awkward. The shows and movies do not generally portray female scientists with socially accepted female traits, reinforcing that STEM is masculine (Farrell & McHugh, 2017). These portrayals influence the view of STEM professionals by young females (Li & Orthia, 2016; Weingart, 2007). The challenges are in the overall portrayal of the characters and how they deal with conflict and who comes out on top when a conflict arises (Carlone, 2012). Carlone continues that it is also researchers that contribute to the challenge of the persona of STEM by simplifying the definitions of a STEM person and the science practices. With a very narrow view of what a scientist looks like, many females who do not feel that they fit the STEM persona are deterred from studying STEM and pursuing a STEM career (Farrell & McHugh, 2017; Hill et al., 2018; Holland & Lave, 2009).

For females in STEM fields, stereotype threats can make them question whether they belong in the field (Hill et al., 2018). There are many females, like other minorities, in STEM who feel they represent all females in STEM and a sense of pressure to break the stereotypes (Boston & Cimpian, 2018; Hill et al., 2018; J. R. Shapiro & Williams, 2012). This pressure to break these stereotypes is not invigorating, nor does the pressure typically lead to positive outcomes. Instead, we often observe the opposite effect, and females do not perform as well and also find themselves with lower self-efficacy (Boston & Cimpian, 2018; J. R. Shapiro & Williams, 2012; A. Steegh et al., 2021b; A. M. Steegh et al., 2019). Shapiro & Williams (2012) conducted a study with Advanced Placement Calculus AB students varying the timing of indicating their gender. One group of students was asked their gender before the exam, and the other was asked after the exam. Females asked their gender after the exam scored 33% higher than those asked before the exam (J. R. Shapiro & Williams, 2012). The pressure to overcome stereotypes accentuates the desire and need to outperform males. This undue added pressure becomes an adverse reaction for many females who may already doubt their abilities (Boston & Cimpian, 2018). However, according to Shapiro and Williams (2012), stereotype threat does not always lead to less motivation and performance; sometimes it has the opposite effect, but it always increases pressure, producing distracting thoughts.

Stereotypes are still prevalent today in many places, especially influential ones. For example, in a 2017 qualitative study, a young European lady described her experience at a career fair:

> I came in for like my careers day and looked around everywhere and I wanted to be like approached by like science colleagues and stuff [but a woman came up and said to her] 'Well you look like you'd like to do beauty, young lady.' I was like, 'I thought you might say that. I don't want to do beauty.' Because I know it sounds horrible to everyone who's done beauty, but when I think of beauty, I just think of someone who messed up their GCSEs and had to do that (Archer et al., 2017).

In this experience, the young lady was presented with the reinforcement that females should not have a traditional female look to enter STEM fields and be accepted within those fields. Unfortunately, the experience described above is not an isolated instance, and many females have reported similar experiences (Archer et al., 2017; Grunert & Bodner, 2011; Levine & DiScenza, 2018). Archer (2017) reports that some females feel they must become more "tomboyish" to fit into the STEM environments, specifically physics and engineering fields.

Social cues, like the one the girl received in the example above, are another source of negative stereotypes for many females because humans are a social species that looks for acceptance (Boston & Cimpian, 2018). In the analysis of social cues done by Boston and Cimpian, they note several seemingly benign acts can be significant deterrents for females continuing in STEM. Boston and Cimpian found even a small side comment overheard by females as young as first grade can deter them from participating fully in STEM activities. Even how teachers partner students in a classroom can lead to a feeling of inadequacy (Boston & Cimpian, 2018). Additionally, a teacher's offer of unsolicited help can be perceived as a negative stereotype (Graham & Barker, 1990). Exploring the early research from Graham and Barker, Boston and Cimpian (2018) found that an offer of help can deter females. Suppose females feel they are being offered unsolicited help because the subject is too hard for them. In that case, they accept the stereotype that females lack the intellectual ability to do STEM (Graham & Barker, 1990). With the offer of help, feelings of self-doubt and inadequacy within this field of brilliance are confirmed (Boston & Cimpian, 2018). Boston and Cimpian found many low-level environmental and social cues are sent to young females. Each of these cues, even though small, is compounded in many young female minds.

Though stereotypes can be overcome and the pressures of stereotypes may not affect all females, many succumb to the pressures and perform at levels lower than their abilities. The best way to rebuff these stereotypes is through self-affirmation (J. R. Shapiro & Williams, 2012). Building confidence and therefore developing a STEM identity is crucial to keeping females in the STEM pipeline (Adams et al., 2014; Archer et al., 2017; Carlone et al., 2011; Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020).

Culture of STEM. Not only do the stereotypes of the people who belong in the STEM fields deter females from participation, but also the culture of the disciplines themselves are a deterrent. The prevalent culture of STEM is more attractive to males partly because there are more males in the field (Dabney & Tai, 2014). In 2012, females in academia for chemistry was only 18% (Levine et al., 2015). According to Levine et al. (2015), it is very common to find no females on the chemistry faculty at universities and colleges throughout the country. If there are females on the chemistry faculty, there are only one or two. STEM Advanced Placement (AP) courses tend to be more male-dominated at the high school level. In 2019, 58% of the AP exams were taken by females, yet for the AP STEM exams, only 48% were taken by females (*Class of 2019 | AP Results*, 2020). According to College Board data, when excluding biology and environmental science, where female representation is on par with overall participation, the female participation rate for AP STEM exams drops to 42%. On the extreme end is AP Physics and AP Computer Science, where only 35% and 25%, respectively, of exams, were taken by females (*Class of 2019 | AP Results*, 2020). Like anyone, females are drawn to areas where there are others like them. Since females are not highly represented in academia, the message is sent, intentional or not, that they do not belong and therefore do not achieve at their ability (Levine & DiScenza, 2018). In addition, STEM is portrayed as highly masculine and even more white and male, where you have to prove yourself as capable to be accepted (Boston & Cimpian, 2018; Carlone & Johnson, 2007a; Farrell & McHugh, 2017; Kim et al., 2018). According to Archer et al. (2017), the answer to changing this culture may not just be getting more females into the fields because the issues begin well before career entry.

In the college setting, STEM has been known to be very competitive and even described by some as “cutthroat” (Adams et al., 2014; Riegle-Crumb, 2017; Riegle-Crumb et al., 2019, 2019; C. A. Shapiro & Sax, 2011). Several studies have shown that females have a lower inclination toward competition and prefer more collaborative systems (Buser et al., 2014; Kleinjans, 2009; A. Steegh et al., 2021b). Introductory college STEM courses are often described as courses where competitiveness is taken to the extreme that if one person succeeds, another cannot (Carlone & Johnson, 2007a). In addition, these same courses are known to be taught by very unfriendly and unapproachable professors who do not commonly promote mentorship (Carlone & Johnson, 2007a; C. A. Shapiro & Sax, 2011). Additionally, STEM classes, and therefore those that take them, are commonly referred to as the smart people classes (Farrell & McHugh, 2017). Unfortunately, there is a view that to contribute to the STEM fields, a person has to be brilliant and the smartest in the room (Nealy & Orgill, 2020). Neally and Orgill (2020) claim this feeling of only the best, with no room for average, being able to succeed is a significant deterrent to minorities in STEM, including females. Among the STEM community, discussions have begun to occur about who can and should be doing STEM to combat this idea, but it is still prevalent, especially among young people (Archer et al., 2017).

One major challenge within the culture of the STEM fields is a perception of its incompatibility with being feminine and family. Grunert and Bodner (2011) state, "The fact that these women want fulfilling family lives in addition to their careers and want to retain their femininity and feminine qualities, but feel that is at odds with a chemistry research career, poses additional problems." (p. 299). Grunert and Bodner explain there is a continued perception that academia and STEM research is a time-consuming process that involves the sacrifice of family and self-care. Due to these perceptions, females do not readily see themselves fitting these characterizations (Grunert & Bodner, 2011;

Papadimitriou, 2004; C. A. Shapiro & Sax, 2011). Additionally, females feel they have to alter their beliefs and attitudes to fit into the STEM world, and those that do fit in the STEM world are not socially desirable (Baram-Tsabari & Yarden, 2008; Grunert & Bodner, 2011; Papadimitriou, 2004; C. A. Shapiro & Sax, 2011). Even though there are more female scientists now conducting research, and much of what is accepted in the STEM workplace has changed, many of the perceptions and expectations of research have not changed and have even become more demanding, so many females believe they have to choose between STEM and being female (Archer et al., 2017; Grunert & Bodner, 2011).

Implicit Bias. Even in today's world, gender bias is still observed in STEM. In a study by Sparks (2018), two-thirds of African American female participants reported more instances of sexism than racism. Even though blatant biases are not commonly seen in most areas, implicit gender bias regarding STEM fields has been reported in 34 countries (Farrell & McHugh, 2017). In addition, systematic implicit gender bias has been reported within the STEM field in multiple studies (Moss-Racusin et al., 2012; Reuben et al., 2014; Schmader et al., 2007; Steinpreis et al., 1999; Trix & Psenka, 2003). Farrell and McHugh (2017) report 34 countries still associate males with science and females with the arts. In addition, several studies have found that females feel they had been treated differently in their STEM courses in grading, classroom activity participation, and other areas (Seymour & Hewitt, 1997; C. A. Shapiro & Sax, 2011; Wasburn & Miller, 2004). Specifically, females report that the climate in some of their STEM courses is unwelcoming and unaccepting of females (Carol L. Colbeck et al., 2001; C. A. Shapiro & Sax, 2011). While these biases are small and not recognized by many, they are still damaging (Archer et al., 2017; Boston & Cimpian, 2018; Farrell & McHugh, 2017; Hill et al., 2018; Papadimitriou, 2004). Gokhale (2015) states, "Discrimination persists because of the accumulation of small disadvantages, rather than the existence of blatant sexism." (p. 515). Microaggressions and negative feedback against women are common within STEM, portraying a white male-dominated culture (Adams et al., 2014; Archer et al., 2017; Grunert & Bodner, 2011; Levine & DiScenza, 2018; Linnenbrink-Garcia et al., 2018). Girls must build and establish a defense against these aggressions to persevere in STEM majors and establish STEM careers.

Why females stay in STEM

Many factors influence adolescent females' decisions as they choose their paths into adulthood that can be amplified or hindered by family, mentors, and schools (Carlone et al., 2011). Perseverance in the STEM pipeline for females is not directly linked to intelligence; instead, STEM identity development and motivation are more critical (Covert et al., 2019). While there are many motivation theories, interest development will be the primary focus in this dissertation, as presented by Hidi and Renninger (2006).

STEM Identity

Identity is not just a set of characteristics a person holds (Krogh & Andersen, 2013). Identity is much more complex. Describing identity as a sense of self is also too narrow to encompass all aspects of identity (Carlone, 2012). Identity is defined as how one feels about themselves, the actions they take due to how they feel about themselves, and how the world around you views your actions and roles (Carlone & Johnson, 2007a; Carter & Mireles, 2015; Fraser & Ward, 2009; Garcia et al., 2018; Holland & Lave, 2009). Holland and Lave (2009) describe identity as a conversation between internal beliefs and perceptions and how the world sees the person. Identity is commonly associated with what groups a person associates with; however, Sparks (2018) suggests that personal identity is separate from group identity even though personal identities are commonly similar to group identities. The similarity comes from a human desire to be part of a group, so a person becomes more committed to the group, and their identity more closely resembles the group identity (Avraamidou, 2014; Carlone, 2012; Carter & Mireles, 2015; Stets & Burke, 2000).

Group identity is a social identity because social identity refers to how you fit in a group, defined by the group and by self (Carter & Mireles, 2015; Stets & Burke, 2000). Membership in a group is dependent on two distinct aspects: the behavior and attitudes of the group and personal identification with the group (Stets & Burke, 2000). According to social identity theory as presented by Stets and Burke, a person does not have just one identity; they have several in a hierarchy. According to the situation, one identity will become more prominent to guide actions and reactions. The balance between group acceptance and the person acting and thinking in a particular way to be accepted by the group is delicate, according to Stets and Burke (2000). The dynamics of social identity are complex due to this balance, and there are many aspects to a person with each element required to make an individual (Kim et al., 2018). STEM identity is considered a type of social identity (Carlone, 2012; Carlone & Johnson, 2007a; Kim et al., 2018). It is important to distinguish between STEM identity and STEM ability (Hill et al., 2018).

Through the last two decades, the focus on the retention of females in STEM has turned to the development of STEM identity due to studies repeatedly showing no gender difference in STEM ability at any age (Archer et al., 2017; Boston & Cimpian, 2018; Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; Fraser & Ward, 2009; Riegle-Crumb, 2017; Xie & Shauman, 2003). STEM identity is not being a person who is interested in STEM or necessarily has high STEM ability or being a STEM person. Instead, STEM identity includes the social structure of STEM, the employment of science practices in a natural and not forced way, a well-developed interest, and expectancy-value (Hill et al., 2018; Kim et al., 2018; Vincent-Ruz & Schunn, 2018). Because STEM identity is seeing oneself as a STEM person and belonging to the STEM group, stereotypes play into identity development by influencing self-views of the capacity to see oneself as a scientist, which has been suggested as the most significant predictor of STEM identity (Blank et al., 2016; Kim et al., 2018; Vincent-Ruz & Schunn, 2018).

As the focus of females in STEM research has turned to explore the development of STEM identity, the questions asked have changed. The focus has changed to examine the female herself within the context of what is going on around her and how these outside influences affect her as a learner, as a scientist, and as a community member (Carlone, 2012; Carlone & Johnson, 2007a; Fraser & Ward, 2009; Kim et al., 2018). Researchers have modified these questions to become less concrete (Carlone, 2012). Carlone (2012) posits that one way to answer these questions is by constructing and analyzing females' stories in STEM. As we begin to understand how identity is developed, we can see how females make choices as they persist through or exit the STEM pipeline (Krogh & Andersen, 2013).

Membership in a group is imperative for STEM identity development. Using the lens of identity, we acknowledge the group aspect of science learning and STEM belonging (Adams et al., 2014; Carlone & Johnson, 2007). With this group identity, Adams suggests that it is easier to withstand the negative stereotypes and sexism in STEM, making it easier to persist through the STEM pipeline. Boston concurred with Adams adding the importance that a sense of belonging is imperative for females to stay in STEM fields (Boston & Cimpian, 2018). Archer suggests the internalization of the social and group ideas of STEM identity will produce the accepted science practices according to Bourdieu's theory of social reproduction (Archer et al., 2017). Carlone and Johnson (2007) also described a similar idea when describing the anthropological ideas of cultural production.

Each time a female makes a choice, identity can be activated. According to Carter and Mireles,

> When an identity is activated in a situation, an internal feedback loop comes under an individual's conscious control. Individuals seek to verify their identities by controlling perceptions of self and others during an interaction. They feel positive emotions when they verify their identities; they feel negative emotions when they cannot verify their identities. (Carter & Mireles, 2015, p. 2)

A female's STEM identity trajectory is inconsistent and is described as "fragile" (Carlone & Johnson, 2007a; Nealy & Orgill, 2020; Vincent-Ruz & Schunn, 2018).

STEM identity development is not immediate. It is a process that builds with small activities over time, sometimes even generations of time (Carlone et al., 2015;

Carlone & Johnson, 2007a). Because STEM identity is fluid and takes time to develop, it is difficult to determine exact methods to develop a STEM identity (Carlone et al., 2015). However, three ideas are prominent in STEM identity development. First, a community on a similar trajectory is needed (Carlone & Johnson, 2007a). Second, science interests and attitudes will contribute to STEM identity development (Aschbacher et al., 2010; Vincent-Ruz & Schunn, 2018). And lastly, there must be a correlation between what is happening in the school curriculum and what is seen in the real world (Archer et al., 2017).

Carlone and Johnson (2007) described STEM identity as having three components: competence, recognition, and performance. Kim et al. (2018) added two more components: perception of scientists and interest in STEM careers. Each of these components is of equal value, cannot be looked at in isolation, and overlap (Carlone & Johnson, 2007a). There is a significant interplay between the five areas, and all five must be developed in conjunction. When all of these five components are developed, females are more apt to feel a sense of belonging and acceptance within the STEM community (Kim et al., 2018).

As previously stated, STEM identity is constantly under construction and very individual, especially for females (Carlone et al., 2015; Carlone & Johnson, 2007a; Kim et al., 2018). According to Carlone (2015), learning and teaching STEM is part of the evolution of STEM identity because learning and identity formation are very closely related. Due to this close relationship between learning and STEM development, teachers can encourage or discourage STEM identity development (Hill et al., 2018).

Learning is not just a cognitive process but also an emotional process, and the emotions in a situation can profoundly influence identity development, especially STEM identity development (Carlone et al., 2015). Holland and Lave (2009) stated,

> Building on Vygotsky, we conceptualize personal identities as psychological formations, in this case, as complexes of memories, sentiments, knowledge, and ideas of environmental action that one can evoke via cultural symbols of identity to organize oneself for environmental action. Viewed in this way, one's identities, once they become entrenched in history-in-person, provide a ground for agency both in guiding one's behavior in cultural activities and in avoiding behaviors that are not compatible with the self-assigned identity. (p. 8)

Students experience STEM by doing STEM activities, and while learning STEM concepts, they are also developing a STEM identity (Adams et al., 2014). The emotional component of developing a STEM identity can be evoked as students participate in STEM activities (Morton & Parsons, 2018. According to Vincent-Ruz and Schunn (2018), males tend to participate in initial to moderate level STEM identity developing activities more than females. However, they also found that females participate more deeply once they are in these activities, and their STEM identity increases (Vincent-Ruz & Schunn, 2018). The challenge is that not a lot of research has been done about what in these activities is affecting the growth of STEM identity (Nealy & Orgill, 2020).

STEM interest

Even though STEM identity includes the development of interest in STEM, the development of personal specific STEM interests warrants a separate discussion because becoming interested in new ideas is part of an evolving identity (Carlone, 2012). Carlone (2012) suggests that STEM identity can be strengthened or weakened as interest changes over time. Additionally, Carlone (2015) specifically points out the need to explore interest in conjunction with identity because the two go hand in hand. Kim et al. (2018) specifically included interest development in careers in their expansion of the components of STEM identity.

Vincent-Ruz and Schunn (2018) and Stringer et al. (2020) have suggested interest is the primary motivation to begin to build a STEM identity. Additionally, learning and achievement are strongly correlated to interest, especially in chemistry and physics (Baram-Tsabari & Yarden, 2008; Cahill et al., 2018; Jansen et al., 2016; A. Steegh et al., 2021b; Wilcox & Lewandowski, 2016). Since interest is such a vital part of putting females on the path to developing a strong STEM identity, developing interest needs to begin at a young age and then cultivate as a female goes through all the developmental stages, especially adolescence (Baram-Tsabari & Yarden, 2008). Unfortunately, declines, not increases in STEM interest, have been seen in middle and high school for females while males tend to show increases (Baram-Tsabari & Yarden, 2008; Cooper & Heaverlo, 2013; Sahin et al., 2015). Cooper and Heaverlo (2013) suggest the decline in STEM interest is due to a lack of confidence and a positive attitude, while Papadimitrou (2004) cites a lack of opportunities for females to continue building science interest.

Additionally, Steegh et al. (2020) found that gender stereotypes have a more significant influence on STEM interest for females than males. Cooper and Heaverlo (2013) suggest that exposure to collaborative, design thinking, and problem-solving in STEM increases females' interest in STEM. Carlone and Johnson (2007) point out that short, quick exposures to these processes and ideas in STEM are not enough to develop a prevailing STEM interest or identity. Adams et al. (2014) posit that long-term engagement is the key to helping females obtain a well-developed interest in STEM subjects and pursue STEM careers. This long-term engagement is typically done through extracurricular activities. However, Cooper and Heaverlo (2013) question whether the involvement in the extra-curricular activity is because of the interest or whether the interest emerges from involvement. This relationship needs to be investigated further.

STEM Extracurricular Activities

While positive school STEM experiences are critical, Krogh and Anderson (2013) have pointed out that the school experience does not appear to be the primary motivator to staying in the STEM pipeline. Therefore, extracurricular STEM experiences are fundamental in developing STEM identity and a well-developed interest (Sahin et al., 2015; A. M. Steegh et al., 2019; Wade-Jaimes et al., 2019). Extracurricular activities are semi-formal learning spaces where students are provided more choice to participate and learn (Hennessy Elliott, 2020; Wade-Jaimes et al., 2019). Typically, extracurricular learning spaces are socio-cultural learning spaces, which acknowledge the involvement of emotions and value development, a fundamental aspect of STEM identity development (Carlone et al., 2011). Extracurricular STEM activities can and should be structured as safe places to explore STEM (Wade-Jaimes et al., 2019). Wade-Jaimes et al. (2019) described well-designed extracurricular STEM spaces as communities of practice that foster skills, provide opportunities to experience STEM in action, learn how STEM tools work, build leadership, and construct a feeling of empowerment. Empowerment in STEM can help students increase STEM interest and develop a more substantial commitment to pursuing STEM (Wade-Jaimes et al., 2019). The most impactful STEM extracurricular programs create fond memories and are long-term (Adams et al., 2014).

In extracurricular STEM experiences, students commonly provide the needed space to experience different STEM areas that are not traditionally taught in school (Adams et al., 2014). These outside the classroom experiences typically are learning by doing models that are more effective in developing STEM identity and deep specific interest (Elmesky et al., 2006; Fox & Cater, 2015). In addition, the science learning in the extracurricular atmosphere provides the students with more choice by presenting challenges that the students figure out how to solve so the students can see the value in their personal life (Carlone, 2012; Hill et al., 2018; Papadimitriou, 2004).

Several key benefits come from learning in a less-structured extracurricular environment. First, students find joy in learning for something other than just a grade in a class (Abernathy & Vineyard, 2001; Covert et al., 2019). Abernathy and Vineyard (2001) saw students more commonly reported liking to learn things outside of the classroom, while Covert et al. (2019) reported students asking questions driven by a desire to develop a more robust understanding of the subjects. Secondly, students are provided with a safe space to try new things, referred to as identity boundary work (Boston & Cimpian, 2018; Carlone et al., 2015). Carlone et al. (2015) point out that it is imperative that when students are working in these new areas that ideas and practices are introduced slowly but with sufficient responsibility to be fully engaged in the practices. Then responsibility and experiences are increased shortly after so the student sees the progress. Lave and Wenger (1991) explained that students with more experience are examples of fully participating and engaging in an activity (Hennessy Elliott, 2020). The key to identity boundary work is learning by doing something new, and in this situation, students are more likely to see themselves as scientists or engineers (Hill et al., 2018). This idea brings another critical benefit; students can experience how STEM fields work (Hennessy Elliott, 2020). Students see collaborative work in problem-solving as more authentic to how STEM fields work and are the basis of good STEM instruction (Cooper & Heaverlo, 2013; Hennessy Elliott, 2020). As student experiences become more problem- and design-based, they are more likely to see themselves as budding scientists and engineers (Nealy & Orgill, 2020; Stets et al., 2017). The question that does still need to be explored further is whether females are attracted to the extracurricular programs because of the collaborative problem-solving aspects or if they become interested in the collaboration and problem solving because of the extracurricular activity (Carlone & Johnson, 2007a; Cooper & Heaverlo, 2013; Stringer et al., 2020). Lastly, in extracurricular programs, the boundaries of who belongs in STEM can be stretched and broken in long-lasting ways (Hennessy Elliott, 2020; Stringer et al., 2020). Hennessy Elliot (2020) pointed out that this boundary-stretching happens, even more when the students are in charge with adult support. In addition, Kim et al. (2018) explained that male peers, parents, and teachers could also learn how to be an upstander in these informal, extracurricular spaces and stop the roadblocking females' experience in STEM fields.

One major challenge in extracurricular STEM programs is female involvement (A. Steegh et al., 2021a). According to the 2016 PISA data, males are more likely than females to participate in STEM extracurricular activities (A. Steegh et al., 2021a).

However, STEM extracurricular activities have shown a much stronger influence on females in terms of motivation and confidence-building (Stringer et al., 2020).

Extracurricular experiences can range from school clubs to formal museum, nonprofit, or college outreach programs to simple television programming and social media. The most common extracurricular experience that reaches most children and adolescents are television programs and social media (Papadimitriou, 2004). As of March 2018, 75% of adolescents have at least one active social media account (American Academy of Child and Adolescent Psychiatry, 2018). However, according to Papadimitriou, the challenge with television programs and social media is the lack of hands-on experiences. As children age, they tend to choose other types of entertainment in place of educational entertainment, specifically STEM-focused entertainment. Therefore, if other opportunities do not arise aside from television programs and social media, science interests dwindle (Papadimitriou, 2004).

When museum, nonprofit, or college outreach programs are available, STEM interests are cultivated and continue to grow over time (Wade-Jaimes et al., 2019). Even after just a one-day hands-on program, female students reported higher interest in STEM overall (Levine & DiScenza, 2018). According to Adams et al. (2014), when programs are over an even longer time of weeks to years, students describe the programs as memorable and influential in their life choices. At the American Museum of Natural History, a multi-year program called Lang Science Program, participants described the program as a second home (Adams et al., 2014). In a review of the Lang Science Program by Adams et al. (2014), the students explain they have developed a network of support that combats the challenges females feel as they enter STEM fields. In addition, the students in the report describe science as their comfort subject. Students from another program, the Herpetology Research Experience (HRE), studied by Carlone et al. (2015), described their program as “familial, collaborative, and caring” (p. 1530). As previously explained, adolescents, specifically adolescent females, are more likely to look for identity validation. Social support is critical to seeing themselves as scientists and developing a strong STEM identity (Hill et al., 2018). However, the challenge is maintaining STEM identity outside of the extracurricular programs since females struggle to maintain the developing STEM identity when they are not actively participating in the program (Wade-Jaimes et al., 2019).

However, Adams et al. (2014) explain that most extracurricular programs have two fundamental challenges. First, tracking students over time and documenting the program’s effect is nearly impossible, especially for short one- or two-day programs. Secondly, the reach of the programs is not as broad as anyone would like. Students who live in areas where the programs are few and far between, such as rural America, may not be afforded these opportunities to develop their interests. In addition, the majority of these programs are either expensive or offered to low-income and/or at-risk students, leaving out middle-income students. For instance, in California, four University of California campuses have the COSMOS program, where students participate in engaging, hands-on STEM experiences with university personnel and their current, active research. This program’s tuition is $2117 for California residents and $4500 for Non-California residents (*About COSMOS | Jacobs School of Engineering*, 2021). There is an extensive middle-income group of students not being served by these programs; therefore, all STEM exposure rests in the arms of the public school systems and the curriculum and programs presented there (Papadimitriou, 2004). In addition, multiple studies have shown public school teachers are the most common and influential role models for students in STEM (Brown, 2002; Desy et al., 2011; Papadimitriou, 2004; C. A. Shapiro & Sax, 2011). Teachers can reinforce or destroy gender stereotypes (Archer et al., 2017). Teachers personify STEM subjects, and based on these perceptions and the interactions females have with their teachers, females either see themselves fitting into the discipline or not (Papadimitriou, 2004; C. A. Shapiro & Sax, 2011). Because teachers can be influential, this shows a need to develop robust programs in schools with teacher support, like Science Olympiad, that provide more opportunities for females to develop enduring STEM identities and well-developed interests. In addition, the literature lacks application of these STEM identities and personal specific STEM interest into K12 extracurricular program design (Fox & Cater, 2015; Wade-Jaimes et al., 2019).

STEM Competitions

As previously discussed, STEM identity has five components: competence, performance, recognition, perception of scientists, and interest in science careers (Carlone & Johnson, 2007a; Kim et al., 2018). STEM competitions are an extracurricular activity that can address these areas of STEM identity, and students generally report positive experiences in STEM competitions, such as Science Olympiad (Abernathy & Vineyard, 2001). Many STEM competitions are designed to help students apply theories to solve problems and critically think about societal problems while proposing solutions to develop competence and perform STEM processes (Carlone, 2012). Steegh et al. (2021b) found students' persistence in STEM competitions was most strongly correlated to topic interest and feelings of competence. While non-competitive programs have also shown increased competence and interest, the increase is different and not always accepted within the STEM community (Fox & Cater, 2015). The area of STEM identity that affects STEM paths directly has been recognition (Carlone & Johnson, 2007a). According to Carlone and Johnson (2007a), recognition is not just a one-and-done action. Recognition must be consistently reinforced. STEM competitions are one way to introduce recognition repeatedly. Based on Carlone and Johnson's findings (2007a), this recognition does not need to be specifically winning awards, but also participating and qualifying to be part of the competition is seen as a form of recognition. Another critical area of STEM identity is interest in science careers. Participating in STEM competitions has been shown to positively correlate with pursuing STEM degrees, especially with females (Buser et al., 2014; Correll, 2001; Riegle-Crumb, 2017; Riegle-Crumb et al., 2019; A. Steegh et al., 2021a; A. M. Steegh et al., 2019).

Even though females have shown a positive correlation between participation in STEM competitions and STEM identity, specifically pursuing STEM degrees, females are not typically inclined to participate in a competition (Reuben et al., 2017; Riegle-Crumb, 2017; Riegle-Crumb et al., 2019; A. Steegh et al., 2021b). In the PISA 2018 survey, 64 of 79 countries, including the US, found that females had an overall negative attitude toward competition (OECD, 2019). In the survey, females in the US had a slightly better attitude toward competition, but they were still generally negative. Females' challenge with competition is the perceived value of the feedback received (C. A. Shapiro & Sax, 2011). According to Shapiro and Sax, females do not value that type of feedback. According to Steegh et al. (2021a), females' aversion to competition has been documented back to preschool play, where males perceive winning as validating their actions. In contrast, females prefer collaboration where there are no winners and losers. Some of this attitude is explained by gender schema and gender socialization, where females are taught from a young age that competing is not ladylike (Riegle-Crumb, 2017). Abernathy and Vineyard (2001) posited another possible challenge: the risk-reward aspect. A female sees not performing well in a competition as a validation that they do not have a place in STEM, while males do not appear to have the same reaction (Abernathy & Vineyard, 2001). In addition, Abernathy and Vineyard explain when the emphasis in a competition changes from learning to performance, devaluing the learning aspect of participation which females enjoy.

It is not clear from the current research how valuable STEM competitions are (Abernathy & Vineyard, 2001). Several studies have shown a correlation between students who participate in STEM competitions and major and/or go into STEM careers (Campbell & O'Connor-Petruso, 2008; Campbell & Walberg, 2011; Eremin & Gladilin, 2013; Gordeeva et al., 2013; Sahin, 2013; Sahin et al., 2015; A. M. Steegh et al., 2019; Wirt, 2011; Wu & Chen, 2001). In addition, there is a gap in the literature for studies exploring the relationship between STEM competitions and gender. According to Fox and Cater, "Research is needed to understand better how different learning strategies, specifically competitive events, and special interest programs, impact the connections among interest, competence, and career interest;" all components of STEM identity (Fox & Cater, 2015, p. 92).

Science Olympiad

Studies have identified small, supportive group membership, pre-college experiences (both in and out of formal schooling), family support, teacher encouragement, intrinsic motivation, and an attitude of perseverance as typical characteristics of females who have entered under-represented STEM fields (Brown, 2002; Carlone & Johnson, 2007a; Russell & Atwater, 2005). While not every extracurricular STEM activity, both competitive or noncompetitive, has these characteristics built into its organization, Science Olympiad has all these characteristics.

A detailed description of Science Olympiad can be found on their website (www.soinc.org) and in their rule book, updated every year (Science Olympiad, Inc, 2022). What follows is a summary of Science Olympiad, drawn from these two sources. Science Olympiad is an Olympic or track meet-style science competition with 23 official events. The event slate is modified each year with the rules and foci changing for events that remain on the slate and about one-third of the events rotating out to allow for new events. The 2021-22 season event slate is shown in Figure 5. The events cover all the areas of STEM, including physics, biology, engineering, chemistry, general inquiry, etc. and are divided into four categories: Core Knowledge, Build, Laboratory/Hands-On, and Hybrid.

Science Olympiad
2022 Event Slate

Life, Personal & Social Science-5	Earth & Space Science-5	Physical Science & Chemistry-5	Technology & Engineering Design-4	Inquiry & Nature of Science-4
Division B 2022 Events				
Anatomy & Physiology (Nervous, Sense Organs, Endocrine) **Bio Process Lab** Disease Detectives **Green Generation** (Aquatic, Air & Climate Change) Ornithology Trial Events **Agriscience** **Botany** **Home Horticulture**	Dynamic Planet (Hydrology) Meteorology (Climate) Road Scholar **Rocks & Minerals** **Solar System**	Physics **Crave the Wave** **Sounds of Music** **Storm the Castle** Chemistry Food Science Crime Busters Trial Events **Solar Power**	**Bridges** **Electric Wright Stuff** Mission Possible Mousetrap Vehicle Trial Events **Aerial Scramble** **Digital Structures**	**Codebusters** Experimental Design Ping Pong Parachute Write It, Do It Trial Events **Write It CAD It** *Approved 04/09/21*
Life, Personal & Social Science-5	Earth & Space Science-4	Physical Science & Chemistry-6	Technology & Engineering Design-4	Inquiry & Nature of Science-4
Division C 2022 Events				
Anatomy & Physiology (Nervous, Sense Organs, Endocrine) **Cell Biology** Disease Detectives **Green Generation** (Aquatic, Air & Climate Change) Ornithology Trial Events **Agriscsience** **Botany** **Home Horticulture**	Astronomy Dynamic Planet (Hydrology) **Rocks & Minerals** **Remote Sensing**	Physics **It's About Time** **Trajectory** **WiFi Lab** Chemistry Chem Lab (Aqueous Solutions & **Redox Reactions**) **Environmental Chemistry** Forensics Trial Events **Solar Power**	**Bridges** Detector Building Gravity Vehicle Wright Stuff Trial Events **Aerial Scramble** **Digital Structures** **Robot Tour**	Codebusters Experimental Design Ping Pong Parachute Write It, Do It Trial Events **Write It CAD It** **Cybersecurity** *Approved 04/09/21*

Bolded text indicates either a new event or topic changes from the previous year

Updated: 6/14/21

Figure 5. Event list for the 2022 Science Olympiad season (Science Olympiad, Inc, 2020).

Core knowledge events are focused on scientific theories and applications of those theories in specific areas of science, such as anatomy and physiology. At each competition, these events are scored based on performance on a unique test. Each core knowledge event has a detailed set of rules that indicate specific topics within the subject area's scope and what resources can be used during competition. For most of these events, students are allowed resources such as a certain number of pages of notes or binders of a specific size that contain information they have researched and gathered. The time and effort put into gathering the information and organizing it into an efficiently searchable set of resources can take hundreds if not thousands of hours. The students consistently revise and add to their resources throughout the season. An example of a rule sheet and a student-generated resource sheet for a Core Knowledge event is found in Appendix A.

Build events require students to construct a device that can perform specific tasks at a competition. The rules give detailed specifications about construction, tasks it must perform, records that must be kept during development, and how the device will be tested. For example, in Wright Stuff, a glider must be constructed to fly for the longest possible time. A rubber band powers the glider and must be within a specific mass range. Each aspect of the construction specifications is detailed, including but not limited to the types of materials and adhesives that may or may not be used. Students go through many iterations of their designs during a competition season and learn how to repair breakages and mishaps during both practices and competitions. A sample of a building event rule sheet is found in Appendix B.

Laboratory/Hands-On events contain a component where students demonstrate the skills they have developed to be used in a STEM laboratory in conjunction with the knowledge they have acquired about the theories and principles in a specific STEM area. In these events, students are expected to collect and analyze data to solve a problem. Students carry out specific lab procedures based on covered topics, like titration for acids and bases in Chemistry Lab. The rules for these events contain information about what resources are allowed during competition and samples of laboratory processes with which students must be familiar. An example of a laboratory/hands-on event rule sheet is found in Appendix C.

Hybrid events are events with both a core knowledge and a building component. These events have become more common over the years. Hybrid events typically have a written test during the competition and a device testing time for the built component. For instance, in Its About Time, students make a timekeeping device and test time standards and the physics related to timekeeping devices. Samples of event rules are found in Appendix D.

A team from a school consists of 15 students. These 15 students then organize to send partners or trios to compete in each of the individual events. Each competition will have a schedule of when teams are to report to each specific event. At times, scheduling conflicts arise, and teams must rearrange which students represent the team in each event, sometimes at the last minute, to ensure a partnership or trio is in each event. Partnerships can earn medals in individual events, and then each partnership's placement in the individual events combines for a team score. The team awards are based on the lowest sum of composite scores from individual events. Teams, not partnerships, advance in the levels of competition: Regional to State to National tournaments.

Science Olympiad is a national organization founded in 1984 by Gerard and Sharon Putz and Jack Cairns. The organization was inspired by smaller similar competitions in Delaware, Pennsylvania, and North and South Carolina (Macbeth, 1977; Wetmore, 1978; Wilson, 1981). Science Olympiads were seen as alternatives to the traditional Science Fair and a way for colleges to recruit STEM students (Wetmore, 1978; Wilson, 1981). The first proposals of a national organization were presented to the National Science Teachers Association and proposed to the conference exhibitors. At the conference, organizers approached the Army, and after a seminar attended by representatives from all 50 states and Puerto Rico, they decided to sponsor the first national tournament. Since the first national tournament in 1984, participation has grown from 17 states to every state, with several needing to be divided. According the Science Olympiad, more than 7,800 secondary schools have registered teams.

Various other organizations are also termed Olympiads, such as Biology Olympiad, Physics Olympiad, and Chemistry Olympiad (*International Biology Olympiad*, 2020; *IPhO - The International Physics Olympiad, Singapore*, 2020; *U.S. Participation in the International Chemistry Olympiad*, 2020). These organizations are not affiliated with the US-based Science Olympiad. According to their websites, these other Olympiads do not have a similar structure to Science Olympiad. In this dissertation, I focused on Science Olympiad as previously described.

While Science Olympiad has grown and is now found in many schools throughout the US, there has not been much educational research done about Science Olympiad (Sahin et al., 2015). In addition, much of the research has either focused on the international Olympiads (A. Steegh et al., 2021b, 2021a; A. M. Steegh et al., 2019) or looked at Science Olympiad as one of the multiple options of science competitions (Abernathy & Vineyard, 2001). Abernathy and Vineyard's (2001) study investigated the differences between science fair and Science Olympiad participation at the middle school level. The study found Science Olympiad had more females participating in comparison, albeit in more biology and life science events, than science fairs (Abernathy & Vineyard, 2001). While Abernathy and Vineyard (2001) specifically looked at science fairs and Science Olympiad, there have been several other studies that have explored female participation in science competitions as a whole (Fox & Cater, 2015; Hennessy Elliott, 2020; Riegle-Crumb, 2017; Sahin et al., 2015). Over three years, McGee-Brown conducted a longitudinal study using data collected in the Georgia State Science

Olympiad organization about how students' group work and inquiry skills developed (McGee-Brown, 2003). Several dissertations have also been written using Science Olympiad as a format to examine STEM involvement and interest, with two cited on the Science Olympiad website (Forrester, 2010; Science Olympiad, Inc, 2020b; Wirt, 2011). However, none of these studies have explored the role science competitions, particularly Science Olympiad, have on the development of science identity and well-developed personal interest in a specific science area in females.

When examining gender differences in any organization, complexities arise due to the multiple factors involved in why females participate in one area and not another (Archer et al., 2017). When examining a group of people, individualism is highlighted. Each person is different and has different motives and preferences (Sparks, 2018). Each female has a different experience, both good and bad, even in the same programs and locations (Farland-Smith, 2015). In multiple studies where females in STEM have been studied, different experiences have been revealed (Carlone et al., 2011, 2015; Carlone & Johnson, 2007a; Hennessy Elliott, 2020; Krogh & Andersen, 2013; Nealy & Orgill, 2020; Sparks, 2018; Wade-Jaimes et al., 2019). Although there are different experiences across the studies and situations, there have been several themes found to contribute to the progression of females in the STEM pipeline, which gives efficacy to continuing to examine the perceptions and experiences of females in different STEM programs.

Research Questions

1. How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?

2. How does participation in a Bay Area High School Science Olympiad program contribute to female students and alumnae maintaining and growing a personal specific STEM interest?
3. What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?
4. What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?

Definition of Terms

Several terms will be used throughout this dissertation that may have several definitions. However, throughout this dissertation, the following definitions will be used.

Alumnae are students who graduated from Milpitas High School, were active participants in the Science Olympiad, and are currently attending college, both graduate and undergraduate, or have graduated and are now establishing their careers. These young women are STEM majors who are either now taking or have taken one of the STEM weeder courses. Some examples of STEM weeder courses are freshman college chemistry, physics, biology, calculus, and linear algebra.

Identity is the type of person one wants to be, including traits and aspirations (Gee, 2000).

Identity Boundary Work are activities that people do that are in new areas that are outside their comfort zone. Often these areas were unimaginable for the person to participate and learn about until exposed through identity boundary work (Carlone et al., 2015).

Personal Specific STEM interest will be used to refer to an emerging or well-developed interest in a specific area of science, such as microbiology, protein synthesis, mechanical engineering, etc. (Hidi & Renninger, 2006).

STEM (Science) Identity is the type of science person one wants to be and congruency with the concept of science (Carlone & Johnson, 2007a).

STEM Pipeline is a series of activities and schoolwork that lead toward a STEM career (Linnenbrink-Garcia et al., 2018).

Science Olympiad is a national extracurricular organization that is school-sanctioned. Teams of 15 compete in 23 STEM events that the national organization determines (Science Olympiad, Inc, 2021).

Weeder courses are introductory and foundational college courses required to pass with a grade of B or better to continue to take more advanced and specialized STEM courses and complete a STEM major. Examples of weeder classes would be first-year college chemistry, first-year college biology, first-year college physics, college calculus, and linear algebra. These courses typically have large class sizes and are significantly challenging to pass. Many universities also limit the number of times a student can retake the class (Ferrare & Miller, 2020).

CHAPTER II:

REVIEW OF THE LITERATURE

While female representation in the STEM fields has shown marked increases since the 1990s, there is still a gender gap in many STEM fields (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). Even though biological sciences have seen an elimination of the gender gap, the gap is still wide in the physical sciences, engineering, and computer science (Adams et al., 2014; Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; Levine et al., 2015; OECD, 2019; C. A. Shapiro & Sax, 2011; *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). While many factors appear to contribute to the persistence of females in the STEM pipeline, the majority of these factors load onto one construct: STEM identity (Carlone & Johnson, 2007a; Kim et al., 2018; Vincent-Ruz & Schunn, 2018). In-school classes are not the primary motivator for females to develop STEM identity and stay in the STEM pipeline (Krogh & Andersen, 2013). Instead, extracurricular STEM programs appear to have the most influence (Abernathy & Vineyard, 2001; Adams et al., 2014; Sahin et al., 2015; A. M. Steegh et al., 2019; Wade-Jaimes et al., 2019). This study explored participants' perceptions in one extracurricular program, Science Olympiad, at a Bay Area High School.

This literature review presents research explaining the critical components of STEM identity and which activities serve as vehicles to help adolescent females develop their STEM identity. First, I will explore what STEM identity is and how it has been used to interpret the actions of females in STEM. Next, I will examine identity boundary work to develop STEM identity. Third, I will explore personal specific STEM interest, a specific and critical component of STEM identity. After exploring STEM identity, the focus will transition to exploring the literature about the role of extracurricular STEM actitivies in developing STEM identity. I will then finish by describing the effect that competition has on extracurricular activities and STEM identity since the extracurricular activity in this study, Science Olympiad, is a competition.

STEM Identity

According to Holland and Lave (2009), identity is a conversation between oneself about who you see yourself as, how you think others see you, and how you interact with others and your environment. Identity is mostly about how you see yourself and how that view directs the actions you take (Krogh & Andersen, 2013). For females, STEM identity is how they see themselves in the STEM community and how they interact with STEM subjects and activities (Kim et al., 2018). An important aspect of STEM identity is the differentiation between STEM ability and STEM identity (Hill et al., 2018). According to Hill et al., (2018) a female with high STEM abilities does not mean they have also have a strong STEM identity. STEM identity must be examined as a separate construct from STEM abilities.

Kim, Sinatra, and Seyranian (2018) conducted a meta-analysis of 47 articles to explore three research questions:

1. What kind of STEM environments do young women experience in middle and high school?
2. What efforts have been made to bring about change in the STEM environment young women experience? Have there been efforts to change the prototypes of STEM identity?
3. What implications and recommendations for theory, research, programs, and policy emerge from investigating the literature from a social identity perspective?

Kim et al.'s analysis found that in order to help girls develop a strong STEM identity, successful activities and programs must focus on assisting females in creating a sense of belonging in STEM activities. Additionally, females need to gain confidence in knowing they can compete with others in the STEM fields. This aspect has an essential distinction between developing abilities and building confidence in the females' abilities. Kim et al. suggest that co-ed programs are most effective as long as the program monitors gender attitudes for all. Kim et al. suggested the need for programs that specifically help white boys, parents, and teachers see the challenges females and other minorities have in STEM and become allies. Finally, Kim et al. expanded the previously developed model of STEM identity created by Carlone and Johnson (2007) to include five areas instead of three, as shown in Figure 1. Kim et al. (2018) added the areas "perceptions of scientists" and "interest in STEM careers." The perceptions of scientists added the crucial aspect of having good role models to help females envision themselves as part of a community. Additionally, Kim et al.'s addition of interest in STEM careers highlights the importance of personal specific STEM interest. Also, it acknowledges the findings of Cooper and Heaverlo (2013) that STEM interest is a separate construct from other motivational areas.

In the current study, the Bay Area High School's Science Olympiad program is a co-ed program with the characteristics that Kim et al. suggest are most effective in helping females develop a STEM identity, specifically helping females develop a sense of belonging in a STEM program. The proposed study will also explore how the co-ed environment has helped or hindered different females in their development of STEM identity.

While Kim et al. further developed the components that made up STEM identity and emphasized the need for co-ed programs where males and females learn how females belong in STEM, Vincent-Ruz and Schunn (2018) explored other attitudinal components that contribute to STEM identity. Vincent-Ruz and Schunn conducted a quantitative, longitudinal study using a subset of the Activated Learning Enables Success 2015 data set. The data was collected from seventh and ninth-grade students in 19 schools with varying demographics from two urban regions of the United States. Science Identity was measured from two perspectives: self-view and perceived view of others. The attitudinal components measured were fascination, values (how important knowing science is to personal life), and competency beliefs. The researchers conducted exploratory factor analysis, and the data loaded in four distinct factors (science identity, fascination, values, and competency beliefs) that were correlated but distinct. The attitudinal factors showed large Pearson correlations between 0.47 and 0.54. Both science identity views (self-view and perceived view of others) loaded together, but none of the attitudinal components loaded together or with science identity. The correlations between the self-view and perceived view of others had a very large Pearson correlation of 0.65, which is expected since these two factors loaded together to form science identity. Additionally, the study showed a strong Pearson correlation, 0.44, between science activity choices students make and science identity, showing that students with budding STEM identities are more likely to participate in activities that enhance that identity.

The research questions for this proposed study are designed to explore the role of Science Olympiad in developing females' STEM identity. The females in this study have chosen to join Science Olympiad in high school. Based on Vincent-Ruz and Schunn's findings, this is probably because the females already have a STEM identity and are looking to strengthen it. Along with examining STEM identity for these females, the current study will also explore personal specific STEM interest development. Vincent-Ruz and Schunn used the term 'fascination' to describe what others in the literature call personal specific STEM interest. They showed it loaded separately from identity even though the Kim et al. (2018) and Carlone and Johnson (2007) models of STEM identity include interest as a part of STEM identity. The contradiction between including personal specific STEM interest as a part of STEM identity or not lends itself to more exploration of identity and personal specific STEM interest in adolescent females. Vincent-Ruz and Schunn's sample was with early adolescents, while my sample will include high school and college-aged adolescents along with young adults. Due to the contradiction and the difference in sample demographics, I will be exploring personal specific STEM interest separately from STEM identity.

When exploring young females' perceptions of their STEM trajectory, interviewing females who persist in STEM can yield important insights. Archer et al. (2017) interviewed females who chose to persist in physics as they began their final years of secondary education in the United Kingdom. The researchers identified and selected these females from a broader longitudinal survey conducted about students' science and career aspirations. Archer et al. found these females shared several characteristics from the interviews conducted. These females (a) were proud to be different, (b) were competitive, (c) had confidence in their abilities, (d) possessed high science capital, (e) went to supportive schools, (f) preferred theory over practice, (g) had a way to deal with being one of the few females, and (h) were generally not characterized as super "girly." While the current proposed study does not focus just on Physics, the methods used of starting with a survey and then moving to focus groups on exploring the ideas initially presented with more depth, as was done in the Archer et al. study will also be used. Additionally, Archer et al. explored the females' perceptions of themselves; a similar design will be employed in the current proposed study.

Many see the costs of the time needed to pursue STEM as high because understanding challenging content and its application is time-consuming (McDonald et al., 2019). Additionally, females in STEM fields encounter situations of sexism and other biases that are difficult to manage (Kuchynka et al., 2018). Cultivating a strong STEM identity is important because females with a strong STEM identity tend to persist in the STEM field despite the challenges (Archer et al., 2017; Carlone & Johnson, 2007a; Kuchynka et al., 2018; McDonald et al., 2019). However, measuring STEM identity is a challenge since it is an ill-defined construct that is fluid and altered by life experiences (McDonald et al., 2019). Typically, STEM identity has been examined through qualitative studies or adapted interest and motivation surveys (Abernathy & Vineyard, 2001; Archer et al., 2017; Carlone et al., 2015; Carlone & Johnson, 2007a; Fox & Cater, 2015; Nealy & Orgill, 2020; Sahin et al., 2015; Stringer et al., 2020; Vincent-Ruz & Schunn, 2018; Young et al., 2013). However, McDonald et al. (2019) developed a single-item measure for STEM identity called STEM Professional Identity Overlap (STEM-PIO-1). This measure, a series of concentric circles shown in Figure 6, was compared to

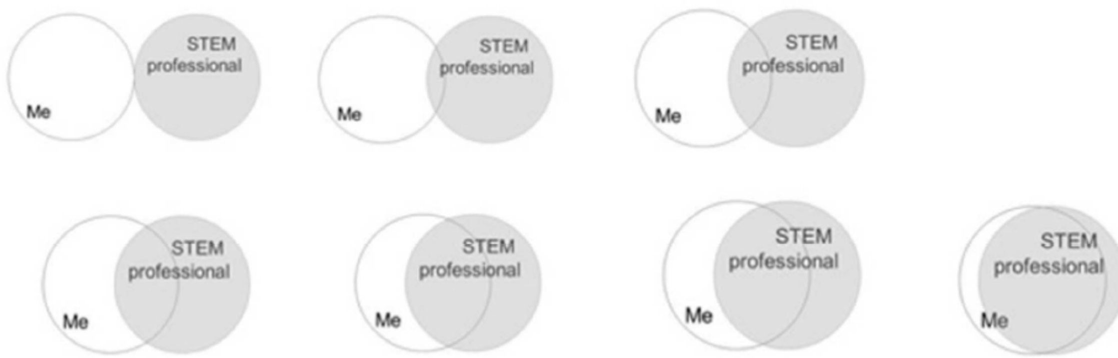

Figure 6. STEM Professional Identity Overlap Measure

(McDonald et al., 2019)

four STEM attitude questions and five STEM identity measures, each measured on a Likert-type scale used in Young et al. (2013). McDonald et al. (2019) detected moderate correlations between the STEM-PIO-1 and STEM identity and attitudes ($r_{(476)} = 0.42$ and $r_{(476)} = 0.39$). When examined across demographics, their results did not vary, suggesting the STEM-PIO was reliable across all gender, racial, and ethnic groups.

McDonald et al. then adapted STEM PIO-1 for each component of STEM identity by modifying the instructions for the graphic to focus on each component of STEM identity (STEM PIO-4). STEM PIO-4 showed good interitem reliability ($\alpha = 0.87$). The overall study results showed the STEM PIO-1 and STEM PIO-4 measures were reliable and valid measures of STEM identity. McDonald et al.'s study used college students as their sample, and even though the proposed current study's participants will also include high school students, the results should be applicable. Therefore, the current study will use the STEM PIO-1 and STEM PIO-4 to measure STEM identity.

Identity Boundary Work

Due to STEM identity being an ill-defined construct, it is not easy to understand how females develop STEM identity (Carlone & Johnson, 2007a). Papadimitrou (2004) suggested the lack of opportunities to see STEM in new ways is one of the most common ways STEM identity and interest development is interrupted for females. Additionally, Adams et al. (2014) and Krogh and Anderson (2013) have suggested that diving into STEM practices to learn by doing is a key to developing STEM identity. Carlone et al. (2015) described these activities as identity boundary work. Carlone et al. further explained identity boundary work as actions or activities outside the student's comfort zone. When females do identity boundary work, an opportunity is presented to develop an interest in an area that was previously something they would never have imagined liking. Experiences in new areas could cause a change in students' thoughts of who they are and what they can do in terms of their STEM identity.

Carlone et al.'s (2015) study observed and interviewed a demographically varied group of students from disadvantaged backgrounds about their experience participating in a summer residential research program. The study described the summer research program as a familial, collaborative, and caring environment where students collected and analyzed data in the field of herpetology to report scientific findings. The students met with scientists and were exposed to various science careers and fieldwork opportunities.

When the program started, participants started with expressions of fear and "I'm not gonna …!" (Carlone et al., 2015, p. 1532). However, they also showed openness and willingness to venture closer to the animals and even engage with them. Throughout the program, the participants had experiences that they would have never tried except for in the program environment, such as tagging frogs and turtles in their natural habitats.

Carlone et al. found that four aspects of the program were key to the students' success and willingness to venture into spaces outside their comfort zone. First, participants have what Carlone et al. termed boundary objects. These items made the learner more comfortable and protected, such as wader boots to enter the water, gloves to hold the animals, and even a clipboard to take notes. Secondly, the program gave participants adequate time and space to engage. They were not forced but encouraged to participate. The program had ways for everyone to engage on the edges of their comfort zone. Thirdly, there was an immense amount of social support and collective agency. One anecdote was shared where two participants chose to be the first to enter a pond to retrieve a trap. The participants entered the water together and supported each other. During their adventure, they answered questions from the other participants, which assured them, and soon the whole group was participating. Lastly, the group leaders provided anecdotal and scientific knowledge and skills. Students saw demonstrations of different processes that they would need to perform. Students learned about the animals and environments they were entering. With these four aspects of the program, participants tried things they never imagined possible. In addition, participants experienced situational interest, which Carlone et al. proposed may have started students on the road toward personal interest, as explained by Hidi and Renninger (2006). Without identity boundary work, the participants would not be introduced to this STEM area.

Another critical finding was letting the participants work through their uncertainty in their own time and space. One participant did not want to touch the animals until the last week of the program. However, they still participated fully by being the note taker for their groups and developed their analytical skills with the data collected.

The participants were actively involved in doing science, and I wonder if the physical fieldwork was why the students began to engage. While Carlone et al. found that the participants engaged in the spaces where they were first fearful and never imagined they would engage, there was no exploration of the influence of the fieldwork aspect. In addition, the authors acknowledge that this experience equated to the first two phases of situational interest as presented by Hidi and Renninger (2006). A follow-up to this study would provide insight into whether these experiences did provide the springboard to developing a well-developed personal interest in the subject area or provided the students with the confidence to begin to explore other areas of STEM where they could find a personal specific STEM interest.

The current case study aims to examine the influence of a Bay Area High School's Science Olympiad team on the development of STEM identity and personal specific STEM interests. The Science Olympiad team has many similar aspects to the program Carlone et al. investigated, including the familial and collaborative environment. Science Olympiad students often work in identity boundary areas due to the specificity of many of the events. For most students, Science Olympiad is the first time they dive into specific areas of STEM, such as ornithology or flight. While teachers in the school science classes may briefly mention some of these topics, the students in Science Olympiad must explore these topics at a much deeper level. Due to the team structure of competitions, students are often asked to do events that are not necessarily in their comfort zone but can develop a solid personal interest after the initial situational interest experience when fulfilling a need for the Science Olympiad team. In addition, the exploration that is done in Science Olympiad generally has the four aspects that support identity boundary work: boundary objects, time and space, social support, and anecdotal and scientific knowledge. Time and space are where Science Olympiad can sometimes fall short. There are times that an event needs to be covered in a very short amount of time, but generally speaking, students have time to engage fully in the events.

Additionally, the positionality of the researchers in the Carlone et al. study is similar to the researcher in the current proposed study. The authors were all involved in the program as either instructors or researchers. While this could have posed a problem due to Carlone et al.'s positions of power within the program, Carlone et al. developed their methodology to minimize this potential bias. The current proposed study will follow a strict methodology in gathering data through multiple forms, including a survey and focus groups, to minimize the researcher's bias.

Personal Specific STEM Interest

A personal specific STEM interest is a well-developed personal interest, as defined by Hidi and Renninger, in a particular STEM area (Hidi & Renninger, 2006). While interest development is one of the areas added by Kim et al. to the STEM identity model, many studies have suggested interest development has a significant impact on the persistence of females in STEM (Adams et al., 2014; Baram-Tsabari & Yarden, 2008; Papadimitriou, 2004; Stringer et al., 2020; Vincent-Ruz & Schunn, 2018). According to Jansen, Ludtke, and Schroeders (2016), interest and achievement are more strongly correlated in the physical sciences than in the life sciences. Therefore, there is a strong need to develop specific interests in the physical sciences and engineering. Studies have suggested interest in STEM fields, in females especially, tends to decline during the high school years mainly due to the lack of opportunities to explore a variety of areas of STEM (Baram-Tsabari & Yarden, 2008; Papadimitriou, 2004; Sahin et al., 2015; Stringer et al., 2020). In the previously discussed study, Vincent-Ruz and Schunn (2018) went as far as to suggest that interest is the primary motivation to build a STEM identity.

The question that arises is how to develop STEM interests. Many studies have suggested exposure to STEM topics as the primary tool to build interest (Baram-Tsabari & Yarden, 2008; Blank et al., 2016; Papadimitriou, 2004; Sahin, 2013; Sahin et al., 2015). However, Cooper and Heaverlo (2013) approached STEM interest differently. Cooper and Heaverlo explored how interest in particular areas of STEM is correlated to interest and confidence in problem-solving and design. The researchers administered a 47-item survey to middle school and high school females attending an engineering conference, therefore showing some interest in STEM. The independent variables used were age, interest in problem-solving, and confidence in problem-solving. Interest and confidence in problem-solving were both measured using a Likert-type scale. The dependent variables of interest in science, math, computer science, and engineering were also measured on a Likert-type scale.

Cooper and Heaverlo used a paired samples *t*-test to show interest and confidence were separate constructs. Females reported feeling more confident than interested in problem solving, $t(967) = 2.67$, $p = 0.008$. However, when asked about creativity and design, the females reported more interest than confidence in creativity and design, $t(963) = 9.86$, $p < 0.001$. These results support the model of STEM identity developed by Carlone and Johnson (2007) and then expanded by Kim et al. (2018). Specifically, the confidence construct would be grouped in the competence category in the model, while interest is in a separate category. In the current study, I will ask questions to explore each category of STEM identity. Cooper and Heaverlo's findings support why I needed to ask separate questions to explore confidence and interest in STEM perceptions.

Cooper and Heaverlo performed four regression models finding that only interest in problem-solving had statistically significant predictions of interest in science, engineering, computer science, and math in all four models. Interest in creativity and design had some statistically significant relationships, but those relationships were negative for science and math. For engineering and computer science, the relationships were positive but with varying levels of statistical significance between $p < 0.05$ and $p < 0.001$. Confidence in problem-solving or creativity and design did not show statistical significance in any models. These findings support the model in the current study, where I will explore interest in different areas of STEM separately, acknowledging that STEM interest is not a single construct. The present proposed study will also focus on interest and use confidence only within the full STEM identity model.

Additionally, Cooper and Heaverlo's findings support the idea that females need activities that help them foster interest in problem-solving through STEM. Most females in the study chose extracurricular activities designed with problem-solving in mind. Although Science Olympiad was not directly mentioned in Cooper and Heaverlo's study, many events are designed to develop problem-solving skills (Science Olympiad, Inc, 2020b). While developing problem-solving skills, students can also develop personal specific STEM interest.

Extra-Curricular STEM Activities

School science classes do not significantly influence females developing specific STEM interests or STEM identities (Krogh & Andersen, 2013). However, Kim et al. (2018) point out that the middle school and high school years are pivotal in developing personal specific STEM interest and STEM identity. According to Kim et al., if students are not thinking about a STEM major or STEM career in middle and high school, the opportunity to enter and then stay in the STEM pipeline has usually passed. Therefore during middle and high school, extracurricular STEM activities are imperative for developing personal specific STEM interest and STEM identity (A. M. Steegh et al., 2019; Wade-Jaimes et al., 2019).

Stringer, Mace, Clark, and Donahue (2020) used a quasi-experimental design to explore who was participating in extracurricular activities and the effect on STEM identity in a group of middle school youth over a school year. The study used a pretest-posttest design, administering a survey at the beginning and end of the school year to measure science motivation, STEM college confidence, and STEM career identity. While science motivation is important, STEM college confidence and STEM career identity are the two measures that apply to this proposed study the most. STEM college confidence was measured using questions that asked students about their beliefs that they could study a STEM subject in college. STEM career identity was measured using several questions related to how the participants viewed themselves compared to a STEM version of themselves. Even though these questions were used in a quantitative study, similar questions will be used in the current proposed study to start the qualitative exploration of what contributes to the participants' views of themselves regarding STEM.

Stringer et al. (2020) found that involvement in STEM extracurricular programs was statistically significant for females but not for males for STEM career identity. Additionally, the difference in pre-and post-test scores for STEM career identity had a slight increase for those in STEM extracurricular activities and a decrease for the participants who were not in STEM extracurricular activities.

While Stringer et al. showed the positive influence extracurricular STEM programs have on females' STEM identity, there are several challenges with the study. First, the sample size that participated in STEM extracurricular programs during the year was small. Only about ten percent of the entire sample participated in STEM extracurricular programs. Additionally, this small group was divided into three different programs with different gender ratios: Math Counts with 24%, Science Olympiad with 49%, and Girls in STEM with 100%. The study did not disaggregate the data for the individual programs. The current proposed study will focus on Science Olympiad, which had close to equal numbers of genders as a coed program in the Stringer et al. study.

Another challenge this study had was two-fold, length of participation and age of the participants. The participants were in middle school. While middle school is a crucial time for STEM identity growth, this is also a time where students are exploring and developing their interests in different areas. So students are often not wholly committed to a program, which can limit the program's effects (Kim et al., 2018). Additionally, the study only looked at one year of participation. According to Carlone (2012), STEM identity develops over time, and one activity, even over a year, does not typically show a significant change in STEM identity.

Adams, Gupta, and Cotumaccio (2014) studied a museum program in New York City with long-term engagement. Participants apply to the program as sixth graders and participate through the end of high school. The program meets for three weeks each summer and then continues with about 15 Saturday or after-school sessions throughout the school year. The program has a significant financial aid program to make it accessible to most residents (American Museum of Natural History, 2022). Adams et al. conducted a focus group with eight female alumni of the program and then conducted follow-up interviews to clarify any data collected in the focus group. The researchers found that long term involvement in the STEM program had four key benefits:

- A collective identity was established.
- A sense of belonging to a physical space was established.
- Exposure to many topics and careers in STEM was embraced.
- Transference of the learning and sense of community to college.

The emergence of these four themes from a long-term extracurricular STEM program demonstrates the importance of female participation in STEM programs that embody characteristics that build these themes into the program.

The current proposed study will be exploring a program that also tends to have long-term participation. However, the main difference between the museum program and Science Olympiad is the school involvement. In the Adams et al. study, the program was funded by and took place at a museum, while the current study focused on Science Olympiad, a school-based program that receives some of its funding from the school itself. Additionally, the present study participation is coed, as is the museum program in the Adams et al. study. Previous work has pointed to the importance of coed programs in developing strong STEM identities in females and building collaborative skills between genders in STEM culture (Kim et al., 2018). In light of the similarities of the programs in the Adams et al. and the current study, the current study design included focus groups. The Adams et al. study design showed how the sharing in the focus groups helps the participants who already had a previous relationship build off each other's points to paint a complete picture of the program's influence on the females' STEM identity development.

Science Competition

While participation in extracurricular programs, in general, has been shown to affect STEM identity for females positively, not all programs contain a competitive element. Since the general perception of STEM includes a highly competitive nature (Carlone & Johnson, 2007a; Riegle-Crumb, 2017; C. A. Shapiro & Sax, 2011), the inclusion of a competitive element in activities aiming to increase female participation in STEM may be necessary. According to Carlone and Johnson (2007) and Kim et al. (2018) models of STEM identity, recognition is an integral part of STEM identity. Competitions are one of the activities that can build the recognition aspect of STEM identity. According to Carlone and Johnson, recognition does not necessarily mean winning awards because there are multiple ways to give recognition.

However, according to several studies, females are not as inclined to compete as males are (Buser et al., 2014; Kleinjans, 2009). Additionally, due to the competitive nature and low representation in many STEM fields, females feel they must do more and be more than their male counterparts, and therefore females may need a stronger sense of competitiveness to stay in the STEM pipeline (Archer et al., 2017; Riegle-Crumb, 2017).

Riegle-Crumb et al. (2019) explored the relationship between perceptions of competitiveness and expectations of majoring in a STEM field in post-secondary studies.

The sample of 633 students was enrolled in an interdisciplinary elective STEM course at 21 public high schools. While their sample consisted of students who had already shown some inclination toward STEM and did not have high generalizability, it represents students in the STEM pipeline and at risk to exit said pipeline. Additionally, the sample represents the typically disproportionate number of males in an elective STEM program, with only 33% of the sample being female. The researchers collected data through a survey administered at the end of the school year by the classroom teachers. The independent variable was perceptions of competitiveness measured with eight questions using a Likert-type scale then compiled to make a single measure. The data showed a statistically significant difference in self-reported competitiveness favoring males over females.

Riegle-Crumb et al. performed two-tailed *t*-tests between gender and each STEM field. The expectation of majoring in various STEM fields was the dependent variable. The authors grouped STEM fields into four major areas: Biological Sciences, Physical Sciences, Engineering, and Computer Science. All *t*-tests showed statistical significance. Biological Sciences had more females intending to major in it than males. In contrast, Physical Sciences, Engineering, and Computer Science all had significantly fewer females than males intending to major. Data collected in this study showed similar trends in gender and expected STEM field majors, as seen in the National Science Foundation 2019 data set where occupations and degrees were measured (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021).

Riegle-Crumb et al. also performed a multiple linear regression with several control variables to measure perceptions of competitiveness with an expectation of majoring in each STEM field. The control variables were race/ethnicity, grade level, and several math measures. Riegle-Crumb et al. found when perceptions of competitiveness were added to the model, the gender coefficients had a statistically significant reduction in both Physical Sciences and Engineering but not in Biological Sciences. In addition, Riegle-Crumb et al. tested for interactions between gender and perceptions of competitiveness in each of the STEM fields. A statistically significant interaction was detected in Computer Science. While males' perception of competitiveness did show a statistically significant influence on major expectations, there was a statistically significant influence for females.

While Riegle-Crumb et al. found the competition aspect of STEM a significant challenge in keeping females in the STEM pipeline, Vineyard and Abernathy (2001) explored the experiences females had in STEM competitions, including both Science Fairs and Science Olympiad. Vineyard and Abernathy (2001) surveyed 943 students who participated in Science Fair or Science Olympiad with questions that explored the rewards students received for participating. In this study, Science Olympiad participation for high school students was male favored, with 63.6% of participants being male. Additionally, students participating in Science Olympiad reported spending more time with teachers or other coaches than parents in preparation for the competition than in the other STEM activities in the study. With the additional time spent with teachers and coaches, the students in Science Olympiad had more exposure to different role models than in the other programs. Vineyard and Abernathy found females' most significant rewards in STEM competitions were not the awards earned at the competition. Instead, females enjoyed working collaboratively with other students and mentors or coaches and learning new applications of STEM topics.

McGee-Brown (2003) conducted a three-year longitudinal study of multiple Science Olympiad programs to explore the use and impact of Science Olympiad on STEM-minded students. McGee-Brown used surveys to collect open-ended responses about student experiences in Science Olympiad over the three years. McGee-Brown reported more students indicated the focus on collaboration, problem-solving, and creativity were the most important aspects of Science Olympiad. As in Vineyard and Abernathy's study, McGee-Brown also found the competition aspect of Science Olympiad was not the main focus of the participants. McGee-Brown found Science Olympiad had two significant social impacts on students. First, participants reported an increase in seeing both genders as competent in STEM fields, supported by the findings of Kim et al. that effective coed STEM programs teach males to be allies for females in the STEM fields. Additionally, the participants reported differences in levels of competence and understanding provided different and valid perspectives on problem-solving. The second social impact was the increase in collaboration skills. These impacts relate to increases in recognition, an essential component of STEM identity.

Riegle-Crumb et al.'s findings that competition aversion has a significant effect on females planning to continue through the STEM pipeline toward physical sciences, engineering, and computer science shows the need to have places where females can experience competition in a low-stakes, safe environment. According to Vineyard and Abernathy (2001) and McGee-Brown (2003), Science Olympiad provides a possible experience where students can experience the elements of competition encased in a program based on other more favorable aspects of STEM for females. In the Science Olympiad program of this proposed case study, more females are involved in the physical sciences, engineering, and computer science than is typically seen in STEM programs. This study explored what this Science Olympiad program does to help females develop their personal specific STEM interest and STEM identity while in a competition arena.

Conclusion

The literature review highlights the importance of studying specific extracurricular programs that are helping females develop their STEM identity and continue in the STEM pipeline. As an ill-defined construct, researchers will consistently need to explore STEM identity in multiple situations to increase understanding (Carlone, 2012). According to Carlone, when focusing on STEM identity development, the questions must be people-focused and not necessarily focused on the program structures and outside influences. These should be examined through the perceptions of the individuals and how they have interacted with the program and other influences. Additionally, Adams et al.'s (2014) examination of long-term engagement in a specific STEM program showed more effect on STEM identity development than programs over a shorter time frame, such as Stringer et al. (2020). Therefore, the current proposed study will be using participants with a long history in the Science Olympiad program. Lastly, Riegle-Crumb et al.'s (2019) work with competition and females in STEM has highlighted one of the main challenges in some of the areas of STEM, the competitive nature of the field. While Science Olympiad is a STEM competition, Abernathy and Vineyard (2001) and McGee-Brown (2003) both suggested that the nature of Science

Olympiad as a collaborative, team environment may lessen the aversion to competition and lead to the development of STEM identity for females. Additionally, the work in Science Olympiad is often identity boundary work. It can help females discover new and intriguing areas of STEM and build the foundation to develop a personal specific STEM interest. Therefore the study of a Bay Area High School's Science Olympiad program will add to the body of literature surrounding extracurricular activities that assist in developing STEM identity.

CHAPTER III:

METHODOLOGY

The gender gap in STEM fields is well documented through national and global data (Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; OECD, 2019; *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). While there are many causes attributed to this gender gap, the development of STEM identity has been suggested as a critical influence on females staying in the STEM pipeline (Carlone, 2012; Carlone & Johnson, 2007a; Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; Kim et al., 2018). This study explored how long-term involvement in a Bay Area High School's Science Olympiad program affects females' STEM identity, including their personal specific STEM interests. The research questions addressed were:

1. How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?
2. How does participation in a Bay Area High School Science Olympiad program contribute to female students and alumnae maintaining and growing a personal specific STEM interest?

3. What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?
4. What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?

Research Design

A case study analysis was used in the investigation of how a Bay Area high school Science Olympiad program helped females develop a STEM identity and personal specific STEM interest. According to Merriam and Tisdell (2016), case studies are most valuable when a studied system has distinct boundaries. There are two distinct boundaries within the questions to be investigated: a specific school and a specific organization within that school. Within these two boundaries, data was collected. In addition, the research questions were focused on how this school and organization influenced females' STEM identity, which are the types of questions that lend themselves to a case study methodology (Yin, 2018). Sometimes case studies are used to delve into a situation where the phenomenon is not being observed to investigate what is happening to prevent the development of specific characteristics. Other times, a case study can be used to investigate how a phenomenon is coming to fruition. Investigations of particular instances that show a phenomenon, such as high female involvement in co-ed STEM programs, fit case study methodology well (Yin, 2018).

The current study employed survey, interview, and focus group methods. The survey was used to identify a purposeful sample of females to be interviewed and participate in a focus group discussion. Survey data was collected over five days.

Interviews followed over the following four weeks, with a focus group discussion occurring two weeks after the survey closed. The total length of the study was six weeks.

Context & Setting

The study was conducted at a large, public comprehensive high school located in the San Francisco Bay area. While there are two alternative high school pathways in the district, the school in the study is the only comprehensive high school in the single unified school district that serves the city. Ten elementary schools feed into two middle schools, which feed into the comprehensive high school. The total enrollment is 3058 students with 150 certificated staff (including eight counselors), 50 classified staff, and six administrators. The student body is predominantly Asian at 51.0%. The Filipino population, 18.5%, is not grouped with the Asian subgroup. The Latino population is 19.5%, and the African American population is 1.8%. White students comprise 3.8%, with other groups comprising the remaining population. The school has an English Language Learner population of 14.4%, and 31.8% of the student body is on free or reduced lunch (CA Department of Education, 2019).

Approximately 80 different clubs and organizations for student participation exist at the Bay Area High School with various foci. Science Olympiad is one of these school organizations. Science Olympiad is also part of a national network. Science Olympiad consists of approximately 100 participants each year, of which at least half are females. Some years, the Science Olympiad group is 80 students, while there are upwards of 140 students in other years. While not all students who participate in Science Olympiad are engaged at the same level and duration, the females that were invited to participate in this study have high and long-term engagement.

In addition to the high school Science Olympiad program, the two middle schools that feed into the high school have programs supported by the high school program. Additionally, the high school program hosts an elementary-level competition where many feeder elementary schools participate. Due to the feeder programs, some students begin their participation in Science Olympiad as early as fifth or sixth grade.

At the Bay Area High School, the Science Olympiad program is student-run with the support and guidance of three teachers in the science department who serve as the coaches. Each spring, the current captains of the team choose the captains for the following year. Next year's captains are selected through applications, interviews, and coaches' consultation. In the fall, veteran members head a recruitment campaign through student presentations in science classes, posters and fliers distributed around the school, and participate in the school club fair. The 2021-22 recruitment poster is shown in Appendix E. The captains share the current year's slate of events, grouped into four or five categories based on the most probable schedule at competitions, with prospective team members. The prospective team members rank the events in each category based on their interest. The captains then make event groups based on student preferences, the number of requests for each event, and team needs. Therefore, there are times students are asked to participate in events that were not one of their choices.

Students then arrange four-hour Saturday practices where the group comes together to learn about each of the events for the current year. Veteran team members, who have applied, are selected by the captains in consultation with the coaches as event leaders. Event leaders prepare lessons to teach the other students about the event during these Saturday sessions and help them begin to prepare to compete. Competitions happen throughout the winter and conclude with the regional competition in March. If a team qualifies, the State competition happens in April and the National competition in May. The captains organize teams of 15 for individual competitions while consulting with the coaches. While more opportunities to compete are generally given to the most active students who demonstrate the desire to grow, all students who participate in the Saturday practices are invited to compete in at least one competition. Students gather after school and on weekends to work with their teammates in intense preparation for individual competitions during the competition season. These intense preparation sessions are referred to as cram weeks and late days by the students. These cram weeks and late days occur afterschool in the coaches' classrooms and can last until eight or nine pm. Cram weeks are unstructured time for the team members to work together in final preparation for the upcoming competitions. Typically cram weeks run for two weeks before a competition with the latest sessions occurring the Wednesday, Thursday, and Friday before a competition.

Competitions generally occur on Saturdays at different high school, college, and university campuses. Dependent on the location of the competition, the day can start as early as 4:45 am and last until 10 pm. If the competition is within a two- or three-hour drive of the school, the students and coaches meet at the school and load all of their equipment needed for competition. Equipment needed for a competition includes their supplies for each event, which can include lab kits, goggles, lab aprons, devices that have been constructed, binders that have been compiled, etc. Additionally, folding tables, camp chairs, canopies, and food for breakfast and lunch are brought for the team to set up "grand central," an area where the team gathers in between events. If the competition is an hour or more away and multiple teams are traveling, charter buses are typically secured. After the bus is loaded, the team travels to the competition. Upon arrival, team members, with the help of the coaches and a few parents that have accompanied the team, set up grand central. One of the coaches goes to check in the teams and the event or events that the team is in charge of running. Team members gather for last minute announcements and reminders. The captains run most of this time with the assistance and reminders from the coaches. The individual events usually begin by 8:30 am and continue until about 3:30 pm. During the event time, students go to the individual events at their scheduled times. Meanwhile, the coaches are often judging and running specific events they have been asked to run. After the events have concluded and the team is waiting for the events to be scored, the team breaks down grand central and loads the bus with all of their supplies. Once the scores are in, an awards ceremony takes place where the top partnerships in each event are awarded medals. Each event contributes to a team score and the top overall teams earn trophies. The team then travels back to the school on the bus, often with a stop for dinner. When the team arrives back to the school, all the team members help put away the equipment from travel and go home. Often times this is as late as 10 pm. If the competition is in a location more than three hours from the school, the team typically will stay overnight close to the competition location.

Participants

The participants for the study was a purposeful sample. Current female students and alumnae of the Science Olympiad program from the Bay Area high school were selected to participate in the study through survey responses. Current students in the Science Olympiad program had just completed grades 9-12. The alumnae participants were in college between their freshman and senior years or had graduated and begun their professional careers or were attending graduate school.

The ten interview participants were selected from the survey respondents using the following criteria. First, interview participants identified as female. Secondly, participants had at least two years of participation in Science Olympiad, including elementary and middle school. Next, the participants selected for interviews had descriptions of a STEM person that showed at least three different characteristics. Additionally, the sample had a variety of perceptions of themselves concerning STEM based on the PIO circle graphic used in the survey. Participants were selected who demonstrate a range of responses on the instruments. The responses ranged from strong STEM identity (G) to weaker STEM identity (A). Lastly, five of the interviewees were alumni and five of the interviewees were students. Introductions to each participant follow the focus group description. Following the introductions, Table 1 contains demographic profiles and Table 2 contains STEM profiles of the interview participants.

The focus group participants were selected based on survey results. The focus group (n = 9) was comprised of both alumni (n = 5) and current students (n = 4). Focus group participants identified as female. Additionally, focus group participants had participated in Science Olympiad for at least three years. Focus group participants' selected demonstrated a strong STEM identity according to the responses on the instruments, selecting PIO circles E-G. Additionally, focus group participants did not select "competing against other students" as one of their top three rewards for participating in Science Olympiad. This selection criteria was used because part of the focus group discussion was about how the participants deal with the competition part of

Science Olympiad. In Riegle-Crumb (2019), females were seen to not be drawn to STEM fields that were highly competitive. While Science Olympiad is a competition based extracurricular program, the number of females that have participated is greater than the norm (Science Olympiad, Inc, 2020a). Two participants, a student and an alumnus, were selected for both the interview and focus group. All other participants were only interviewed or participated in the focus group. When the participants were being selected from the survey responses, I looked at the selection criteria for individual interview participants separately from the focus group participants without eliminating those that had been selected for the other participant group. Additionally, in order to have individual interview participants with higher STEM identities, I had to include some of those that were selected for the focus group. Following the participant introductions below, Table 3 contains demographic profiles and Table 4 contains STEM profiles of the focus group participants.

Participant Introductions

Abigail (current student and focus group participant) is a twelfth grader who has participated in Science Olympiad since eighth grade. Fossils, Ping Pong Parachute, Geologic Mapping, Rocks and Minerals, and Dynamic Planet are Abigail's favorite events. When Abigail moved in eighth grade, Science Olympiad is where she felt that she found friends. That continued in high school. During the COVID-19 pandemic, Science Olympiad was Abigail's social outlet. Abigail spends her free time drawing. She loves to draw and explained that she sees architecture (her intended college major) as the perfect mix of STEM and art.

Alice (alumna and interview participant) is a recent college graduate with a major in Animal Science. Alice participated in Science Olympiad for three years in high school and then continued to participate in college as an event supervisor. Alice's older sister also participated in Science Olympiad in high school. Alice listed Ornithology, Materials Science, Forensics, and Fossils as her favorite events.

Camila (alumna and focus group participant) is a college graduate who participated in Science Olympiad throughout her high school experience. Rocks and Minerals, Material Science, Wright Stuff, Mission Possible, and Protein Modeling are Camila's favorite events. Post high school she helped run competitions as event assistants and supervisors. Camila is a software engineer and sees her time in Science Olympiad as a time that she was able to explore and experience other areas of STEM. Her family all work in STEM fields.

Claire (current student and interview participant) is a twelfth grader who participated in Science Olympiad on and off through middle school and high school until her eleventh-grade year when she became highly involved in Science Olympiad. Claire intends to major in Public Health in college and attributes finding her major to Science Olympiad. She listed Disease Detectives, Anatomy and Physiology, Write Stuff, Green Generation, and Dynamic Planet as her favorite events. Disease Detectives is the event she credits with helping her find her college major. Claire's parents both work in STEM fields but her older siblings are majoring in business.

Elizabeth (alumna and focus group participant) is in her third year of college majoring in Microbiology, Immunology, and Molecular Genetics. She participated in Science Olympiad throughout high school. Elizabeth's favorite events are Green

Generation/Ecology, Designer Genes, Microbe Mission, and Chem Lab. Her older sister, a medical doctor, also participated in Science Olympiad during high school. When Elizabeth's father passed in high school, Elizabeth expressed that Science Olympiad was a comfort for her and she found the support she needed there.

Emily (alumna and focus group participant) is in her first year of college and participated in Science Olympiad since eighth grade and has continued to work at competitions in college. Codebusters, Thermodynamics, Write It Do It, Wright Stuff, and Experimental Design are Emily's favorite events. Emily started in the Robotics club and a little bit of Science Olympiad, but then felt a stronger connection to Science Olympiad and became more involved. Emily's family does not work in STEM fields. Emily's college major is materials science and engineering.

Emma (current student and focus group participant) is a twelfth grader who participated in Science Olympiad since eighth grade. Emma listed Experimental Design, Balsa Events (bridges, towers, and boomilever), and Codebusters as her favorite events. Emma has been interested in constructing things throughout Science Olympiad. She developed her structures by studying theories and then applying those theories and making needed adjustments. Both of Emma's parents work in the STEM field.

Leah (current student and interview participant) is a ninth grader who started Science Olympiad in sixth grade. Leah's favorite events are Anatomy and Physiology and Write It Do It. Leah explained her family is a STEM family. Most of the family conversations center around STEM topics so she feels she has been exposed and pushed toward STEM her entire life.

Lily (alumna and focus group and interview participant) is in her first year of college and participated in Science Olympiad since eighth grade. Lily listed Forensics and Food Science as her favorite events. Lily comes from an immigrant family. While her family worked in STEM fields in Vietnam, they do not now. Lily is majoring in applied mathematics in college and is planning to teach mathematics. Lily stated that she loved the hands-on events where she could apply principles to different laboratory situations.

Madison (alumna and focus group participant) is a college graduate who is now a chemistry teacher and Science Olympiad coach. She participated in Science Olympiad throughout high school and was also involved in Student Government as a class officer. Madison's younger sister also participated in Science Olympiad. Madison's favorite events are Forensics, Write It Do It, and Ping Pong Parachute.

Maria (current student and focus group and interview participant) is a tenth grader who has been in Science Olympiad since sixth grade. Maria's favorite events are Write It Do It, Codebusters, Cell Biology, Designer Genes, and Experimental Design. Maria enjoys running and is involved in student government. Maria is an only child whose father passed away unexpectedly when she was a baby. Her mother, a software engineer, has shown her how education and determination make her a strong female. Maria is not sure what she would like to do when she grows up but is exploring law and STEM connections.

Naomi (alumna and interview participant) is in her second year of college majoring in business. Naomi listed Ornithology, Herpetology, Water Quality, and Microbe Mission as her favorite events. While her family sees her as more of a STEM person, she expressed that she did not see herself as a STEM person because she does not learn STEM topics quickly and easily.

Natalie (alumna and interview participant) is a college graduate and well established in her career as an accountant. Natalie participated in Science Olympiad all through high school when the studied team was in its infancy. Natalie was one of the members of the team that first qualified for the state competition. While Natalie listed Mousetrap Vehicle and Bridges as her favorite events, she explained that those were two that she really remembered. Natalie attributes Science Olympiad for teaching her how to learn and explore independently.

Olivia (current student and interview participant) is a tenth grader who has participated in Science Olympiad since seventh grade. Olivia listed Ornithology, Write It Do It, Forensics, and Thermodynamics as her favorite events. Her parents are divorced. She lives with her mother who is a history teacher, and she has a strained relationship with her father who is an engineer who works in the tech industry. She does not consider herself a STEM person, but does well in all her STEM courses and thoroughly enjoys participating in Science Olympiad. Olivia is a published author of a young adult fantasy novel and loves writing.

Sophia (current student and focus group participant) is a twelfth grader who has been in Science Olympiad since tenth grade. Sophia's favorite events are Disease Detectives, Protein Modeling, Anatomy and Physiology, Green Generation, and Chem Lab. Sophia extended herself from her typical peer group to join Science Olympiad and found a second group of friends. She expressed that she never felt torn between the two groups, but saw how she could have interests in multiple areas. During her twelfth-grade year, Sophia was asked to have a more prevalent role in her home taking care of her younger siblings while her parents dealt with illnesses of her grandparents. Sophia specialized in the biology events and her intended college major is Molecular and Cell Biology.

Victoria (current student and interview participant) is a tenth grader and has participated in Science Olympiad since sixth grade. Victoria's favorite events are Rocks and Minerals, Fossils, Thermodynamics, It's About Time, and Codebusters. Victoria plans to major in geological sciences and finds minerals fascinating. Her parents both work in STEM fields. Victoria sees being part of a team as one of her highest rewards of being in Science Olympiad.

Violet (alumna and interview participant) is a college graduate beginning a doctorate program in microbiology. Violet participated in Science Olympiad throughout high school like her older brother. In middle school Violet was adamantly opposed to doing Science Olympiad but then found she loved it when she tried it out. Violet listed Microbe Mission, Mission Possible, Write It Do It, Disease Detectives, and Wind Power as her favorite events. Violet explained that Microbe Mission and a summer program is how she has found her career path.

Protection of Human Subjects

Data was gathered in compliance with APA guidelines for research. Permission was obtained from the superintendent and the principal at the time of the study to conduct the study at the Bay Area High School. Letters from the superintendent and principal are found in Appendix F. In addition, an application was submitted and approved by the University of San Francisco's IRB before subjects were recruited. Before starting data collection, all participants had consent forms signed and on file. For high school students, the parents signed consents for their child to participate. The consent forms are found in Appendix G. Each subject's identity was kept confidential by using pseudonyms. Data was stored on a hard drive and backed up to a cloud-based server to maintain security.

Table 1. Interview Participant Demographic Profiles.

Name	Grade Level	Years in Science Olympiad	Ethnicity	Parent Education	Parent STEM Field Profession	Older Sibling (Field of Study)	College Major (Intended/ Declared)
Current Students							
Olivia	10th grade	4	White	Master's	N/A	No	N/A
Victoria	10th grade	4	Indian	Master's	Software Engineer, Data Analyst	No	N/A
Maria*	10th grade	4	Indian	Master's	Software Engineer	No	N/A
Claire	12th Grade	2	Indian	Bachelor's	Computer Science, Nurse	Yes (Accounting and Global Studies)	Public Health
Leah	9th grade	2	Indian	Master's	Engineer	No	N/A
Alumnae							
Lily*	1st year of college	5	Vietnamese	Some College	N/A	No	Applied Mathematics
Naomi	2nd year of college	4	Chinese	Some College	N/A	Yes (Marketing and Accounting)	Business
Natalie	College graduate	4	Chinese	Bachelor's	N/A	No	Accounting and Information Systems
Alice	College graduate	6	Chinese	Vocational Training	Accountant	Yes (Chemistry)	Animal Science
Violet	Graduate student	4	Vietnamese	Bachelor's	Software Engineering	Yes (Mechanical Engineering)	Microbiology

* Participated in both focus group and interview.

Table 2. Interview Participant STEM Profiles.

Name	STEM Circle	Top 5 Rewards	Lowest 5 Rewards	STEM Person Definition
Current Students				
Olivia	C	• Fun • part of a team • work with partners • work with coaches • work with a team	• win medals • name in paper • please parents • please teachers • meet students at other schools	Someone who's willing to experiment to find the workings of our world, and who wants to explore the sciences.
Victoria	F	• fun • learn new things • part of a team • learning scientific process • prepare for future	• please teachers • please parents • name in paper • meet student at other schools • compete	A STEM person would probably be someone who is interested in the STEM subjects and is good at doing whatever subject they're interested in. Someone who spends a dedicated amount of time each day to pursuing said STEM topics, such as participating in the STEM based competitions, clubs, and events in and outside of school.
Maria*	E	• prepare for future • learn new things • part of a team • fun • work with partners	• please teachers • day at university • please parents • meet students at other schools • name in paper	A STEM person to me is someone who associates with any field even mildly related to the topics in STEM (science, technology, engineering, math). I think a STEM person can be someone who is multifaceted, but their job involves STEM in some way. For instance, a navy officer who works on military technology, a musician who works with sound engineering, a STEM subject related teacher, etc. A STEM person is most likely a humanitarian who wishes to use his or her skills to improve the world around them and help others. However, a STEM person may also simply be someone who wants to earn a good amount of money and has skills in the department or is willing to learn whatever skills are necessary.

Claire	E	• learn new things • fun • make new friends • part of a team • work with partners	• please parents • please teachers • learning scientific process • day at university • meet students at other schools	A STEM person is someone who pursues their scientific interests while bringing change to the world. To me, they are someone that utilizes their scientific knowledge and intersects it with other problems in the world. They love science and remain innately curious.
Leah	E	• look good on college apps • prepare for future • please parents • make new friends • work with partners	• please teachers • learning scientific process • compete • meet students at other schools • win medals	I think a STEM person would be smart, analytical, logical, and driven.
Alumnae				
Lily*	G	• part of a team • fun • prepare for future • work with coaches • work with partners	• meet students at other schools • day at university • name in paper • learning the scientific process • compete	Intense, ambitious in finding opportunities toward STEM related occupations, sleep-deprived, self-conscious, relates their self-esteem to achievements, has a calling toward STEM subjects (whether that be from true interest, or because STEM is the moneymaker/family pleaser)
Naomi	B	• part of a team • fun • learn new things • work with friends • work with partners	• day at university • name in paper • please teachers • share ideas • please parents	Smart, interested in the subjects, willing to pursue, more logical and calculative thinker, more formal and follows a specific instructions/schedule (methodical)
Natalie	B	• Learn new things • work with a team • work with partners	• please parents • please teachers • day at university	• someone who majored in or works in the field of math and science (such as computer science, programming)

		• work with coaches • part of a team	• make new friends • name in paper	
Alice	D	• work with friends • work with partners • work with team • part of a team • learn new things	• name in paper • please parents • please teachers • prepare for future • share ideas	A person in STEM is someone who is part of sciences, technology, engineering, OR mathematics. Someone can be more involved in STEM if they're part of all the fields, but a person in any of the fields can be considered part of STEM. This is the loosest definition of a "STEM person" to me. Every individual is different. A person in STEM is likely typically decent in math, but that does not necessarily have to be the case. Some people can be really good at grasping concepts without math. For one, I am not someone particularly good at math, but I can definitely get behind the concepts. Equations are good but they don't give the whole picture at times. I would rather prefer to understand the phenomenon as a whole. This isn't to say that STEM people aren't good at liberal arts either. STEM people can be really eloquent in writing and can also be good at art. They are 100% creative individuals. Much of research is done with creativity at heart, finding solutions to problems that require creativity. It is a stereotype that people in STEM must suck at liberal arts, which is not true. I do love to do art and creative writing in my free time!
Violet	F	• Learn New things • make new friends • Fun • prepare for future • part of a team	• Name in paper • meet students at other schools • day at a university • please parents • please teachers	Someone who is heavily involved in and interested in the sciences, engineering or mathematics. Thinks like a scientist, is analytical, curious, wants to learn and understand how the world works through STEM. Enjoys discovery, solving problems, and creating and uncovering new knowledge.

Note. STEM circle A shows 0% overlap between "You" and "STEM Person", B: 5%, C: 20%, D: 40%, E: 60%, F: 80%, G: 100%.
* Participant participated in both focus group and interview.

Table 3. Focus Group Participant Demographic Profiles

Name	Grade Level	Years in Science Olympiad	Ethnicity	Parent Education	Parent STEM Field Profession	Older Sibling (Field of Study)	College Major
Current Students							
Abigail	12th	5	Taiwanese	Doctorate	Computer Engineering	Yes (History/ Education)	Architecture
Emma	12th	5	Indian	Master's	Microbiology, Engineer	No	Industrial Engineering and Operations Research
Maria*	10th	4	Indian	Master's	Software Engineer	No	N/A
Sophia	12th	3	Chinese	Bachelor's	Engineer	No	Molecular and Cell Biology
Alumnae							
Camila	College graduate	6	Filipino/ White	Bachelor's	Software Project Manager, Systems Engineer	Yes (Software Developer)	Computer Science
Elizabeth	3rd year of college	6	Chinese	Doctorate	Software Engineer	Yes (Medicine)	Microbiology, Immunology, and Molecular Genetics
Emily	1st year of college	5	Indian	Some College	Marketing, Accounting	No	Materials Science and Engineering
Lily*	1st year of college	5	Vietnamese	Some College	N/A	No	Applied Mathematics
Madison	College graduate	8	Chinese	Vocational Training	Accountant	N/A	Chemistry

* Participant participated in both focus group and interview.

Table 4. Focus Group Participant STEM Profiles

Name	STEM Circle	Top 5 Rewards	Lowest 5 Rewards	STEM Person Definition
Current Students				
Abigail	E	• learn new things • part of a team • fun • work with a team • make new friends	• name in paper • please teachers • please parents • win medals • look good on college apps	I do not know if it is because of the number of people I know that could be considered a STEM person, but I cannot pinpoint specific characteristics that could describe a STEM person, other than that they are people who are always excited to learn more about their favorite STEM subjects. I guess there is also the stereotype of a STEM person being more academically inclined and antisocial (nerd essentially); however, in my opinion, that does not have to be the case.
Emma	E	• prepare for future • learn new things • learning the scientific process • part of a team • make new friends	• name in paper • please teachers • please parents • look good on college apps • win medals	A STEM person is someone who is interested in and spends prolonged periods of time doing science, technology, math and engineering activities. A STEM person can think from an analytical point of view and has good problem-solving skills. This doesn't necessarily mean they can solve problems very quickly, but rather have the patience and tenacity to sit and think something through. STEM people are also curious which pushes them to learn more about the topics they are interested in.
Maria*	E	• prepare for future • learn new things • part of a team • fun • work with partners	• please teachers • day at university • please parents • meet students at other schools • name in paper	A STEM person to me is someone who associates with any field even mildly related to the topics in STEM (science, technology, engineering, math). I think a STEM person can be someone who is multifaceted, but their job involves STEM in some way. For instance, a navy officer who works on military technology, a musician who works with sound

				engineering, a STEM subject related teacher, etc. A STEM person is most likely a humanitarian who wishes to use his or her skills to improve the world around them and help others. However, a STEM person may also simply be someone who wants to earn a good amount of money and has skills in the department or is willing to learn whatever skills are necessary.
Sophia	E	• learn new things • work with a team • learning scientific process • prepare for future • fun	• name in paper • please parents • please teachers • meet students at other schools • compete	A STEM person is deeply curious, interested in learning new things that are STEM related, and unafraid to approach new theories or concepts that may challenge them. A stem person typically takes many classes related to STEM.
Alumnae				
Camila	F	• part of a team • fun • learn new things • share ideas • work with friends	• day at university • name in paper • meet students at other schools • compete • please teachers	A STEM person is an individual who has a curious mind for how things work on a lower level. The lower level includes the specific mechanics and composition of an object or idea. STEM people are problem-solvers who find satisfaction in the success of creating something complete or discovering the inner-workings of something. They are also directly involved in STEM fields. While one half of the definition of a STEM person is an inclination for STEM, a STEM person is primarily defined as someone who studies or works in a STEM field, regardless of STEM competency.
Elizabeth	G	• learn new things • make new friends • prepare for future • fun • learning scientific process	• please teachers • day at university • win medals • name in paper • please parents	A STEM person is one who prefers the hard sciences and hard skills such as programming, math, or chemistry compared to soft sciences and soft skills such as English, writing, and language. STEM people also tend to be more straightforward and to the point, as they rely more on concrete evidence as opposed to feelings to make decisions.

Emily	F	• learn new things • part of a team • share ideas • work with a team • fun	• day at university • name in paper • meet students at other schools • please teachers • please parents	A person who thinks logically and is more inclined to be interested in science and math as opposed to other topics. They are more interested in the physical world as well as how things function.
Lily*	G	• part of a team • fun • prepare for future • work with coaches • work with partners	• meet students at other schools • day at university • name in paper • learning the scientific process • compete	Intense, ambitious in finding opportunities toward STEM related occupations, sleep-deprived, self-conscious, relates their self-esteem to achievements, has a calling toward STEM subjects (whether that be from true interest, or because STEM is the moneymaker/family pleaser)
Madison	G	• learn new things • fun • prepare for future • part of a team • learning scientific process	• name in paper • please teachers • please parents • win medals • day at university	Someone who majored in STEM and is currently employed doing something related to the STEM fields. Someone who uses critical thinking and analytical skills on the daily.

Note. STEM circle A shows 0% overlap between “You” and “STEM Person”, B: 5%, C: 20%, D: 40%, E: 60%, F: 80%, G: 100%.
* Participant participated in both focus group and interview.

Instrumentation

Data was collected using three instruments: survey, interview, and focus group questions.

Survey

An online survey, administered using Qualtrics, was used to compile a purposeful sample of females to participate in interviews and the focus group. The survey included questions that addressed the following topics: demographics, perceived recognition, description of a STEM person, perceived rewards of Science Olympiad, and favorite Science Olympiad events. Table 5 provides an overview of the research questions, survey question topics, and sources. The survey questions are found in Appendix H.

Table 5. Overview of Survey topics and Research Questions Addressed

Survey Question Topic/ Area Addressed	Sources questions adapted or based upon	Research Question the Data will be used to address
Demographic information (e.g. # of years of participation in Science Olympiad, age, grade, gender)	Abernathy and Vineyard, 2001	N/A
Perceived recognition from different groups: peers, family, and teachers	Stringer, et al. 2020; McDonald, et al. 2019	1
Description of a STEM person	McGee-Brown 2013, Stringer et al. 2020	4
Rewards students value from participating in Science Olympiad	Abernathy and Vineyard, 2001	3
Favorite Science Olympiad Events	N/A	2

As part of the demographic information, a question was included about the length of time a student participated in Science Olympiad and how they viewed their participation in the organization. Additionally, the survey contained a question about the rewards students valued from participating in Science Olympiad. These questions were adapted from the study by Abernathy and Vineyard (2001). The rewards question was adapted to the proposed case study participants' experience at the competitions. For instance, Abernathy and Vineyard asked only about spending a day at a university. However, the competitions the proposed case study participants compete in occur at high school, community college, and university campuses, so the question was modified to more accurately reflect the participants experiences.

Both the survey and interview instruments contained questions that referred to STEM circles. These STEM circles, shown in Figure 7, were adapted from McDonald et al.'s (2019) STEM PIO-1 graphic. The study used the same seven circles, but "STEM professional" was substituted with "STEM person" because of the age of the majority of the participants. McDonald et al. examined the reliability and validity of the STEM PIO-1 on college students and found good correlations between previously used STEM identity measures. Previously used STEM identity measures typically employed five or more questions measured with Likert-type scales and then compiled into one measure (Stringer et al., 2020; Young et al., 2013).

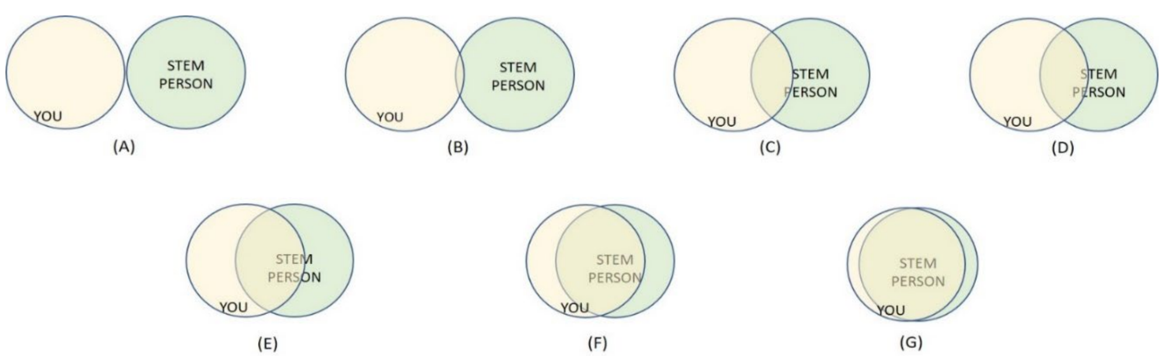

Figure 7. STEM circles used in survey and interview questions adapted from McDonald et al.'s STEM PIO (2019).

For the recognition component of STEM identity, I asked participants three questions to explore perceived recognition from different groups: peers, family, and teachers. These three groups are based on the study by Vincent-Ruz and Schunn (2018). Vincent-Ruz and Schunn (2018) probed about recognition by others using a four-point Likert scale with high reliability (Cronbach's alpha = 0.84). In the study, I combined the work from McDonald et al. (2019) and Vincent-Ruz and Schunn (2018) by asking about the groups that Vincent-Ruz and Schunn (2018) found to be important to high school students but using STEM circles based on the graphic of McDonald et al. (2019).
The one component of STEM identity that did not use the STEM circles is the perception of a STEM person. Asking for a description of a STEM person is aligned with questions asked of other Science Olympiad participants in McGee-Brown (2003). To measure the perception of a STEM person, I asked participants to describe a STEM person in the survey.

Interviews

Similar to Archer et al. (2017), the survey was used to develop a purposeful sample for interviews (*n* = 10) and a focus group (*n* = 9). The ten interviews explored why participants picked specific graphics and gave particular descriptions in the survey. While participants described a STEM person in the survey, the selected participants were asked to elaborate and explain their answers in a similar method that Archer et al. (2017) asked their participants.

The interview continued to explore the other components of STEM identity as defined by Kim et al. using the STEM circles. First, as previously explained, recognition by self and different groups are delineated based on Vincent-Ruz and Schunn (2018). I used the same set of graphics to measure the competence and performance components of STEM identity by altering the instructions to fit each component. McDonald et al. (2019) found good interrater reliability (α = 0.87) using the same graphics while varying the instructions to focus on each specific component of STEM identity. Additionally, I used the same structure to explore the interest component of science identity by relating the participant's interest in particular Science Olympiad event topics.

The interview also explored particular attributes of Science Olympiad. I developed the questions that dealt with specific features of Science Olympiad, consulting the few studies that have explicitly dealt with features of Science Olympiad and similar programs, specifically McGee-Brown (2003) and Sahin et al. (2015). Specifically, Sahin et al. (2015) asked questions that explored the benefits of a specific international Science Olympiad program. Sahin et al.'s (2015) questions produced high inter-coder reliability 0.85). Table 6 provides an overview of the research questions, interview question topics, and sources from the literature. The interview questions are in Appendix I.

Focus Group

The focus group was a group of nine participants comprised of both alumni and current students. I developed the focus group questions based on Adams et al. (2014). Similar to the participants in the Adams et al. study, the participants in the focus group have participated in Science Olympiad together. During the focus group conversations participants shared experiences in response to ideas they heard from others, they discussed identity boundary work (Carlone et al., 2015) and shared how they developed interest in particular STEM fields. Lastly, the focus group explored the rewards students find valuable in participating in Science Olympiad. Building on the questions designed

Table 6. Overview of Interview topics and Research Questions Addressed

Interview Question Topic/ Area Addressed	Sources questions adapted or based upon	Research Question the Data will be used to address
Perceived recognition from different groups: peers, family, and teachers	Stringer, et al. 2020; McDonald, et al. 2019	1
Description of a STEM person	McGee-Brown 2013, Stringer, et al. 2020	4
Perceived competence in STEM subjects	McDonald, et al. 2019	1
Perceived performance in using STEM skills	McDonald, et al. 2019	1
Perceived interest in STEM fields	McDonald, et al. 2019	
Rewards students value from participating in Science Olympiad	Abernathy and Vineyard, 2001	3
Favorite Science Olympiad Events	N/A	2
Reasons for participating in Science Olympiad	Sahin, et al. 2015	1, 2, 3
Influence of Science Olympiad on future interests/college majors	Sahin, et al. 2015	1, 2

by Abernathy and Vineyard (2001) and the work by Riegle-Crumb et al. (2019), I collected data about where the competition aspect of Science Olympiad lies on the continuum of desired Science Olympiad features. Table 7 provides an overview of the research questions, focus group question topics, sources. The focus group questions are found in Appendix J.

Procedures

Data collection occurred over eight weeks. The first stage was the recruitment and selection of the interview and focus group participants through an online survey administered through Qualtrics. First, an email was sent to all of the current Science

Table 7. Overview of Focus Group topics and Research Questions Addressed

Focus Group Question Topic/ Area Addressed	Sources questions adapted or based upon	Research Question the Data will be used to address
Descriptions of the role of Science Olympiad in their STEM life	Adams, et al. 2013	3
Development of STEM interest from identity boundary work	Carlone, et al. 2015	1, 2
Influence of the competitive element in Science Olympiad	Riegle-Crumb, et al. 2019	3

Olympiad parents, $n = 76$, to inform them of the study and ask if they would give consent for their student to participate. Students were informed through Google Classroom and other announcements to the team that their parents had received the email so that they could encourage their parents to respond. Parental consent was obtained through an online form administered through Qualtrics. Thirty-nine parents completed the parental consent. After parents had given consent for their student to participate, their student was sent an email with the online survey link and was asked to complete the survey. The first part of the online survey was a student assent form. The parental consent and student assent forms for participation are shown in Appendix G. Students whose parents did not sign the consent form were removed from the survey distribution. Additionally, a similar email was sent to all alumni in the Bay Area High School Science Olympiad alumni group, $n = 23$, to inform them of the study, invite them to participate in the online selection survey, and give consent to participate. In addition to the group of alumni that was registered in the alumni contact list, alumni were asked to reach out to other alumni to inform them of the study creating some snowball sampling. There were ten additional respondents to the selection survey that were not in the original alumni database indicating that other alumni that had not been in the original contact group received the invitation email. The consent form for the alumni is found in Appendix G. The selection survey was distributed on a Friday and remained open through Wednesday for five days. On the Monday and Wednesday following the distribution, a reminder email was sent with the link again. The survey closed on Wednesday night. After the survey closed, I analyzed the 58 responses to the online survey and selected possible interview and focus group participants. Invitations were sent out to 19 individuals to participate and schedule times for interviews and the focus group. Due to scheduling, two of the invited participants were unable to participate.

The ten interviews were conducted over two weeks. Interviews were conducted either on Zoom (n = 8) or in my classroom (n = 2), depending on the preference and location of the interviewee. Each interview was recorded. After the recording, I used *Descript* to transcribe the interviews for data analysis. *Descript* is an online tool for audio and video editing. One of the many features of *Descript* makes transcripts of recorded video and audio files. At the beginning of each interview, I reviewed the consent form. The interviewee was provided the questions before the interview and had a copy of the interview questions available for reference during the interview.

The focus group (n = 9) discussion occurred two weeks after the survey closed. The focus group discussion occurred on Zoom to allow participants who could not easily travel to the area to participate. The discussion was recorded and transcribed using *Descript* for data analysis. The focus group took approximately 100 minutes.

Data Analysis

The data collected in this study were survey responses, interview transcripts, and focus group transcripts. The survey data, as previously explained, served as a method of developing the purposeful sample and providing a starting point for some interview questions. As described earlier, the survey data was organized by question to select the sample. The interview transcripts were arranged in two ways using Microsoft Word (Meyer & Avery, 2009). First, the interview data was organized by the respondent. Secondly, I organized a duplicate set of interview data by question. For the focus group data, I organized the data by question using the same process as the interview data.

After organizing the data, I began the coding process described by Saldaña (2021) using the Atlas.ti program. I used the constant comparative method for data analysis. By comparing and contrasting the responses of one participant with another, I saw patterns that provided evidence for each research question. When developing the codes, I used an inductive coding process, allowing the codes to emerge from the data. Even though the codes were created as I analyzed the data corpus, the codes reappeared throughout the data and therefore became deductive as predicted (Saldaña, 2021).

The coding process took place in two cycles. The first coding cycle used in vivo, descriptive, and value coding techniques. In Vivo codes describe data in the participants' own words (Saldaña, 2021). In Vivo coding allowed the participants' voices to come through the data without dilution or interpretation. Descriptive codes describe the topic of the data, not the content (Saldaña, 2021). Using this coding process allowed me to find the ideas around STEM identity, personal specific STEM interest, and features of Science Olympiad that resonated with the participants. During the first cycle of coding, I also employed values coding. According to Saldaña (2021), values coding includes attitudes, beliefs, and values. Since research question four asked explicitly about the attitudes females in this Science Olympiad program hold about who belongs in STEM, values coding helped me discover the participants' attitudes and beliefs about STEM participation. The code book is found in Appendix K.

The codes were analyzed following the first coding cycle to highlight common themes throughout the data corpus. This step was followed by a second coding cycle to synthesize the data into findings (Saldaña, 2021). I used the second cycle coding process Saldana calls Pattern Coding. Saldaña explains pattern coding as a type of meta-coding, often using metaphors, grouping themes into larger patterns that are hypotheses of how the data relate (Miles et al., 2020). Saldaña cautions that some patterns will stick while others will be discarded as the data is analyzed. After establishing the patterns, I took each research question and looked for what patterns responded to each research question. A few patterns and codes were discarded as they did not answer a particular research question. Once the patterns were organized by research question, I developed themes in response to each research question.

When analyzing research question 1 about the development of STEM identity, I found eleven patterns that responded to the question. These patterns were then organized into four themes: (a) space for progression of identity and skill development; (b) Multiple identities; (c) Opportunities to express identities construct others' views of identity; (d) Rewards are necessary. While the research questions were not analyzed by specific interview or focus group questions, the data for research question one primarily came from the interview questions using the STEM circles outlined in Table 6 and the second question during the focus group as outlined in Table 7.

Seven patterns were used to answer research question two about specific personal STEM interest. The seven patterns were distilled into three themes: (a) interest is emotional; (b) exposure to a variety of topics is critical to fostering interest; and (c) interest develops over time with increasing levels of exposure. The individual interview questions about favorite events and how the participants found those events gave rich data for analysis surrounding personal specific STEM interest. Additionally, explanations of the participants' choices in college majors provided more data about interest development. The focus group discussion around favorite memories and events in Science Olympiad provided data for personal specific STEM interest development analysis.

Research question three, that focused on which features of Science Olympiad encouraged long term participation, was answered using data from individual interviews and focus groups. The data collected throughout the individual interviews and focus group was used to answer this question. However, specifically the individual interview questions about why the participants joined Science Olympiad and then describing how they dealt with challenges in Science Olympiad provided rich data for research question three. From the nine patterns that emerged from the data, three themes emerged: (a) the social component of Science Olympiad is imperative; (b) mentorship opportunities are crucial; and (c) gender representation is a vital feature of the studied Science Olympiad team. Additionally, the focus group thoroughly discussed the parts of Science Olympiad they found to be pivotal in their STEM identity development.

Research question four, about who the participants saw as a STEM person, was answered using data from the online selection survey, the individual interviews, and the focus group. Six patterns were distilled into two themes: (a) STEM people have specific characteristics, and (b) STEM people major in and have careers with titles in specific areas of STEM. The online selection survey asked the participants to describe a STEM person. Additionally, the individual interview participants were explicitly asked to expand on parts of their answers from the selection survey. Even though the focus group was not asked directly about the characteristics of a STEM person, the discussion had several references to characteristics they thought were essential to be a STEM person.

The findings of the study are presented in the following chapter. Those findings are organized by the themes that emerged in response to each research question.

Position of the Researcher

As I introduce my research, it is imperative that my position with respect to the research is delineated. As a female in a STEM field, I have arrived at my research topic not only as an observer but also as a one who has experienced the challenges of entering a male dominated field.

While in high school I was known as the “science nerd” in my traditional, rural community. Even though I took the math and science classes and did very well, inside and outside of school I was not encouraged to pursue these studies. In fact, when I took physics my senior year, I was one of two females in the class. I remember the challenges of the attitude from my teacher who made it evident that he believed females did not belong in the sciences despite the fact that the two females in the class were the highest performers. Leaving high school, I had no intention of pursuing anything in STEM. I did not see how those studies would be beneficial.

In college, I had to take the basic science and math classes for my general education credits and my Physical Science 100 class changed my attitude and view. It was my absolute favorite class and started me down the road toward becoming a science teacher.

Looking back on my road to becoming a science educator, I see how my stubbornness and wanting to prove people wrong was an asset to getting to where I am today. I know the roadblocks that were put in my way. Even though progress in the STEM fields has been made, there are still roadblocks for females to enter STEM fields, specifically the physical sciences and engineering.

As a STEM educator at the Bay Area High School where the study was conducted, I have noticed how the gap for female students in the physical sciences is not nearly as pronounced as in other locations. I am one of the coaches for the studied Science Olympiad program. As I have taken our school teams to competitions, I noticed the composition of the team was different than many. The team had a lot more female students competing in the physical science and engineering events. For many of the predominantly male events our team was composed of either half male and half female students or all female students. And when awards were presented, I would watch our female students stand up with all the other male students. I always had an immense pride in their accomplishments, but I have also asked what is so different about this group? What role is Science Olympiad playing in this difference?

To examine these phenomena, my sample came from the students that I interact with each year in Science Olympiad. One challenge with this group was presumably these female students were already interested in STEM. However, just because the female students are interested in science, does not mean they will study STEM in college or go into STEM careers, as shown by the data collected from the alumnae. The experiences female students have in a school setting, whether in classes or in extracurricular activities sponsored by the school, can either support or deter them from their pursuit of a STEM career.

Data collected was scrutinized, but I also worry that the participants responded in a way that they thought I would like them to respond because of our existing relationships. However, at the same time, I also believe that participants were more willing to open up and share experiences because of the relationship they had with me. I am a supporter of Science Olympiad and believe it is a program that can give female students STEM experiences that can strengthen their STEM identity, but as I started my research, I have been careful to take a step back and looked at the program with a critical lens.

CHAPTER IV:

FINDINGS

This study explored how long-term participation in a Bay Area high school's Science Olympiad program influenced female participants STEM identity and interest. Through ten interviews and a focus group, participants shared their perspectives on the program's influence on their lives concerning STEM. The study addressed the following four research questions:

1. How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?
2. How does participation in a Bay Area High School Science Olympiad program contribute to female students and alumnae maintaining and growing a personal specific STEM interest?
3. What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?
4. What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?

The findings of this study are presented in the following section by research question. Each research question is addressed by themes that emerged from the data corpse during data analysis. I will explain each theme, including subthemes and evidence to support that theme.

Research Question 1

Research question one explored the process of developing a STEM identity and the Science Olympiad program's influence on that development. To analyze the participants' STEM identity, the following overlapping circle diagrams shown in Figure 8, referred to as STEM circles, were used for the participants to describe their STEM identity in comparison to their view of a STEM person. The data refers to these STEM circles as the participants a method for the participants to describe their STEM identity. The more overlap between the "You" circle and the "STEM Person" circle, the greater the participants' STEM identity. Therefore, circles A and B were seen as having a low STEM identity while circles E, F, and G were seen as having a stronger STEM identity.

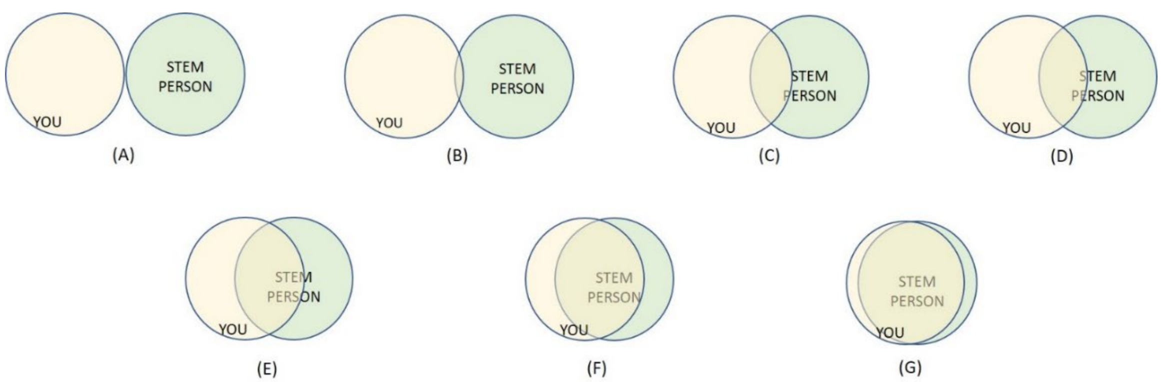

Figure 8. STEM circles used in survey and interview questions adapted from McDonald et al.'s STEM PIO (2019).

Four themes emerged during data analysis, along with several subthemes, shown in Table 8 and discussed in detail below.

Theme 1: Space for progression of identity and skill development

By examining the data from the focus group and individual interviews, all participants relayed the importance of having a safe space to develop aspects of their

Table 8. Themes for Research Question 1.

Themes	Subthemes
Space for progression of identity and skill development	• Safe space to explore • Confidence building • Contribution to the team
Intersectionality of identities	• Other identities • Development of various identities in conjunction with STEM identity
Opportunities to express identities influence others' views of identity	• Activities involved in • Relationship level • Opportunities available • Expectations of family and friends
Rewards are necessary	• Importance of winning medals • Learning skills and knowledge gained • Growth Mindset

STEM identity and the skills they perceived necessary to succeed in STEM fields. Three subthemes emerged through analysis: the need for a safe space to explore different aspects of STEM, confidence building, and being able to contribute to a STEM group by being a member of a team.

Safe space to explore

Participants explained that Science Olympiad provided a place to explore and develop their identity and gain skills. Seven interview participants specifically talked about how Science Olympiad allowed them to build their STEM identity by exploring new things. Additionally, the focus group had 17 specific mentions of developing STEM identity in Science Olympiad. Lily, an alumna who has just completed her first year of college, explained the following while the group discussed how Science Olympiad influenced what it meant to do science:

> It was Science Olympiad gave me the opportunity to do something that I usually didn't do. Cause all my events were like forensics and or at least

> the events I liked, they were very lab-based, and what I'm doing today is not lab-based. And so I think just doing in, like being in Science Olympiad itself, gave me the opportunity to do something that I wouldn't get to do at all elsewhere.

Camila, another alumna who was a recent college graduate in Computer Science, while responding to the same question, stated:

> I think the events also, like they really helped you open your mind because it wasn't like school where it's like, we're gonna learn this and this, it's you learned everything related to that subject. And I think that's really helped in college because it's like you have to do school to learn, not to just finish the assignment, and learning how to learn such a broad range of things was really beneficial to me.

Many of the other participants expressed sentiments similar to these. Science Olympiad gave them a place to explore things that have become part of their STEM identity that they did not have in other areas.

Additionally, the participants attributed Science Olympiad participation to developing specific skills. During the focus group, while responding to Science Olympiad's influence on the construction of her STEM identity, Emily, an alumna who was just completing her first year of college, stated, "I think that also helped me learn how I learn." Camila explained that her mind was "opened" because her exploration was not dictated by assignments to complete as in a traditional classroom, and "learning how to learn such a broad range of things was really beneficial to me." When Natalie, an alumna who is established in her career in finance and currently employed at a tech company, was asked about a challenge in Science Olympiad during her interview, she responded:

> I think something that I had to get used to, but I think that skill has been super helpful in school, like in college, and right now in my career because there's a lot that my boss doesn't teach me. My team doesn't teach me, and I just take the initiative to like learn things or figure things out on my own. So, I think that was a phenomenal skill to pick up.

While the idea of less guidance than the participants were used to getting in a traditional classroom was initially intimidating, as Natalie explained above, the participants consistently explained that developing their direction and exploring new things was imperative to their success in college and beyond. Madison, an alumna who is now a teacher and has returned to coach the studied team, in the focus group described her development in learning and doing science as:

> I think growing up, I was just very, I guess my parents have been really like traditional where it's like. You learn something, and then you apply it. And there's really no in-between, but for me now, it's you get to learn something, and it's just for fun; you don't have to like necessarily apply it anywhere. Like it doesn't have to be like necessarily useful in the real life, and so it's fun. It's like you get to explore new things. And so that's why or that's, I guess, what it means to me, for me to learn and do science.

The same applied to some of the students. For instance, Maria, a student who had just completed the tenth grade, added to the same discussion in the focus group:

> I think it really helps you realize because in, in school, you have physics, you have bio, you have chem, and then you have a couple science classes like forensics or biotech. But again, the range you get with Science Olympiad is not something you can get just like in your academic classes. And I think that's really cool.

Confidence Building

A subtheme prevalent in six interviews and the focus group was how participation in the Science Olympiad program built the participants' confidence in doing STEM, a part of recognition and performance. Emily, an alumna completing her first year of college, shared a particularly poignant experience when the focus group was asked about experiences that they felt shaped them:

> I think it helped build my confidence. And I learned, or it made me realize that I can do science too. Especially one time I was event leading, and I was in a lot of like physicsy events. Not a lot of girls, and I wasn't too confident either. I was trying to learn and teach other people. And that one week, my partner was gonna be gone. So I was like, all right, I'll take over. He was a little older too. So he would sometimes take over those slides. But I was like, I know the physics too; I can teach it. I'll be fine. But I remember I think he asked one of the students, like, oh, she needs help. Like, you can like sub in for me. And I thought that was weird, but I think the student also thought it was weird, so he didn't really do anything. And that class was really fun because I did a Quizlet or no, what are those things called where you like answer the questions or no, those things. And

> I was answering, going through every question. And I think I explained pretty well. So, after that, I was like, you know what? I can do this too. I'm pretty good at this. That's another thing that I remember. Kind of shaped me too.

Many participants shared similar experiences and described a time in Science Olympiad that gave them confidence in their STEM identity.

The feelings of confidence also expanded to outside of Science Olympiad. Camila expressed that her confidence in "talk(ing) to teachers in college" grew because she knew her "brain works. And it's like valid for me to have these questions." Violet, an alumna who has graduated from college, worked in the biotech industry and is preparing to enter a doctoral program in bioengineering, described her change in self-talk when she started something new in STEM due to her participation in Science Olympiad. When asked what leads to the feeling that she can be successful, she described,

> And every single time I start, I'm like, oh my God, I'm never gonna be good. I never don't understand any of this. But then I always get to the point where I'm like, no, I can do it now. I think. It's just an understanding that you've done it in the past. So just having more trust in yourself and that could take time, like you have to trust yourself and that comes with like, experience.

Contribution to the team

Another subtheme emerged: the females' contributions to the team were vital in building their STEM identity. Olivia, a current student who completed tenth grade, was one of the participants with a lower perceived STEM identity. She describes herself as not a STEM person and selected STEM circle C, the circle with 20% overlap, yet thoroughly enjoys and excels in Science Olympiad. When asked why she participates in Science Olympiad, Olivia said:

> I’ve never really thought of myself as like a science-oriented person. Mm-hmm but like the way that science Olympiad is set up, it, it makes me feel like I kind of am a science person. I, I mean, is definitely the community. It’s definitely the people who are in Science Olympiad and who, like a lot of them, are so supportive and kind, and it’s just wonderful to be around just knowing that there is something that I can do while not being, like, entirely good at it. I can still contribute.

When asked to describe what has made her believe she has a place in STEM, she further explained, “Just the fact. You know, I can do well in some of these events, and I’m going against people who probably like are, who, who have thought of themselves as science people. And it’s just like, I, I can do this even though I might not be the most science-oriented person.” Olivia went on to further explain that she has built her confidence by being a member of the team and seeing how her contribution to the team was a part of the team’s success. Abigail, a student who was just completing the twelfth grade and preparing to enter college, explained that “having community and connections [with the team] and the experience with science” increased her confidence in putting herself “out there” in the STEM world. Having a partner and a team that the female participants competed with instead of competing against others as an individual gave the participants a safe way to explore STEM and further develop their STEM identity.

Theme 2: Intersectionality of Identities

The second central theme that emerged from the data was that the participants did not feel their identities were exclusive to STEM. The theme of having multiple identities emerged when the interview participants explained why they chose the STEM circles (see Figure 8) that represented themselves. These other identities took away from their STEM identity.

Other identities

When the interview participants were probed about why they chose different STEM circles, they all described that the "STEM person" circle was exclusive to only STEM. The STEM person circle represented a singular identity; if they had other identities, such as social justice, it took away from that circle. For instance, Claire, a twelfth-grade student preparing to enter college, expressed, when asked about why she picked the STEM circle E, the circle with 60% overlap:

> I believe that a large part of me, like a large part of my life and my interests do revolve around STEM. Like, especially academically, that's probably the biggest part for me, but however, there's also like another part of me that's very passionate about like advocacy and social justice and et cetera.

Four of the interview participants talked about this same idea for themselves. Still, most participants discussed this idea when asked how their families, friends, and teachers saw their STEM identity. The following is how Olivia described her family's perception:

> I'm very, you know, engaged with my family, and they see me with Science Olympiad and, you know, doing that outside of school even. And

> so that would keep them from choosing a one with less overlap. But the reason they wouldn't choose one with more overlap is because, I mean, they, they know me, and they know that I'm not entirely STEM oriented at times. Like there are stuff that exists outside of STEM for me.

Similar to Olivia, the participants described how others saw them do other things besides STEM and felt that took away from their STEM identity.

Development of various identities in conjunction with STEM identity

The alumnae interviewed each expressed the desire to continue to develop their other identities along with their STEM identity. Especially with the alumnae, participants explained that their personal identities were still forming and their different identities besides STEM were still developing. Violet explained, "There's more to me than just my career in the academics…but they aren't fully finished. Okay. Like they're just not specific enough."

When the participants were asked about the role their STEM identity played in their lives, five talked about STEM being a significant character in the movie of their lives, and two spoke about STEM being a best friend that has a substantial influence on the main character. Natalie, one of the alumnae more established in her career, explained that her vision of her identity development was similar to the portrayal of emotions in Pixar's movie *Inside Out*. She explained,

> I feel like kid me, there's all the different, like, characters in my head, like the STEM, the finance, like, like everything in there and they're all like equal, they're all kind of exploring the world, like as a toddler, just you know, figuring things out. And then by high school, it's like, okay, really?

> Some characters start to become a little more dominant. And so they're still testing things out, but like the STEM character, the STEM person is. Trying things. And it's interesting, but it's like clearly not their strength. And so they shrink a little bit. And then business, the business character, try a little bit. It's like, oh, this is interesting. And, like, I'm not too bad at it. And so, like, that character gets a little bigger. And then in college, I envision, like, because I majored in accounting and information systems. Finance business character in my mind gets even bigger and stronger. And then the STEM person stays roughly the same. Maybe doesn't get smaller, but like, it's still kind of there, but the dominant character would still be like the finance, the business person.

Each identity grew in different ratios. Natalie's description was mirrored in several of the alumnae's responses.

Theme 3: Opportunities to express identities influence others' views of identity

Participants completed a survey and were asked to select an image using the STEM circles, shown in Figure 8, to better understand how much overlap they viewed themselves as having with a "STEM person". In addition to selecting an image that represented how they viewed themselves, they were asked how much they thought others (family, friends, and teachers) viewed them as a STEM person. Participants could choose from seven STEM circles, which were labeled from (A) to (G), with (A) being no overlap between the individual and a "STEM person" and (G) representing complete overlap between themselves and a "STEM person". Thus, those who chose images (A) or (B) would be characterized as not strongly identifying as a STEM person, as opposed to an individual who chose image (E), (F) or (G) – could be characterized as someone who strongly identifies as a STEM person.

Table 9 provides an overview of each participants' STEM circles selections, while Figure 9 shows aggregates of the participants' STEM circle selections. The first chart shows a distribution that includes higher STEM circles (E)-(G) overall due to the selection criteria of the focus group. The focus group participants all had STEM circle selections between (E) and (G). Although the sum of (E)-(G) STEM circle selections remained generally consistent between family and friends, the highest STEM circle (G) increased from 18% for self to 35% for the family to 47% for friends. While the teachers' (G) STEM circle remained constant, the (F) STEM circle increased to 35%. Overall, the sum of those who chose the STEM circles (E)-(G) stayed consistent through each group but redistributed toward the higher STEM circles for the family, friends, and teachers' perceptions of the participants.

When the participants chose the STEM circles to reflect their perceptions of their STEM identity and others' perceptions of their STEM identity, the data often showed a mismatch between the participant's and others' views of their STEM identity. Only one of the participants chose the same STEM circle for themselves, their family, friends, and teachers. Sixteen participants showed at least some variation between their perceptions and others' perceptions of their STEM identity. Four participants felt that their family saw them as much of a STEM person as they did, while nine felt their family had a perception of only one graphic different from theirs. The difference was not consistently above or below the self-perception graphic. Friends closely mirrored the data for family perceptions, with four participants choosing the same STEM circle and nine choosing one

Table 9. Participant STEM Circle selections.

Participant	Self STEM circle	Family STEM circle	Friend STEM circle	Teacher STEM circle
Violet (Alumna)	F	E	G	G
Madison (Alumna)	G	G	G	G
Camila (Alumna)	F	G	G	F
Natalie (Alumna)	B	A	A	B
Alice (Alumna)	D	D	D	C
Lily (Alumna)	G	G	G	E
Naomi (Alumna)	B	D	C	C
Elizabeth (Alumna)	G	E	G	F
Emily (Alumna)	F	G	G	G
Olivia (Student)	C	C	B	D
Maria (Student)	E	F	F	F
Claire (Student)	E	F	D	E
Sophia (Student)	E	G	F	F
Leah (Student)	E	G	G	F
Abigail (Student)	E	F	F	E
Emma (Student)	E	F	E	F
Victoria (Student)	F	E	G	E

Note. STEM circle A shows 0% overlap between "You" and "STEM Person", B: 5%, C: 20%, D: 40%, E: 60%, F: 80%, G: 100%.

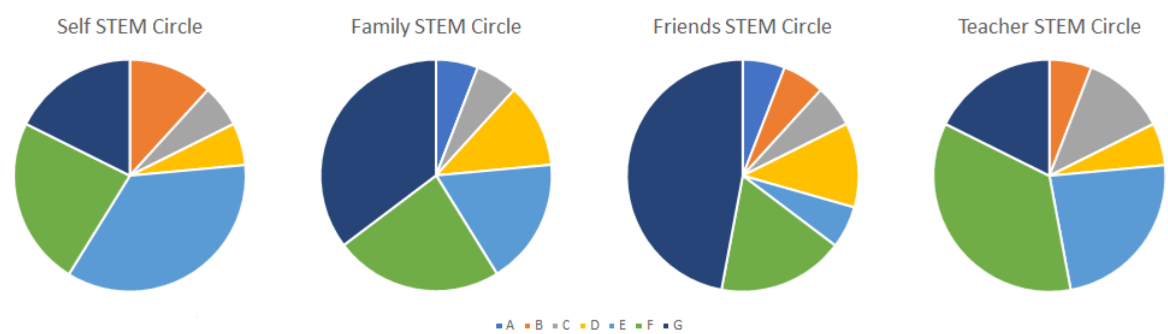

Figure 9. Aggregated STEM circle selections.

circle above or below their chosen STEM circle. There was also variation between self-perception and teacher perception. Five of the participants chose the same circle for themselves and how they thought their teachers perceived them. The differences between the STEM circle selected for themselves and the one chosen for their teachers were one STEM circle different except for one participant, Lily, who chose a STEM circle (E), the circle with 60% overlap, for how she thought her teachers viewed her, which was two below her self-perception choice (G), the circle with 100% overlap.

As stated above, recognition of a participant's STEM identity by others did not always match the participant's self-perception. This difference was dependent on several ideas: the activities the participant was involved in, the type of relationship between the participant and the other person, what opportunities are available to the participant, and the expectations of the other person for the participant.

Activities involved in

Outward expressions and activities that a participant is involved in are how others develop their perception of a female participant's STEM identity. For example, Naomi, an alumna who completed her second year of college as a business major, picked STEM circle (B), the circle with 5% overlap, as her own STEM identity, but (D), the circle with 40% overlap, for how she thought family saw her, and (C), the circle with 20% overlap, for how she thought friends and teachers saw her. When asked why she thought her family would pick STEM circle (D), the circle with 40% overlap, Naomi explained, "They (family) pretty much see Science Olympiad as my defining trait in high school…So I think they expected me to major in something in science as well, but I didn't." Alice, an alumna who recently graduated from college with a degree in animal science, when asked why she picked STEM circle (C), the circle with 20% overlap, for her teachers, explained, "Teachers don't actually see me like outside their classroom that much," so the other subject matter teachers do not realize what STEM she is doing. Victoria, a tenth-grade student, when asked why she chose STEM circle (G), the circle with 100% overlap, for her friends' view of her, focused on their perceptions and explained:

> So just based on my outlook, towards my friends, like the things that they see me pursuing, they put me down as more of a STEM person than I am because I don't always tell them, like, I don't always share how…interested I am in other subjects as compared to STEM, because it's just easier to fit in with like the STEM perception, cuz that's been going so long and it's not entirely wrong either, but it's just, they don't know the full workings of what goes on behind the scenes.

When others see these participants involved in more STEM-based activities, like Science Olympiad, others see them as having more of a STEM identity. A student, Olivia, explained that teachers saw her as more of a STEM person based on their observations. She explicitly noted, "And Spanish, but only because she would see me coming through with my (ornithology) binder."

Relationship Level

For the participants interviewed, the importance placed on how others perceive their STEM identity is based on their relationships. For instance, when I asked Naomi, an alumna in college, how important it was to her if her teachers saw her as a STEM person, her response was, "Honestly, not really…I'm not close to any of the teachers at college." However, Victoria, who works in the STEM field, was very concerned that her boss and colleagues saw her as a STEM person. Natalie, who works at a tech company, explained that even though her family and friends would not see her as a STEM person at all, her boss or teacher equivalent would be more apt to label her as more of a STEM person because of her role in her team at work. Each student participant spoke about the value of their teachers' views depending on the subject the teacher taught. Most described a greater need for acceptance as a STEM person by their STEM teachers.

Opportunities available

The STEM circle the participants chose to represent how they perceived their family, friends, and teachers saw them depended on the opportunities the participants had to express different aspects of their identity. Lily explained, "I believe it's just that growing up in Silicon Valley. You have so much STEM resources around you. It's hard to avoid it." Maria related this to classes in school also:

> I'm mainly interested in STEM, I think. Okay. I think because I've been doing mainly STEM-based activities, but also in our school. Options for classes is very like the I've been in, in accelerated math programs. And then in terms of APs and stuff, I am taking AP chem, for example, next year. And I did honors chem this year. And so, whereas for English, for example, it's very, it's English is just like 1A, 2A, like there's no there's no option to accelerate in. So I see why people would think of me as more of a STEM person because most of my classes, in terms of classes that I'm taking advanced courses in, are STEM-related.

Most participants discussed their opportunities in their schooling to take advanced coursework in STEM areas.

Expectations of family and friends

Another part of how the participants saw their STEM identity and felt their family and friends saw it was based on expectations. Due to their background or what they had done in the past, the participants thought they were expected to be STEM people. Victoria, a tenth-grade student, said, “I come from a STEM-based family.” Leah stated, “My family, in general, we’re like a very like math and science-oriented family…They see me more of a STEM person.” The participants, who identified the higher STEM circles for themselves and their families’ perceptions, each volunteered information about the conversations that tend to occur in their household are about STEM, so they are surrounded by STEM in many aspects of their life.

Additionally, the participants recognized that their family backgrounds were part of why they were seen more as STEM people. Lily, another alumna, stated, “Not a lot of my family members ever do something non-STEM related.” Violet, an alumna getting ready to pursue a doctorate in a STEM field, stated, “I saw them (my family) in, like a STEM area, and it’s like, I was like, okay, I’m also gonna be in a STEM area.” Several participants labeled STEM as their family business, but the family vision of STEM is often narrower than what the participants felt. For instance, Natalie explained,

> They also think STEM as like hardcore computer science. Like if you’re not computer science, like you’re not like coding and whatnot, you’re not STEM like, eh, and they, I think they hear the accounting part of my major more heavily than the information system side. And so it’s like, oh yeah, she’s in accounting. She’s in business. It’s not really like a STEM major.

While many participants pointed out that the family expectation played a significant role in their STEM identity, Maria also pointed out that her ethnicity was a big part of the expectation, “…if you’re Asian, most people just assume you go into STEM.” Victoria, a tenth-grade student, explained that others adopted her expectations:

> And now it's just become a part of my identity because, you know, it used to be like, oh, I'm doing Science Olympiad. And now it's like, oh, I'm definitely doing Science Olympiad. And then people kind of, it's kind of like expectations that you have for yourself and other people start having for you.

Theme 4: Rewards are necessary

For these participants to develop a strong STEM identity, the data suggested rewards were an integral part. However, the rewards that the participants mentioned were not always extrinsic. In fact, the longer-lasting rewards the participants reported were intrinsic in nature.

Importance of winning medals

During the focus group, the participants repeatedly mentioned medals won during competition as helpful in building their confidence. Still, as they reflected on their Science Olympiad experience, the medals became less important. Camila, an alumna, explained, "I think it's really interesting that, like, all of you guys are listing the medaling as your core memory. Cause four years out now, I don't remember the medaling at all. Cause I remember in the moment, I guess, like the feelings. Great. But now I barely remember me medaling." Multiple participants repeated Camila's explanation of liking the feelings in different ways. While the medals gave some affirmations at the moment, after the competition day, the affirmations changed. Madison, another alumna, stated, "…the day of the competition, the competing aspect does obviously take a big factor, but after the fact, like after you compete, after, everything settles down for a little bit when I really think back to it that's when I realized the competing aspect, isn't really a big part of it." Lily, an alumna in her first year of college, expressed her perspective on medals:

> I think the medals is like a good way to say oh, your hard work is paying off, but it shouldn't be the main or the soul. Results of hard work is like part of it, but it should only be a minor part of it…Remind me that the fact that we see the medals more like achievement, not as the main aspect is more about what you learn. Help me in class as well. An aspect that I stopped comparing myself to others as much like you. I focused on how I was doing.

Maria explained that medals were more of an extra confidence builder than what the participants had to have, saying, "The first time medaling for both those times was like, okay, so at least I know that. Like I can do this because if I've done it once, then I think I can do it again. It was like that mentality that you had to find."

Learning skills and knowledge gained

As the participants thought about the rewards they gained through participation, many focused on the knowledge and skills they gained as they competed as a bigger reward than winning a medal. Claire, a twelfth-grade student who is planning to major in public health, stated:

> I think this year, I actually didn't medal in any of my study events, which was definitely hard. Cause I put a lot of effort into it. But at the same time, like this is something I had to tell [my partner] a lot too. Like our progression was very noticeable. It was just like, the competition just kept getting tougher. Like, in all honesty, it's I feel like it was just the regions

> were in, but like, we definitely were doing a lot better than we were at the beginning of the season. And that's what kept me going…just seeing myself improve, like I know deep down like I did better. I saw my scores go up for my sections, so that did; I didn't need the medal.

The sentiment became a recurring theme as participants considered what they gained in Science Olympiad. Leah, a ninth-grade student, further explained, "part of it is that I really enjoy science in general. Like learning new things is very fun for me. Like it's a rewarding process."

Growth Mindset

During the focus group, there were eight specific mentions of developing a growth mindset as a reward for participating in Science Olympiad, which increased their STEM identity. Similarly, eight of the ten interviews referred to measuring their success by how much they were learning and growing, a fundamental idea of a growth mindset. Abigail, a twelfth-grade student, explained when the focus group discussed the role of competition in Science Olympiad:

> This test score was better than the last one. And that's great for me cuz I've learned something and I've grown and I stopped comparing being like, Hey, even like my test score is not as high as someone else's. That was not a thing. I stopped doing that after learning and seeing our mindset in science; it became more about how am I doing rather than how am I doing compared to everyone else.

Participants related that the specific program focuses on personal growth and enjoyment of the subject, which made the competitions less stressful and more fun. Specifically, an alumna, Emily, shared, “I think it also has to do with the [team] culture…We just want you guys to have fun. The end result doesn’t matter. And even though everyone’s still thinking about medaling, it was nice to have that culture of it doesn’t matter how I do in other people’s eyes.” While participants acknowledged the focus shifting to a growth mindset instead of only winning was critical for their enjoyment, they also explained how having the competition element was helpful. Madison, an alumna and college graduate, said,

> In college, you can see the amount of people in those intro classes, and those numbers drop dramatically in your second year of college with just a lot of the classes like you could start off with…it was crazy to see the numbers drop. And so you can see like how competitive it is, but and a lot of people, I feel like, do STEM thinking that they’re really good at STEM. And then when they realized they weren’t really good at STEM or there was a class that always stumped them, they end up just dropping out of it because they’re like, oh, it’s not for me. But like with the competition element in Science Olympiad, it helped me realize yes, it’s hard, but if I can learn something and if I tried, then that’s fine. And so it allowed me to stick through a lot of the classes that were considered like hard for me at least. And see it through the end.

Summary

According to the data, participation in a Bay Area Science Olympiad program influences female participants’ STEM identity. The participants related that Science Olympiad was a space for them to develop their STEM identities and skills to participate in STEM. Additionally, participants described how they see STEM as only part of their complete identity, an integral part for those with a higher STEM identity. However, those other parts of their identity detracted from what they thought a STEM person should be. Science Olympiad provides a place for the participants to express their STEM identity so others can recognize that part of their identity. Lastly, for a STEM identity to flourish, rewards are crucial. However, those rewards need to be balanced between extrinsic and intrinsic rewards.

Research Question 2

Research question two explored how participation in a Bay Area Science Olympiad program influenced personal specific STEM interests. Three themes emerged during data analysis, along with several subthemes, shown in Table 10 and discussed in detail below.

Table 10. Themes from Research Question 2.

Themes	Subthemes
Interest is emotional	• Interest leads to desire to spend more time • Positive emotions
Exposure to a variety of topics is critical to fostering interest	• General STEM interest is different from specific STEM interest • A variety of events allow for variation in interest • Accidental and assigned events help find other interests • Events help career and college major decisions
Interest develops over time with increasing levels of exposure	• What you are exposed to determines your interest • Deep dives help develop a more profound interest

Theme 1: Interest is emotional

Interest was explored by asking participants about their favorite events and explicitly asking them to rank their interest level using the STEM circles. The participants described their interest in STEM topics using words that describe emotions, as shown in Figure 10. Interest captivates attention, and positive emotions are felt were two subthemes that emerged through data analysis.

Figure 10. Emotions participants used to describe interest.

Interest leads to desire to spend more time

The participants explained that as their interest grew, they would want to spend more time learning about a specific topic. They would look to understand anything and everything they could find about the topic and spend as much time as they could exploring different aspects of the topic. Violet, an alumna, explained the progression of her developing interest in microbiology:

> I really love microbiology. You're just like, this seems cool. And then you do it, and you're like, this is now, it's like, this is what I to do. This is like something. And then, like you become engrossed in it.

Lily, an alumna, described wanting to spend more and more time learning about the STEM topics she found the most interesting:

> The aspect of science was also pretty intriguing, or at least the parts that I enjoyed; there were a couple that were not my cup of tea that I didn't have much motivation or discipline to do, but the ones that I was super into I wanna spend all day in it. I would not mind spending all day with it.

In response to another question about her STEM identity concerning doing STEM, Lily explained the connection she saw between time and interest:

> I just would spend like hours just in, in the corner of your it's literally in the corner of your room just touching different powders, and oh, this is grainy, or this is soft or this…and so I think having that hands-on aspect, plus being able to regurgitate information to other people that is what helps me learn a lot and become really interested into STEM.

Many participants described the time they would spend doing their favorite Science Olympiad events and its relation to developing a deep interest in the topic.

Positive emotions

When the interview participants described their interest levels in response to the questions about interest in STEM topics and their events in Science Olympiad, they related feelings of joy and happiness. Alice, a recent college graduate, when explaining what she found interesting about one of her favorite events, ornithology, that she had written tests for competitions, said:

> So, you can actually see some of the birds like around all the time. And I just thought it was really cool that I could just, I would be writing a test, and then I would just look up and be like, oh my God, that's actually a bird that I was looking at!

Alice described the excitement of seeing what she had been learning about in the world around her. Claire, a twelfth-grade student, expounded on that joy and excitement when she stated:

> I realized I really enjoyed learning about it and also taking tests much more than I expected about STEM topics, and like every single competition, like the test on there, the information that was on there, what I learned was just fascinating. Like there was always something new to learn, and I really liked that part of Science Olympiad.

When participants described the events they classified as their favorites, many described the same joy and happiness as Alice and Claire did.

Theme 2: Exposure to a variety of topics is critical to fostering interest

In the data corpus, the participants repeatedly responded to the questions about their interest in STEM, explaining that their Science Olympiad was crucial for developing a personal specific STEM interest because of the variety of opportunities. Four subthemes emerged: (a) STEM is vast, so interest in STEM is different from an interest in particular areas of STEM; (b) variety in the events that Science Olympiad has allowed for diverse interests to develop; (c) events that the participants were asked to participate in, even though they did not select the topics in their initial registration for the team, helped them develop different interests; and (d) the events that the participants participated in during Science Olympiad helped many participants choose majors and careers.

General STEM interest is different from specific STEM interest

During the interviews, participants were asked about their interest in STEM in general (interview question #8) and then asked about their interest in specific areas of STEM (interview question #9). In addition, the survey asked participants to rank their interests using the STEM circles. Generally, participants showed a greater interest in a particular topic in STEM than in STEM overall. When asked about their specific STEM interest, when compared to their responses about their interest in general STEM, seven participants responded with higher STEM circles, two responded with the same STEM circle, and one participant responded with a lower STEM circle. Table 11 shows the responses of each interview participant.

Table 11. STEM circle interest responses for interview participants.

Participant	General STEM	Specific STEM/Event
Alice	E	G
Claire	D	D
Leah	F	G
Lily	C	E
Maria	F	G
Naomi	D	G
Natalie	E	D
Olivia	D	F
Victoria	F	G
Violet	F	F

Note. STEM circle A shows 0% overlap between "You" and "STEM Person", B: 5%, C: 20%, D: 40%, E: 60%, F: 80%, G: 100%.

When asked about general STEM interest Lily, an alumna who had just finished her first year of college, struggled to pick a STEM circle. She explained:

> For example, comp side, Not interested. Hate coding. Cannot. I took a comp sci class last semester because I thought that maybe it would be okay and I was already hesitating to begin with. Cause I already knew that I wasn't that interested in coding, but I figured why not try because a lot of different majors do require some sort of like coding class. And also, coding's a really good skill to have anyways. Didn't like the class whatsoever, and so interest so low. But then, like interest for other STEM subjects are really high. And then I think all the others, they vary, right? It's like physics is higher than like chem and bio, but that doesn't mean chem and bio are low. That just means that they're just a bit lower than the other subjects. And it's between those range because it's not like it's not like A and B where it's very little, but it's not like F and G where it's a lot. I feel if I can quantify the amount of subjects that are in STEM, I feel like half of them, I would be super interested, and the other half would be a little more meh. And then, like, maybe a couple would be, like, down right no, but it's very in between there. I can't quantify it so well.

Lily's response when asked about her interest specifically in specific areas, she stated:

> I think that someone who's really interested into forensics and food science and or food science would probably spend a lot more time looking into those subjects than I did or I currently do. But it's also because, like someone who, because forensics, food science are things that I have

> interest to, but it's not what I'm studying. And so, I'm placing my time on the things that I am studying, but that doesn't mean I lost interest in them. Like I have a bunch of like scientific cookbooks that go over food science at home, and I would read them in my free time.

Olivia, a tenth-grade student, responded similarly to both questions. When asked about general STEM interest, she explained, "Probably closer to (D). Okay. Because I, I, I tend to focus on specific areas like with, you know, Ornithology or, I don't know, forensics. I, I. mm-hmm, like my work in those specific areas." But when asked what would change if it was just the areas she was interested in, her STEM circle selection went from (D), the circle with 40% overlap, to (F), the circle with 80% overlap, and she stated, "Because once I like to have a specific area and I hone that, I feel more like a STEM person then." When Olivia was asked if I changed the STEM person to an ornithologist, she excitedly stated that she would select "(G), really!" referring to the circle with 100% overlap.

A variety of events allow for variation in interest

Through examining questions asked in the focus group and interviews about Science Olympiad's role in their life and finding majors and interests, participants recounted that the variety of events offered in Science Olympiad allowed them to explore many different areas of STEM and find the specific areas of STEM in which they then developed personal specific STEM interest. Violet, an alumna, when asked about the role Science Olympiad played in her major choice, relayed, "It was just like the experience of like such a broad range of science topics. And just let me get a feel for like how each of them were and which ones of them I was most interested." Maria, a tenth-grade student, recounted:

> Cause I remember having this conversation with [another student] and I was like something that's interesting about Science Olympiad is it tells you, it shows you what you kind of, it shows you what you're interested in, but it also shows you, it also helps you decide. It's like, okay, this is not for me. Like this is something that's not for me. And so I feel like that. Yeah, that's kind. How it's also impacted my life.

Madison, an alumna who has returned to Science Olympiad to coach, related how Science Olympiad helped her in contrast to the science courses she took in school:

> The courses that were offered at [the school] when I was in high school, actually wasn't as diverse as the courses, the science courses were offered now. So really, I went like a very traditional path where it's Bio, physics, and then chem and AP bio or AP chem without being able to explore the other sciences really. And so with Science Olympiad, it actually allowed me to be able to do that and figure out what I like and what I don't like. Just because I thought I was gonna be very interested in anatomy and physiology. And I know there was a class at [the school] for it, but I just didn't have time to take it. But I got to do that in Science Olympiad. And I realized I actually didn't like anatomy and physiology. And so that actually helped narrow it down a little bit for me and just figure out like what I like and what I don't like.

Most participants related experiences where they found topics that interested them in Science Olympiad, whether those became majors or careers or if they were just hobbies.

On the flip side, multiple alumna participants related they found things that did not interest them and steered them away from certain majors in college, similar to Madison.

Accidental and assigned events help find other interests

When the teams are constructed with 15 members, there are many times that certain events need another person, and team members are asked to compete in those events for the team. The participants described these as accidental or assigned events. Many times, when the participates were asked to explain how they found their favorite events and the topics that interested them the most; many described these accidental or assigned events. During the focus group discussion about key memories of Science Olympiad, Lily, an alumna, responded, "A lot of events I was thrown into. I ended up liking it. Some events were like neutral and other events were like, Ooh." Alice, another alumna, during her interview when discussing her favorite events, stated:

> As a competitor, I think my favorite one was material science, but that's, I think that's mostly because of how we ended up being assigned. Like I think if I got to do other events, maybe I would've liked them more, but because of how we were assigned. Which is understandable, obviously, because you wanna assign for like people who know what they're doing and will medal and stuff. I ended up becoming doing material science and I found that I liked it a lot. I guess I just never thought about how like, materials actually work. And it was very applicable.

Alice did not end up majoring in material science but found it interesting and did well with the event. Maria, a tenth-grade student, described her finding one of her favorite events, Codebusters, an event in cryptology, by saying:

> I think I was given code. And it was just a scheduling, like they had to I didn't have it for Saturday school last year. I was given codes just as like, We really need you to sub in for this event or something at one of the competitions. And so I that's how I went for codes. And so, okay. Had like a week prior and I think it was [another student] was just like, I'm okay, well, we'll get on a call and I'll teach you all the different ciphers and stuff. And so, we went through it and I was like, cryptography is so interesting. Cause it's like, it's very cool. It's very. I don't know, just it's one of those things that, that it's not tedious at all. Like you it's, because it's new, it's something different every time. It's not even if it is like memorization, like, it can be really fun. Like when you're asking about decrypting, certain messages or encrypting certain messages, I think it's that feeling of satisfaction when you're like done with it.

While Maria talked about Codebusters and cryptology in her interview, the excitement oozed from her words about this event. When the focus group was asked why they thought the accidental or assigned events were so interesting, Emily, an alumna, described why she felt the assigned events evoked interest for her:

> I also think it's different competing in an event for Science Olympiad and being in it for Saturday school, it's a different goal and a different environment. And then you learn different things, but I don't know if it's just because I chose bad events for myself, but I don't know. I was just exposed to more. And I was like, oh, this clicks or some random events I would just be good at.

While the focus group or interviews did not continue to probe deeper with the idea of different goals or environments' effect on interest specifically, they did discuss these areas in what made Science Olympiad a place they wanted to be. This is discussed further in research question three.

Events help career and college major decisions

In participant interviews, the twelfth-grade students and alumnae were asked about the effect they thought Science Olympiad had on their college major and career choices. Most participants felt that Science Olympiad had an effect, some stating that it steered them away from STEM majors. Both of the alumnae who chose lower STEM circles to represent their STEM identity explained how their experiences in Science Olympiad steered them toward business majors. Natalie, an alumna who now works in finance at a tech company, stated:

> Yeah, I think it did have a little bit of like, an impact in what I chose as my major, cuz I ultimately went and majored in accounting and information system. So not traditional, like computer science or like chemistry major. And I think at that point when I was applying to college, I was thinking about the experiences I had in high school. And I think Science Olympiad was one of 'em. What I, when I was thinking through that, my experience in Science Olympiad, I was never really like super strong in any category. I mean, it was fun to like, for example, like work on the mousetrap vehicle, but I never felt like it came naturally to me. And so that's when I was like, oh, I don't know if these STEM majors are for me. And so that's kind of why I went towards more like accounting and business stuff.

Natalie’s college major and career focus is in the information systems side of finance, which has a STEM influence. Naomi, another alumna majoring in business, stated:

> I guess for the negative side, it definitely steered me away from like biology, chemistry. I was like, oh, I’m definitely not more suited for that because I can’t handle all the memorizations and formulas. I did think about doing like, like animal sciences or life biology, just because I like animals, but I didn’t think it was really a good time or optimal for me at the moment. So, I ended up like choosing business.

However, when Naomi was probed about whether she felt that the skills she gained were imperative in her major. She stated, “I think like being a captain has definitely helped me with like reading, communicating with people, for sure. And I think like, just being in Science Olympiad has helped me understand like other fields more.”

Several other participants were on the other end of the spectrum because Science Olympiad helped them discover their major. Violet, an alumna starting a doctorate program in biomedical research and engineering, explained the role Science Olympiad played in her journey to her program:

> I think that maybe came into the part of me being more like how Science Olympiad had helped me figure out what things are more inclined to do is that like, I feel like I found it a lot easier for me to like, understand topics. In certain events like Microbe Mission or whatever, and maybe that ability to do well. Cause I, I think everyone has the ability to do learn about things they want to learn about. So maybe that came from just me wanting

> to learn more about those things versus like for physics, I was just like, ah, math it just wasn't as interesting to me.

Claire, a twelfth-grade student who is planning to major in Public Health, described her journey:

> Science Olympiad really helped me figure out what I want to do in the future, because before my parents were like meds, CS cuz that's really stable. And I knew that, but I felt like I didn't like either field. Cause I didn't feel as flexible to do like some of my other interests and passions in life and really feel like I'm making the change I want to make in the world. And then like also like humanities or social justice. It's also just not the most stable thing. Which I know is like a very practical thing to be scared of. Like, I don't really wanna end up in that situation, but then like when I joined Science Olympiad, I kind of realized, especially through Disease Detectives, that there is that middle ground. Where it doesn't have to be six figure salary, 200 K a year, but I will still be stable.

Like Claire, Lily explained, "Science Olympiad made me think of other things that I want to major in." The exposure to the variety of STEM fields the participants described influenced their choices in majors and for the alumni who have started careers, their careers.

Theme 3: Interest develops over time with increasing levels of exposure

In the data collected from interview questions about favorite events and levels of interest in STEM, participants responded that the time they spent diving deeper into topics and being exposed to various topics helped them develop more interest in STEM topics. Two subthemes emerged through the analysis: what you are exposed to determines your interest, and deep dives help develop deeper interest.

What you are exposed to determines your interest

The first subtheme that emerged when examining the responses to interview questions about interest, specifically the questions about the participants' interest in specific Science Olympiad events, was interest is determined by exposure to topics. A ninth-grade student, Leah, explained:

> I'm really interested in science, like science, specifically the science part of STEM. When I think of STEM, I don't really think about the technology and engineering because I'm not really, I've never had exposure. I'm not, my parents are engineers, but I'm not exposed to it really. So, I think more about science and math is something I'm pretty good at it. I'm not as interested in it (math) and science I'm really interested in it. And I think I'm also pretty good at it.

Leah pointed out that due to her limited exposure to the engineering and technology aspects of STEM, she was unsure what her interest in them would be. Violet, an alumna preparing to begin a doctoral program, expounded on the idea that Science Olympiad allowed her to experience a variety of STEM areas. She stated,

> I think science, Science Olympiad had exposed me to a variety of sciences…it was just like the experience of like such a broad range of science topics. And just let me get a feel for like how each of them were and which ones of them I was most interested in yeah. And I think it just

> showed me like that I enjoyed science. And so, like, I know I wanted to do in my college academic career.

Claire, a twelfth-grade student, when asked about how Science Olympiad helped her find a specific area of STEM that she has developed a personal specific interest in, stated:

> But I think like Science Olympiad really allowed me to see how doing like STEM could also intersect with the other stuff in my life that I enjoy… I think my perspective definitely changed after Science Olympiad.

Deep dives help develop a more profound interest

Although all the participants acknowledged that they had to be exposed to a topic in some way to develop situational interest, they explained that personal specific interest was developed when they would explore the topics in more detail. Maria, a tenth-grade student, when asked about her level of interest in STEM, related how she saw that Science Olympiad had helped her develop a deeper interest in some topics:

> It's why Science Olympiad works really well…You're diving a little bit deeper. And then so you're understanding applications and most of the time in tests, they always give you like even though it might seem like annoying sometimes, cuz you know, you're trying to go through those tests faster and, but they always give you scenarios. Like they will always give you some kind of scenario where you have to apply something or a principle or it's like, you're learning about titration curves and all of a sudden you have it here.

Victoria, a tenth-grade student, when asked about her favorite Science Olympiad event and how she developed a deeper interest in Rocks and Minerals admitted:

> I wasn't very interested when I started it, because it did seem like it's a lot of memorization that you have to do with the names and such, but then once you get into details about the minerals are more of my favorite part, but once you get into the details about them, the way they look, the reason for why they look the way they do, and then you kind of started to get a grasp of things. And when I started to get that grasp and eventually it's like, I'm starting to think about it all the time. And then eventually after like a couple of competitions and doing it, I was like, wow, I really enjoy this.

Due to the nature of learning about the different topics for the events and how the events are tested at a competition, the participants felt they were given the opportunity to develop a personal interest in several STEM topics.

Summary

Science Olympiad's structure plays a crucial role in developing personal specific STEM interest. The participants related the ability to explore various topics at a deeper level helped them develop more interest in specific areas they would not have previously explored. Additionally, the emotional aspect of interest was evident in the words the participants used to describe their favorite events and their intonations.

Research Question 3

Research question three examined the features of the Science Olympiad program that encouraged and hindered participation. While the participants primarily discussed what encouraged their participation in Science Olympiad, a few hindrances were discussed and are woven into the aspects that promote partcipation. Three themes emerged during data analysis, along with several subthemes, shown in Table 12 and discussed in detail below.

Table 12. Themes from Research Question 3.

Themes	Subthemes
The social component of Science Olympiad is imperative.	• Working Together • Team and partner focused • Friends • Caring Community
Mentorship opportunities are crucial.	• Peer Mentors • Teacher involvement
Gender representation is a key feature of the studied Science Olympiad team.	

Theme 1: The social component of Science Olympiad is imperative.

Science Olympiad's team structure and the social aspect of the studied Science Olympiad team was a theme that emerged during data analysis. The participants specifically discussed the subthemes of working together, having a team and partners to work with, their friends in Science Olympiad, and the caring community they became a part of.

Working Together

When analyzing the responses to the questions, why do you stay in Science Olympiad, and what are some of the challenges of Science Olympiad, several participants contrasted the program studied to other science competitions and Science Olympiad programs at other schools. Participants mentioned the collaborative nature of the studied program as a positive for the participants continuing in STEM. The more competitive nature of other programs was explained as challenging for them. Maria, a tenth-grade student, stated:

> It’s collaborative and it’s not very like, I, I wouldn’t say like cutthroat, because that seems very, like, that seems kind of excessive, but a lot of clubs and a lot of competitions that you would think, or like other, I remember like Bio-Olympiad, for example, or like other competitions are like very like individual based as well. And so sometimes it feels like. When you’re competing with those types of competitions, it is kind of just like you competing. And then this is also more like motivating because you get to learn from different people and you get to at least for the past two years, cuz I’ve been considered like underclassmen, so I got to learn a lot from like upperclassmen and yeah, you get a lot of like guidance too.

Similarly, Naomi, an alumna, explained her interactions with other teams by saying, “I didn’t really like some of the competitors because they were like, oh, I scored higher than you, that means like, you’re automatically worse than me. You’re not smart. Like you’re like dumb or something.” When probed about who made her feel this way, she talked about other teams, and then when asked about how the studied team functioned, she stated,

> Yeah, well, it was like more collaborative, also like more tight knit that we could like come teach each other and ask for help. And like, we were like bonding, not just that, like. Like doing work together, but also as like friends.

The collaborative nature of the studied team was an aspect that made Science Olympiad an organization that the participants wanted to be in, while when the competitiveness overtook the collaboration, it became negative.

Team and partner focused

In the background survey, 16 of the 17 participants chose “being part of a team”, “working with a team”, and/or “work with partners” as one of their top five rewards for participating in Science Olympiad. The participants repeatedly mentioned the team and partner aspect when asked about what they enjoyed about Science Olympiad. Then they continued to explain that working with others was part of what they saw as a key component of doing STEM. Lily, an alumna, said, “I like working as a team. I like working with other people and getting to know my teammates more.” Camila, another alumna, related that one of her favorite parts of Science Olympiad was “the cram weeks when we just spent like a lot of time after school and got to like bond with everyone else on the team, cuz we were all exhausted and all doing the same thing.” Abigail, a twelfth-grade student, stated, “But definitely the time we get to spend with all the other teammates stands out more than other things.” Leah, a ninth-grade student, explained why she liked the event, Write It Do It, so much was “because it was just really fun to get to work with my partner.” Another student who doesn’t identify as much of a STEM person, Olivia, explained, “I got [another student] as my partner, and we worked very well together…I can communicate and I just liked it.” Maria, a tenth-grade student, explained why she enjoys Science Olympiad over other STEM clubs saying:

> Whereas when I came to Science Olympiad, it’s always felt like the people really enjoy what they’re doing. And so, it makes me kind of wanna join it and be a part of it as well, because I enjoy being around the people. And I feel like they’re a good company and it’s better than just the competition where it’s like, oh, you have to bring other people down to get

> ahead because this is a team effort. So, it's like you work together to like build your skills and kind of get better so that your entire team can move forward. So, I like that for sure.

While the participants pointed out the advantages of having partners, they also explained that partners were sometimes one of their greatest frustrations. Olivia, who thrives with a good partner, explained, "I don't like the people who join but don't actually contribute." And Alice, an alumna, described her frustration and how she dealt with it:

> It was definitely when I got partnered with people that didn't really do much. I mean, like the only way to deal with that is that if you want to actually do the event, then you just do it solo or maybe try to convince them somehow.

Lily, another alumna, explained the advantage of the team and partners she had when she was asked to do an event that she did not feel confident in or particularly enjoy, saying, "Cause I know some people get into events where they don't like it, but they're still there. And if I was in that situation, I would still be there because I have my teammates."

However, the team sometimes could cause feelings of insecurity but then turn them into comfort. Elizabeth, an alumna, during the focus group described her freshman year saying:

> I had imposter syndrome a little bit on science. Especially like what [Maria] was saying, like being on blue team, especially since freshman year, there was like this pressure to like, do well in your events, like more than like other people. And I didn't always feel like I did a good job in my events and I think one thing that did help me with that is like having team

> members who would be like, oh, but your events are like more difficult and it's a lot more study based and just so much information. And I think I like really try to put myself to a higher standard, but just a lot of the times I didn't really feel like I was really cut out to be in science, just cuz like I would always see like other people medaling and like just like getting really good scores on their tests and I would be like, oh, like, why can't I also get to that level? Yeah, I think definitely like having team members who were supportive and knowing that I was like the only one of the only people who like really did bio events too, like was like, oh, like they need me somehow. Cuz there isn't really anybody else fill my niche I guess if I leave Science Olympiad so a little bit of that team accountability.

Elizabeth's reliance on the team to overcome a STEM challenge was key to her success and continuance in STEM.

Friends

In the background survey, nine participants listed friends as one of their top rewards for participating in Science Olympiad. In the interviews, when the participants were asked why they stayed in Science Olympiad, several discussed their friendships. For instance, Maria explained her transition from elementary to middle school, "I knew the group of people that were going into Science Olympiad from my elementary school. And so I think that prompted me to participate in it as well." Maria continued that when she transitioned to high school, amid COVID and online school, "So even if it was online, it helped me meet people, and it helped me make friends. And I think Science Olympiad is one of the few reasons I made friends in my freshman year and met new people." Victoria, another student, explained a similar experience,

> It was my first year in [the city] and I guess Science Olympiad, it seemed like a fun way to make friends, even though it was kind of towards the end of the year. A lot of the current friends I have in Science Olympiad right now, were the same friends that I made then.

Leah, a ninth-grade student, also stated she wants to continue in Science Olympiad "because of the like relationships I built from Science Olympiad, I would like to further those and make more." Another student, Abigail, explained in the focus group how Science Olympiad helped her social skills grow, "There was multiple similar incidences to this. But whenever like upperclassmen helped me out cuz I wasn't the most social and having that, going to high school already knowing people not just in my grade was really helpful."

Caring Community

Throughout the interviews and focus group, every participant talked about the community that the Science Olympiad program developed. The participants described the community as caring and one that helps each other. Violet, an alumna, simply stated, "It's a good community of people." Alice, another alumna, when asked in her interview why she joined and stayed in Science Olympiad explained:

> So, I started or I continued doing it because I definitely liked the, like the atmosphere, I guess. I don't know how to explain it, but you know, going in there and just like seeing bunch of other, like-minded students, all working on like different things and just being able to like, you know, just

> take a walk and see what everyone is doing and, you know, just having that sense of also…And so it was just like that feeling of going to a different home, I guess, after school to like, do, to like work on things where everyone just can just be themselves and just, you know, get through whatever they're working on together. And you know, people often just take breaks together, like in the hallway or just. You know, just talk about stuff and then go back to doing whatever they were doing. I just really that kind of atmosphere.

During Claire's interview response to the same question, she stated:

> I was a nerd and it was, we could just like geek out over the smallest, silliest things like biology and then something that sometimes we make the nerdiest jokes, but it just like, all felt very safe and welcoming. Like no one was judgmental there and it just felt like somewhere where I could actually be me cuz so everyone was so similar to me in that sense.

While Claire, a student who identifies as more of a STEM person, explained she felt at home with the people in Science Olympiad, Olivia, a student who does not identify as a STEM person, described the community influence in the following manner:

> I've never really thought of myself as like a science-oriented person. Mm-hmm but like the way that science Olympiad is set up, it, it makes me feel like I kind of am a science person. I, I mean is definitely the community. It's definitely the people who are in science Olympiad and who like a lot of them are so supportive and kind, and it's just wonderful to be around.

In the focus group, the participants discussed the memories that stood out most about Science Olympiad. Madison, an alumna, explained:

> What stands on my memory is probably the cram weeks as well. Just like staying late and then just being so tired that you don't even know what you're doing anymore, but it's just so fun because everyone's like feeling the exact same way. And then there are like snacks around that you get to just like munch on and like study and talk to other people. And sometimes the community that's formed during those times just really stands out to me.

Madison made another comment later in the conversation about the supportive reactions during the competition that showed her appreciation for the community of the studied Science Olympiad team:

> So actually to add onto that too I feel like the competition aspect is good in a sense that for at least for [the studied team], it's like when someone medals it's like the whole team like medals and it's like a celebratory thing for everyone involved and not just the individual versus I'm sure there's some schools out there where it's like, when one person medals it's really oh, I did it. It's not really a team effort. And I feel like that plays into just like how Science Olympiad or experience with Science Olympiad is because it's like, if you don't medal, that's okay because no one's gonna blame you for it. And I don't think you're gonna blame yourself for it either, just because, you tried your best and you it's okay to do that versus some other schools where I'm sure if they don't medal, like then they it's

> like a, it's like an individual thing for other teams versus the whole team here, which is definitely a different experience.

The community was a key aspect of the studied program that helped the participants feel they belong in STEM.

Theme 2: Mentorship opportunities are crucial

Two areas of mentorship were discussed in the data collected. Participants had different types that stood out to them. Still, the majority discussed that mentorship was a key feature of Science Olympiad that helped them develop their STEM identity and participate in Science Olympiad the way they had. Participants discussed both peer mentorship and teacher mentorship.

Peer Mentors

Many participants shared experiences where their peers were mentors for them and when they were mentors for their peers. Lily, an alumna, stated, "And whenever I needed help, I didn't feel any sort of hesitation to ask them for help." Maria, a tenth-grade student, stated, "I've been considered like underclassmen. So, I got to learn a lot from like upperclassmen and yeah, you get a lot of like guidance too." Emily, an alumna, related a similar experience from her first year in Science Olympiad:

> I was placed as an alternate for Thermo, I think. And I was like, okay, I've never done Thermo. Let me try this out. And my partner, he was busy, so I pretty much did the build by myself. And I was like, I was really determined. I was like, you know what, I'm gonna do this. This is gonna be fun. I'm gonna learn. And I did the build and I like I knew what I was doing, but I was. I don't know, I just made the build. It was like the little

> calorimeter thing. And I remember [an upperclassman boy], I believe he was, I don't know if he did the event or if he was the event leader, but he helped me at some point. And when I finished or when I finished competing, he said something, he was like, oh, [Emily]'s really good at this event. Or oh, like she built something. It was really good. I don't know what he said, but that made me think, oh, wow, I can really do this. I'm good at it. I can do it too. Because at that point I was like, oh, I'm just a freshman. I'm, I can't be good at an event. It's just the other people are the older students.

Abigail, a twelfth-grade student, said the mentoring was not always specifically related to science topics. She shared, "There was multiple similar incidences to this. But whenever like upperclassmen helped me out cuz I wasn't the most social and having that, going to high school already knowing people not just in my grade was really helpful."

The participants also related that as they became older, the tables would then turn, and they became the mentors to the younger students, which built their confidence even more. Emma, a twelfth-grade student, shared:

> I think I, I have a memory similar to that from junior year when I first started it was my first year event leading and…during that year, I think everything was virtual. So, we were teaching lessons off of like Google Meet. And then we had opened up our social media so that people could contact us if they needed help. And I remember someone from the class. They DMed me on Instagram asking for help with homework. And I remember like going back and forth with them for an hour where I'd write

> out some stuff and I'd send a picture of that to them. And then they'd come back with more questions. And then at the end they were, I think, able to finish homework, but that like feeling of helping someone through something and, or just like helping answer their questions and successfully, that was, I think it was just similar to what everyone's saying. It just made you realize, wait, I actually know something like, enough that I can teach it to someone and they can understand it or I can help them understand it. And it, it empowers you because it's I'm like, you're still a student, but it just tells you that I can be in a position. Where I can lead. I don't know if that makes sense, but it's like you, for so long, you've been in the position where you're learning and you're always learning, but to be able to be like, no, wait, I actually get something. I can teach this to someone. Yeah, it just builds your confidence.

Even though the older students mentor the younger students, the studied Science Olympiad program gives the younger students the opportunities to lead and mentor others. Maria, a tenth-grade student, described her experience:

> I don't feel like I'm being dismissed. Like they value, if I talk to my partners or if I take initiative and something they'll support me with it, they won't just be like, oh, I got this let's or like, yeah.

On the opposite end of this idea of participants feeling mentored and mentoring others, Emily, an alumna, described a more negative experience with another STEM organization:

> I quit because I did robotics in middle school actually with [another participant] and, we were pretty good. Like we knew what we were doing, we would do well at those competitions. So, when I joined in freshman year, they didn't really put me on a team. Like it was weird. I was like, I don't know what I'm doing here. I can do robotics, but I felt like I was just wasting time. And I tried for a little bit because I was like, it was freshman year and I was really determined and I thought that robotics was what I wanted to do forever or at least in high school. But at some point, I was like, this is not worth it. I don't like the community here. I don't like. What I'm doing, I'm just waiting around. And then I think that semester I also joined some computer science club or something. It was the same thing there. It was pretty much all boys, and it was a little weird.

Emily mentioned the idea of gender representation, another theme in the data that will be addressed in detail later.

Teacher involvement

In addition, to having peer mentors, several participants explained that having teachers involved with the studied Science Olympiad program added a level of mentorship. They explained that interacting with the teachers differently than in the formal classroom gave them the confidence to ask questions of the coaches and even other teachers. Olivia, a tenth-grade student, described her experience with the teacher/coaches:

> Because I think if it was parent run, it would, it would be kind of uncomfortable, cuz you'd be dealing with your friends' parents and it's

> like, this is this cuz even when there are parents at Science Olympiad, I feel kind of awkward. But with the teachers, I, I don't feel awkward. You don't at all. Yeah. I feel, I feel like I can go to them for questions and they can explain a concept to me.

Abigail, a twelfth-grade student, explained her experience with teacher coaches during the focus group:

> And then it continued into PPP, which I had no connection to until I got placed into it for Vegas. And I was like, I don't even know where to final one liter bottle and I don't even know what this rocket's supposed to be like. But then I think how I got to that was because no one else that was no one else's event. Now I got to make it my own thing. And I got to be the thing that I enjoyed. And also, I remember when prepping for Vegas during winter break, [one of the coaches] was there to help throughout it all. And that having that assistance made me more, feel more confident and just seeing all the crazy things that happen in the event made me like it more. And it's actually something I enjoy now.

Camila added during the focus group discussion that her interactions with the teachers in Science Olympiad "gave me a lot of confidence to even talk to teachers in college and just feel like, oh yeah, my brain works. And it's like valid for me to have these questions." However, Elizabeth, another alumna who focused more on the biology events, explained that sometimes the areas of STEM focus for the teachers were a challenge:

> I just feel like there isn't as much support, like from [the school] like faculty necessarily like for bio events. Like I think there's a lot of support for like chemistry, like with [a specific teacher]. And then I think [another teacher] also like really supported our physics students in Science Olympiad. But a lot of the bio teachers weren't like super involved in Science Olympiad. And so, I think not having that teacher support like deterred people from pursuing more bio events, at least that's like kind of the reason that I saw.

Elizabeth highlighted the importance of the various teachers' support in all subjects.

Theme 3: Gender representation is a key feature of the studied Science Olympiad team.

The third theme that emerged from the data analysis around why the participants joined and participated in Science Olympiad was the gender representation they saw. The alumnae in the focus group described the experiences they have had both inside Science Olympiad and also outside of Science Olympiad. Camila, a recent college graduate, contrasted her experiences, saying:

> Because when you're in like male dominated settings, as a woman in STEM, you always feel the need to have to prove yourself and work over the top and be better than other people to be seen as equals. And in Science Olympiad, I never got that feeling. I think just because there was so much female leadership and we had a lot of female captains as well, like over half the captains in the past eight years or something had been

> female. I never had that feeling that I needed to prove myself to be at equal level with anyone there.

Elizabeth, another alumna, added that it was not just the studied program but also across other Science Olympiad programs that she saw the same idea:

> And I would say one last thing for me is like just the community of scientists. Like not only within [this school] itself, but also like competition day. Like I'm sure we'll have like really chaotic memories from actually going to the competitions and like speaking to other students from other schools, and in terms of seeing like other girls, as role models for how well you do, like you see people getting awards and that's oh, like I can do that too. I think that was also something really valuable that I got, especially from competition days.

Claire, a twelfth-grade student, acknowledged it was not just the female part of representation that she found so valuable when she explained:

> I think it definitely pushed me like into doing what I want to cause I met other people that, that other girls have done what I want to do too. More people that are like me. So, like South Asian or their parents are immigrants and stuff like that. So, like I resonated with that and it made it feel more accessible and like, this is something I could really do. So, I know it was really good to see and I just wanna shout out my peers once again, cuz they also just made me feel like a lot more confident heading into the field of STEM.

Lily, another alumna, described an experience outside of Science Olympiad but within the same school of the studied program that was not positive:

> I was just talking about like how I would come across a problem. And one of my classmates who was a male didn't really listen to me. And he was like, so why do you think that, oh, is that right? He seems so condescending. And I didn't know whether or not that was because he didn't value what I thought or if it was because I was a female or anything, but yeah, one of the, that was one of the things that kind of ticked me off.

Lily's experience outside of Science Olympiad showed a different feeling between the genders in Science Olympiad. Maria described gender balance in other tech clubs on the same campus stating:

> [Another girl] was talking about how girls who code was a club that she started, or she founded with a couple of other officers because she felt like when she went to other like computer science club, she felt very out of place because it was only, it was very male dominated. And so, I do think that's very apparent in like, especially tech clubs, tech computer science, robotics, especially like technology and engineering is like very like male dominated. Yeah. But in Science Olympiad, I feel like it's more even, yeah. In Science Olympiad have the other stuff. Yeah, we have, I think it's because I get to see everything in one place. Like it's not just like, one type of like, it's not only technology. Like Science Olympiad is like STEM. Like it's completely like it has biology. It has chemistry, physics. It has technology. It has like a lot of different parts of STEM. So, I feel

> like seeing everything in one place, it gives everyone an opportunity to try something, whether they want to do builds, whether they wanna do bio.

Maria believes part of the reason that Science Olympiad has a better gender balance is due to the variety of events. However, Abigail pointed out when she was asked about challenges in Science Olympiad that the organization is not perfect and sometimes has difficulties with gender equity:

> It was one of the few times where I experienced, like I had to prove myself in my event. Like I previously mentioned that Science Olympiad something was one of the places where I felt like I didn't have to show that was better than the male counterparts or something like that. But this year, the build felt like that. And it sucked, but again, I wouldn't quit because of that.

The participants stated that the gender representation overall made Science Olympiad a place where they could explore and develop their STEM identity, but still had to be monitored to maintain the collegial atmosphere between the genders.

Summary

The studied Science Olympiad program has helped the participants develop different levels of STEM identity through multiple aspects. The participants discussed the positive social atmosphere as one of the essential components of the program. The team and partner collaboration helped the participants feel they had a place in STEM. Additionally, the mentorship within the program emphasized the importance of assisting others in feeling they had a place within the STEM organization. Lastly, the gender representation in Science Olympiad, both the studied program and as a whole, gave the participants confidence and encouragement to continue in STEM.

Research Question 4

Research question four explored the participants' perceptions of who belongs in STEM fields. Two themes emerged during data analysis, along with several subthemes, shown in Table 13 and discussed in detail below.

Table 13. Themes from Research Question 4.

Themes	Subthemes
STEM people have specific characteristics	• STEM abilities are innate • STEM people can be labeled as smart • STEM people are logical thinkers who problem solve • STEM people are curious • STEM people help other people • STEM people are ambitious and work through tough things
STEM people major in and have careers with titles in specific areas of STEM	

Theme 1: STEM people have specific characteristics

When the participants were asked to describe a STEM person, specific characteristics emerged from the data. The following subthemes emerged from the data: (a) STEM abilities are innate, (b) STEM people can be labeled as smart, (c) STEM people are logical thinkers, (d) STEM people are curious about how and why things in the world around them work, (e) STEM people help others, (f) STEM people are ambitious and work through tough things, and (g) STEM people lack some social skills.

STEM abilities are innate

The analysis of the descriptions of STEM people provided by the participants, and in the interviews, the follow-up questions asked about their definitions of a STEM person showed that the participants described at least a base of specific abilities that were not learned but just possessed. The participants used words such as innate, natural, intuitive, and instinctive to describe STEM people. Leah, a ninth-grade student who identified her STEM identity with STEM circle (F), the circle with 80% overlap, stated, “I think that understanding things like STEM topics is pretty, it comes pretty easily to me because I think I have the ability to logically problem solve essentially. And I think that’s a lot of what STEM is.” Leah explained these abilities as coming quickly to her.

In contrast, Natalie, a college graduate who selected STEM circle B, a circle with 5% overlap, to represent her STEM identity, explained, “I never felt like it came naturally to me. And so that’s when I was like, oh, I don’t know if these STEM majors are for me. And so that’s kind of why I went towards more like accounting and business stuff.”

STEM people can be labeled as smart

The participants described STEM people as having an aptitude for more challenging STEM topics. Two participants, student Leah, and alumna Naomi, specifically used the word “smart” to define a STEM person. Six other participants also described STEM people as being good at specific subjects. Ninth-grade student, Leah’s definition of a STEM person was, “I think a STEM person would be smart, analytical, logical, and driven.” During her interview, she elaborated on what she thought the characteristics of a smart person would be:

> Well, when I say in this specific scenario, when I said smart, I meant that like there's someone who would be able to quickly grasp information, like be a quick learner and be able to figure out a way to utilize that information. Like being able to organize what you learn, being able to learn it in a quick like time period, and then being able to organize that information so you can keep it for later use. I think that being smart, I mean, essentially, it's like kind of like being a good student, but mostly being able to pick up on new things and being able to organize them in a way that you can use later is what I would refer to as smart in the scenario.

Leah's definition of smart was focused on the speed of understanding topics and then applying those concepts. Victoria, a tenth-grade student, focused on the speed at which a STEM person would grasp STEM topics when asked to elaborate on her definition of a STEM person. "What really differentiates a STEM person from somebody else is because of the time that they spend pursuing that subject, they're just naturally bound to get the grasp of concepts quicker." However, the alumna and older students were more prone to relate that STEM people do not have to be quick to understand all STEM topics or are inclined toward some STEM topics. For example, Alice, an alumna, stated, "A person in STEM is likely typically decent in math, but that does not necessarily have to be the case. Some people can be really good at grasping concepts without math." Sophia, a twelfth-grade student, described a STEM person as "deeply curious, interested in learning new things that are STEM-related, and unafraid to approach new theories or concepts that may challenge them."

STEM people are logical thinkers who problem solve

The study participants described STEM people as thinking about the world differently than non-STEM people. Naomi, an alumna who does not consider herself much of a STEM person, selected STEM circle (B), the circle with 5% overlap, to represent herself, explained,

> I think. Yeah. It's just like the more. Analytical more. Just, I feel like the way they think is just like different from how I think. Just like the way they process things. I think they more like, like a logic calculus standpoint while I just, I feel like I also think about emotional standpoint of things, so like makes a slightly different.

While Naomi explained the differences between herself and a STEM person, many participants who identified as more of a STEM person explained the same type of thinking. In her survey, Emily, an alumna, stated that a STEM person is one "who thinks logically." Emma, a twelfth-grade student, said, "A STEM person can think from an analytical point of view."

Problem-solving and critical thinking skills were an additional aspect of the logical thought process that emerged as the participants' definitions were analyzed. Problem-solving or critical thinking was specifically mentioned in six of the participants' definitions of a STEM person. Camila, an alumna, stated, "STEM people are problem-solvers who find satisfaction in the success of creating something complete or discovering the inner-workings of something." Violet, another alumna, described a STEM person as one who "enjoys discovery, solving problems, and creating and uncovering new knowledge." Emma, a twelfth-grade student, stated, "A STEM person can think from an analytical point of view and has good problem-solving skills." Elizabeth, an alumna, explained, "STEM people also tend to be more straightforward and to the point as they rely more on concrete evidence as opposed to feelings to make decisions."

STEM people are curious

Curiosity is another trait for a STEM person that emerged through data analysis. The participants repeatedly mentioned a need for curiosity in STEM fields. Sophia, a twelfth-grade student, described a STEM person as "deeply curious." Emma, another twelfth-grade student, expanded on the idea when she explained, "STEM people are also curious, which pushes them to learn more about the topics they are interested in." Camila, an alumna, repeated the same idea: "A STEM person is an individual who has a curious mind for how things work on a lower level. The lower level includes the specific mechanics and composition of an object or idea." Violet, an alumna, used a phrasing she learned in her STEM job, describing a STEM person as one who "thinks like a scientist, is analytical, curious, wants to learn and understand how the world works through STEM."

STEM people help other people

The participants also focused on the humanitarian nature of STEM. Maria, a tenth-grade student, described a STEM career in the following way:

> I've always thought of a STEM major as humanitarian because I think no matter what type of profession, you're in that field, you're somehow helping humanity. Whether it's advancements in medicine, advancements

> in technology advancements in math, or just the understanding of the world around us.

Violet, an alumna, echoed a similar sentiment when explaining why she has chosen a STEM major and career, “I enjoy volunteering. Or I enjoy helping people. That’s part of why I like science is that allows you to help people, specifically biomedicine.” Claire, a twelfth-grade student, when asked to describe a STEM person, stated, “A STEM person is someone who pursues their scientific interests by bringing change to the world. To me, they are someone that utilizes their scientific knowledge and intersects it with other problems in the world.”

STEM people are ambitious and work through tough things

The data analysis also revealed that the participants believe that STEM has many challenging subjects and topics. A STEM person’s characteristics are perseverance and a drive to achieve. Sophia, a twelfth-grade student, described in her background survey that a STEM person is “unafraid to approach new theories or concepts that may challenge them.” Naomi, an alumna, elaborated on her initial description of a STEM person “willing to pursue,” stating, “I think they’re just like more willing to push themselves further.” Emma, another twelfth-grade student, described a STEM person’s perseverance in her background survey: “This doesn’t necessarily mean they can solve problems very quickly, but rather have the patience and tenacity to sit and think something through.” In the focus group, when discussing the role competition played in Science Olympiad, Madison, an alumna, described what she saw in STEM people through her college coursework:

> …but and a lot of people, I feel like do STEM thinking that they're really good at STEM. And then when they realized they weren't really good at STEM or there was a class that always stumped them, they end up just dropping out of it because they're like, oh, it's not for me. But like with the competition element in Science Olympiad, it helped me realize yes, it's hard, but if I can learn something and if I tried, then that's fine. And so, it allowed me to stick through a lot of the classes that were considered like hard for me at least. And see it through the end.

Madison attributed the building of her tenacity and perseverance as a STEM person to her participation in Science Olympiad.

Theme 2: STEM people major in and have careers with titles in specific areas of STEM

While all the participants described qualities STEM people had, eight of the participants specifically pointed out that to be a true STEM person, they needed to major in STEM and have job titles and careers in specific areas of STEM. For instance, Madison, a college graduate, defined a STEM person in her background survey as "Someone who majored in STEM and is currently employed doing something related to the STEM fields. Someone who uses critical thinking and analytical skills on the daily." Camila, another college graduate, responded to the same question on her survey:

> They are also directly involved in STEM fields. While one half of the definition of a STEM person is an inclination for STEM, a STEM person is primarily defined as someone who studies or works in a STEM field, regardless of STEM competency.

Sophia, a twelfth-grade student, explained that "a STEM person typically takes many classes related to STEM."

Natalie, a college graduate working at a tech company in the Bay Area in finance, felt she identified with STEM circle (B), the circle with 5% overlap. In her initial background survey, she defined a STEM person as "Someone who majored in or works in the field of math and science (such as computer science, programming)." In her interview, she was asked about her role at the tech company. She explained, "Maybe, it's a tech company, but my role, I don't consider to be a STEM role." Natalie went on to explain,

> Most people consider like you're STEM person or you're working in a STEM role based on their title or their role or what they majored in more and more. I feel like it is more superficial. I feel like, yeah. In that's official. So more super official wise.

While the alumna focused on specific titles, Maria, a tenth-grade student, was more general:

> A STEM person to me is someone who associates with any field even mildly related to the topics in STEM (science, technology, engineering, math). I think a STEM person can be someone who is multifaceted, but their job involves STEM in some way.

However, most participants saw an official capacity, major, or job as a vital characteristic of a STEM person.

Summary

The participants defined STEM people using characteristics, major choices, or job titles. The participants described STEM people as curious, analytical thinkers who persevere and work through tough challenges and topics.

CHAPTER V:

SUMMARY, LIMITATIONS, DISCUSSION, AND IMPLICATIONS

In this chapter, I will present an overview of the study and the implications of the findings. First, I will summarize the problem studied and how it was studied. I will then present the main findings of the study, followed by the limitations of the study. I will then present a discussion of the relationship of the findings to the existing literature. I will conclude with some implications for both research and practice.

Summary of the Study

There is a disparity between the number of females and males in the STEM fields, even though there is no difference in the achievement between the genders (Boston & Cimpian, 2018; Cooper & Heaverlo, 2013; OECD, 2019). Even though there have been great strides in the last fifty years in STEM overall, this disparity is still particularly pronounced in the physical sciences, engineering, and computer science (Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) et al., 2020; J. R. Shapiro & Williams, 2012; *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 | NSF - National Science Foundation*, 2021). Bringing more female perspectives into the underrepresented fields of STEM can introduce the different perspectives needed to tackle today's challenges (Fox & Cater, 2015; Hill et al., 2018; Milgram, 2011).

How females develop the persistence to stay in STEM is not well documented, partly due to the variance between females as a group (Carlone & Johnson, 2007a; Holland & Lave, 2009; Wilcox & Lewandowski, 2016). However, the development of a strong STEM identity and a personal specific STEM interest has been shown to have a significant impact on those females currently in the STEM fields (Baram-Tsabari & Yarden, 2008; Carlone & Johnson, 2007b; Vincent-Ruz & Schunn, 2018; Wilcox & Lewandowski, 2016).

STEM identity is the view of oneself in relation to STEM. Carlone and Johnson (2007) found three components of STEM identity, and Kim et al. (2018) added two more components to describe STEM identity. These components are (a) competence, (b) performance, (c) recognition, (d) perceptions of scientists, and (e) interest in science careers. Carlone and Johnson (2007) first described the components of STEM identity as competence, performance, and recognition. Competence is the understanding of how science principles and recognizing how those principles work. Performance is the application of those principles and outwardly doing science. The third component, recognition, is building confidence in doing science. Recognition can come through awards, but more importantly, having a person's work in science acknowledged by others and self. The perception of scientists is the fourth component added by Kim et al. (2018). This area includes seeing positive role models of what STEM people look like and what they do. Part of having experiences with a positive role model is showing what STEM people can look like. In this way, the negative stereotypes of STEM people are being debunked, an important aspect of changing the perception of STEM people.

Lastly, the final component is interest in science careers. In this study, I explored personal specific STEM interest. This interest is not just for STEM in general but in particular areas of STEM and understanding that a person does not have to enjoy or be good at all areas of STEM due to the broadness of STEM.

Personal specific STEM interest is based on the interest model built by Hidi and Renninger (2006). Personal specific STEM interest is the type of interest that tends to prevail in an individual that is develops a strong STEM identity. Hidi and Renninger's model includes four phases of interest: (a) triggered and situational interest, (b) maintained situational interest, (c) emerging individual interest, and (d) well-developed individual interest. In the first two phases of the model, interest is fleeting and can either be cultivated or disappear quickly. When individuals develop an interest in a topic they return to on their own and begin to investigate more fully, they move into the third and fourth phases of interest. The fourth phase of interest is where personal specific STEM interest falls. It is enduring and drives the person's work.

Because of the distinct boundaries, a case study was used to investigate the Science Olympiad program at a Bay Area High School (Merriam & Tisdell, 2016). The studied program is a co-ed extracurricular STEM program at a large comprehensive high school. A focus group with nine participants, and ten individual interviews were conducted to collect data. The participants were selected from current members and alumnae of the program using an online survey. The online survey was emailed to all current members and all alumnae whose contact information was available. I asked the alumnae in the email to share the survey with any other alumnae.

The online survey gathered demographic data, including Science Olympiad participation; rewards the respondents felt they received by participating in Science Olympiad; and perceptions of their STEM identity as seen by themselves, family, friends, and teachers. STEM identity was expressed using STEM circles. The STEM circles used were adapted from McDonald, Zeigler, Vrabal, and Escobar's STEM Professional Identity Overlap (PIO) Measure (2019). The more overlap between the circles reflects a greater STEM identity.

Fifty-eight people responded to the online survey. Seventeen participants were chosen to participate in the interviews and/or focus group. All 17 participants were female and had actively participated in the Science Olympiad program for at least two years. The focus group was comprised of four current students and five alumnae. The focus group participants had all selected STEM circles that reflected the three highest levels of STEM identity. Additionally, the focus group participants had not selected competition-based factors as one of their highest five rewards for participating in Science Olympiad. Five current students and five alumnae were the individual interview participants. Two of the focus group participants (one student and one alumna) also participated in individual interviews, but the other eight interview participants did not participate in the focus group discussion. The interview participants selected a variety of STEM circles to represent their STEM identity. Additionally, those selected to participate in the interview were those that gave detailed definitions of what they saw as a STEM person, in the online survey. Two of the participants were in both the focus and interview groups.

The focus group and individual interviews were each transcribed. The transcriptions were then coded using in vivo, descriptive, and value coding in the first round, as described by Saldana (2021). A second round of pattern coding was employed to find the themes for each research question.

The study addressed the following four research questions:

1. How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?
2. How does participation in a Bay Area High School Science Olympiad program contribute to female students and alumnae maintaining and growing a personal specific STEM interest?
3. What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?
4. What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?

Summary of Findings

The analysis of the data revealed several themes for each research question. The themes are summarized in Table 14.

In response to research question one, the themes showed the importance of creating a safe space where the participants were rewarded for their work and progression. Participants reported gaining confidence in the skills they developed and the knowledge they gained. Additionally, the view that family, friends, and teachers had of their STEM identity was greatly influenced by what the participants were observed doing. Therefore, the opportunities the participants had to express their STEM identity was critical in how much they perceived others saw them as a STEM person. Lastly, participants recognized that a STEM identity was not their only identity. Many participants viewed their STEM identity in competition with their other identities. So, the participants would describe themselves as having a lower STEM identity because their other identities would take away from their STEM identity.

Table 14. Themes that answer each research question.

Research question	Themes
How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?	• Space for progression of identity and skill development • Intersectionality of identities • Opportunities to express identities influence others' views of identity • Rewards are necessary
How does participation in a Bay Area High School Science Olympiad program contribute to female students and alumnae maintaining and growing a personal specific STEM interest?	• Interest is emotional • Exposure to a variety of topics is critical to fostering interest • Interest develops over time with increasing levels of exposure
What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?	• The social component of Science Olympiad is imperative • Mentorship opportunities are crucial • Gender representation is a key feature of the studied Science Olympiad team
What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?	• STEM people have specific characteristics • STEM people major in and have careers with titles in specific areas of STEM

Data analysis to answer research question two about STEM interest revealed one theme that characterizes STEM interest and two themes that explain how the participants developed their personal specific STEM interest. The participants all described STEM interest using words that expressed positive emotions. The data revealed that the development of STEM interest requires exposure to a variety of topics and time to explore the topics with increasing depth. Developing STEM interests encouraged the participants to spend more time learning and working with specific topics.

Data analysis to answer research question three, the features of Science Olympiad that encourage and hinder participation, revealed that the social nature of the team and partnerships were crucial to the participants. All participants discussed how working with others helped them develop their STEM identity and encouraged them to continue in STEM in different forms. Additionally, the mentoring element of the Science Olympiad team was important for the participants. Peer mentors helped the participants learn how to work collaboratively. Participants also related that teacher involvement taught them how to interact with teachers more effectively and ask questions that help them learn. Finally, gender representation was an essential feature for the participants. Seeing and interacting with other female individuals in a STEM-focused environment helped them find a place of belonging.

In response to research question four, the participants described characteristics they saw as part of a STEM person. Many participants described STEM people as having college majors in STEM and careers with titles specifically related to STEM. Additionally, the participants described STEM people as those who contribute positively to the world by helping others. Additionally, STEM people were described as ambitious and problem solvers.

Overall, there were three main findings of the study. The data revealed the community built in the program, the team focus of the program, and that the variety of events in Science Olympiad are crucial to the program's influence on female participants' STEM identity and personal specific STEM interest development. STEM identity development, of which personal specific STEM interest is a component, is a critical component of females pursuing STEM careers and college majors, and participation in the studied Science Olympiad program fosters growth in both of these areas (Carlone & Johnson, 2007a; Kim et al., 2018).

Limitations

As with all case studies, generalization was a limitation. However, there are two types of generalization: statistical and analytical (Yin, 2018). According to Yin (2018), statistical generalization is where the challenge lies with a case study. Since the sample size is small and within several boundaries, applying the findings to a larger population is difficult. In contrast, analytic generalization is possible since it is based on advancing a theory that the case study was designed to examine (Yin, 2018, p. 73). In this case study, I reviewed the aspects of STEM identity based on the work of Carlone and Johnson (2007) and Kim et al. (2018) and the features of an extracurricular program, Science Olympiad, that promotes STEM identity in female participants based on findings from other studies such as Adams et al. (2014).

STEM identity is influenced by many factors other than gender. Race, ethnicity, family influence, opportunities available to explore STEM, and socioeconomic status are just a few. While this study focused solely on gender, it is important to recognize that there are many other aspects to identity and each of those parts are also crucial in building STEM identity and should be explored in other studies. In fact, several participants in this study mentioned the influence of their families on the choices they have made with regard STEM. Since that was not a focus of this study, those ideas were not explored further.

Using this sample presents limitations in the data that was collected. The study's sample was a group of current and former female students who have actively participated in Science Olympiad over time. This sample has most likely had a good experience in Science Olympiad since they have increased their participation over their time in high school. Additionally, in the focus group, the participants were all in one of three groups: a team captain in high school, a team member that returned to coach the team, or a potential captain in their senior year. The team members selected as captains are devoted to Science Olympiad and helping others have a good experience in Science Olympiad. The selection process for captain includes an interview where the students are given the time to show their STEM philosophy matches the team objectives. The interview participants were not all captains but still were very active participants in Science Olympiad.

Another limitation is the researcher. Since I am one of the three coaches for the studied program, bias is challenging. This case study was done from an emic perspective. I am an insider, and the argument can be made that the participants may have the challenge of speaking their truth about how this Science Olympiad program has affected them. The counter-argument can also be made that the rapport needed to have valuable interviews had already been established (Carlone, 2012; Merriam & Tisdell, 2016). Another limitation with the researcher are my feelings about Science Olympiad. I am a firm believer that the program has many valuable components, specifically the focus on team work and community building. Additionally, the broad range of topics covered in the events allows for students to explore many more avenues of STEM they may not have even been aware existed. The participants in the study also know my position on Science

Olympiad and may have had challenges speaking against Science Olympiad and STEM in general.

Gender gap research in itself is a limitation. Wilcox and Lewandowski (2016) pointed out four specific critiques of gender gap research. First, gender is treated as all-encompassing even though gender is not a solitary defining trait. Second, the variance within the gender group is typically greater than between genders. Third, one gender is defined as the standard while the other is compared to that group. Lastly, the focus tends to be placed on the gap itself instead of the causes of the gap. When the causes are focused on, then interventions can be developed.

In contrast, Wilcox and Lewandowski (2016) posit that when the existence of the gap is the focus, the focus is not on remedying the problem but more on acknowledging there is a problem. At this point in the research, the problem has been well documented. The remedies need to be the focus. While this study does not focus on the gap, there are still some limitations in the tendency of the participants to focus on the gap instead of the remedies in their responses.

Discussion of Findings

Through the analysis of the data collected through the focus group and ten personal interviews, three main findings emerged: the community built within the program, the team focus of the program, and the variety of events or topics available in Science Olympiad each have a significant influence on the STEM identity and personal specific STEM interest of the participants. Following is a discussion of the findings organized by research question.

Research Question 1: STEM Identity

Research question one, “How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?” was answered using data gathered from the focus group discussion about core memories from the participants’ time in Science Olympiad and the influence on their perceptions of doing STEM. Additionally, individual interview data from questions about STEM identity were analyzed. A discussion of each theme that emerged from the data analysis follows.

Space for progression of identity and skill development

Identity is fluid and changes, especially during the teenage years (Avraamidou, 2014). Natalie, an alumna well into her professional life, reflected on her time in Science Olympiad and explained that her experience in the program allowed her to explore her own identity and find what interested her. Many other participants related that the time in Science Olympiad allowed them the space to explore who they are, which is imperative to forming a strong STEM identity (Carlone et al., 2011, 2015). Carlone’s identity boundary work (2015) explains that a space that is comfortable and safe for this exploration is needed to develop a strong STEM identity. While not all participants perceived their STEM identity as strong or chose STEM college majors or careers, none were opposed to STEM.

The time the participants spent with STEM topics through their participation in Science Olympiad helped them construct a STEM identity, as Carlone (2012) explained. Active participation in Science Olympiad gave the participants time to explore and then put ideas into practice which is an essential part of constructing a STEM identity

(Carlone et al., 2011; Kim et al., 2018). Camila, an alumna who has just completed college, explained that Science Olympiad "opened her mind" to other topics not dictated by a teacher or an assignment. She explained that this allowed her to explore the topics in depth and then put those things into practice. Camila related being at an engineering fair and conversing with different groups about topics she had learned and done in Science Olympiad. She described that her time doing science practices in the other areas of Science Olympiad helped her develop her STEM identity.

Being in a group of people with similar identities is imperative to developing a stronger STEM identity (Adams et al., 2014; Boston & Cimpian, 2018). Additionally, after you become part of a group, you work to stay in the group, which can also strengthen your STEM identity (Stets et al., 2017). All participants discussed the power they felt in being in a group. Like Adams et al.'s (2014) findings, the participants said that Science Olympiad had given them the confidence to go and be confident in their STEM identity. Abigail, a twelfth-grade student, explained that she had added confidence because she knew she had a group to back her up.

Capacity to see oneself as a STEM person is one of the most significant predictors of going into a STEM field (Kim et al., 2018). The participants all described their participation in Science Olympiad as being one of the activities that increased their confidence in doing STEM. Camila recognized that her questions were valid. Those questions she had were not a sign of not belonging but the opposite. The questions showed her desire to understand and build her competence in STEM. Emily, a college student, explained that Science Olympiad made her realize that she "can do science."

These experiences make STEM more attainable and something that the current student participants could work for and learn to do.

Intersectionality of identities

A person's identity comprises several sub-identities that combine to make a whole (Fraser & Ward, 2009). This is a challenge for identity studies because identity is so complex (Kim et al., 2018). The participants in the study related similar challenges. Violet, an alumna, explained that there was more to her than just STEM, and although she has devoted most of her time to developing her STEM identity, the other parts of her need attention too. Natalie, another alumna, expressed similar sentiments when explaining her identity and how one becomes stronger than another through activities. Many participants picked STEM circles with less overlap because they saw the other identities as taking away from their STEM identity. Their view of a STEM person was that the ideal STEM person only did STEM and was completely focused on STEM. The alumna tended to see the separation between STEM identity and other identities more quickly when asked to explain the role of STEM in their lives. Those with stronger STEM identities described STEM as a main character but acknowledged other characters had considerable influences in their life while not subtracting from their STEM identity. However, the students still described their STEM character using descriptions that indicated they saw each identity as a part that competed with another identity instead of a more synergistic description of each identity. A competitive conceptualization of identities is one wherein one identity grows and another one shrinks or is removed, while a synergistic conceptualization of identities is one where each identity can have equal influence and add together instead of taking away from the other identities. The more competitive focused conceptualization may be due to a lack of experience within the STEM field and a lack of seeing STEM people who have many diverse interests outside of STEM. The students are still learning what STEM means and the many opportunities within STEM. Because of this learning process, they put STEM into an exclusive box that initially seems more unattainable until they get more experience in STEM through various activities (Adams et al., 2014).

Opportunities to express identities influence others' views of identity

There is a distinct need to express budding STEM identities since identities are constructed based on what we do (Carlone et al., 2011; Papadimitriou, 2004). All participants related the time they spent doing Science Olympiad as a critical aspect of developing their STEM identity because identity construction has a very social part to it (Holland & Lave, 2009). The participants explored and experienced STEM in a way that allowed them to develop their STEM identity and show it to others. Naomi, an alumna who did not express a strong STEM identity, explained that her family sees her as having a stronger STEM identity than what she perceives of herself, because of the time she spent in Science Olympiad. Victoria, another alumna, expressed the same sentiment that what her friends see her doing is mostly Science Olympiad, so they also see her as more of a STEM person than she related for herself. Maria, a current student, pointed out that the classes she takes and the activities she does are more related to STEM than other subjects so others tend to see her as more of a STEM person. All of the participants explained that their outward actions were the main determiner in their friends, family, and teacher's perceptions of their STEM identity.

Another factor that the participants repeatedly discussed was the location where the study took place. The Bay Area is known for its STEM industries. The opportunities the participants have in the geographic area are much greater than others. Additionally, the advanced course work and options available at the studied high school are more significant in the STEM fields than in other areas. Further, many participants talked about their families being a "STEM family," meaning that most of their family members work in STEM fields, and many of the home discussions are about STEM topics. The family dynamics, therefore, push more toward the STEM fields and excelling within those fields. Thus, the demographics of the area and participants were also a factor brought up specifically by a current student, Maria. One of the stereotypes about individuals of Asian and Indian ethnicities are that they go into more STEM careers. While Maria specifically pointed out that her ethnicity developed an unspoken expectation that she would excel in STEM, other participants explained that their families had similar expectations. The family background, demographics, and opportunities available are all termed science capital, and Archer et al. (2017) found that higher science capital had a positive correlation with developing stronger STEM identities.

Rewards are necessary

Recognition is a key component of STEM identity (Carlone & Johnson, 2007b; Kim et al., 2018). In the focus group discussion about core memories of their Science Olympiad experience, many participants, particularly the current students, pointed out the medals they earned. The alumna, however, discussed how the skills they learned in Science Olympiad were more important to them. Both groups discussed that being recognized for their work in Science Olympiad, either with medals or through other means, was essential to building a STEM identity. Fox and Cater (2015) explain that competition-based and non-competition-based rewards are impactful. Based on the data, the students put more emphasis on the competition-based rewards, whether it was an actual medal or looking at the placement at a competition and seeing what other teams they had placed higher than or their placement progression during the competition season. However, as the participants continued in Science Olympiad, each one started to see learning new things as a reward. In the focus group, Emily discussed that the culture of the program empowered her. She pointed out that the program's idea of success was not measured by medals only. The rest of the focus group then discussed how the focus was not exclusively on the competition-based rewards and this different focus encouraged each of them to continue and learn even more about the topics that interested them. Because individual competition results are not the best feedback for developing STEM identity for females (Abernathy & Vineyard, 2001; Riegle-Crumb, 2017; C. A. Shapiro & Sax, 2011; A. M. Steegh et al., 2019), the framing of competition results is imperative for females to continue to develop their STEM identity (Boston & Cimpian, 2018). The framing needed for a competition must be that winning a medal does not mean a person does STEM better than another person or one can do STEM only if they win medals in competitions. Instead, the personal growth and enjoyment of STEM must be the focus of the competition. Helping competitors understand that the structure of the competition in itself influences outcomes as much as the competitors personal abilities.

Additionally, the perception that only certain types of females can do STEM is a significant deterrent in STEM fields (Boston & Cimpian, 2018; C. A. Shapiro & Sax, 2011; Wade-Jaimes et al., 2019). There is a perception that minorities, including females as a whole, only belong in STEM if they are at the top (Nealy & Orgill, 2020), and framing the rewards in STEM is imperative and stressing that the top award is not the only goal. Learning and progressing can be a reward in itself. Camila, an alumna who has just completed a degree in Computer Science, related the confidence she gained in Science Olympiad and the rewards she gained through participation gave her the capital she needed to persist in STEM. She could frame the competition she felt in a university classroom and continue through the coursework. Science Olympiad gave her the low-stakes opportunities she needed to know she could succeed (Boston & Cimpian, 2018).

Research Question 2: Personal Specific STEM Interest

Research question two, "How does participation in a Bay Area High School Science Olympiad program contribute to the maintenance and growth of a personal specific STEM interest in female students and alumnae?" was answered through analysis of the data collected in the focus group discussion about events that sparked the participants' interest and individual interview questions about interest in specific events and rankings of interest using STEM circles. The following is a discussion of each of the themes that emerged.

Interest is emotional

When the participants were asked about their interest in particular events in Science Olympiad, they would describe their interest with words that described emotions. According to Carlone (2012), interest development is the emotional part of learning and identity construction and has even been argued as one of the most critical components of STEM identity development (Papadimitriou, 2004; Vincent-Ruz & Schunn, 2018; Wilcox & Lewandowski, 2016).

Exposure to a variety of topics is critical to fostering interest

One of the study's key findings was the variation in STEM interest by topic. Participants explained that the vastness of STEM made it hard to describe their interest in STEM in general. Lily, an alumna, explained it best when she named different topics and ranked her interest in each. When STEM interest is investigated, it is an essential and key contributor to building a strong STEM identity (Baram-Tsabari & Yarden, 2008; Carlone, 2012; Vincent-Ruz & Schunn, 2018). However, the challenge when ranking interest in STEM as a whole is the significant variation in topics. Violet, another alumna, acknowledged that one of the strengths she saw in Science Olympiad was her ability to explore different topics and find the ones she liked the most. All participants mentioned this as one of the advantages they found in Science Olympiad over other STEM extracurricular activities. Science Olympiad was a one-stop shop for many STEM topics. Alice, another alumna, explained that she was exposed to things she had not imagined being interested in until she was introduced to the topic in Science Olympiad. Cooper and Heaverlo (2013) questioned whether interest brings females to STEM extracurricular activities or if the interest is developed through participation. I posit that the answer is both. A general STEM interest, even if not a strong interest and the program's structure will attract female participants to an extracurricular program. Still, a specific STEM interest can be developed through participation in the program. The personal specific STEM interest grows because the students are empowered to take charge and explore differently than in the traditional classroom (Hennessy Elliott, 2020). Natalie, Lily, and Camila, all alumnae, described how their experiences in the classroom were so different from Science Olympiad and that freedom to explore and dig deeper into topics was vital to developing their interest in different STEM topics.

Interest develops over time with increasing levels of exposure

It has been well documented that the most powerful learning is done when students are doing science (Elmesky et al., 2006; Fox & Cater, 2015; Hill et al., 2018; Stets & Burke, 2000). The personal specific STEM interest development came when the participants did more and more with different topics. Victoria, a current student, described her experience with Rocks and Minerals. She explained that at first, she thought it was memorizing this and that, but then her learning evolved into the application and "thinking about it all the time" as she spent more time with the topics.

Additionally, long-term engagement is another critical factor in continuing to develop a situational interest into a personal specific interest (Adams et al., 2014; Hidi & Renninger, 2006). All of the participants shared experiences of how the extended time they spent with their events was how they developed more interest in the topics. Olivia described this with her Forensics event. She started with a particular part of the event and expanded her interest into multiple facets because of her time investigating. Although developing a personal specific STEM interest is crucial, it is only part of creating a STEM identity (Carlone & Johnson, 2007b; Hill et al., 2018; Kim et al., 2018; Stets et al., 2017).

Research Question 3: Features of Science Olympiad

Research question three, "What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?" was answered through the analysis of the data gathered during the focus group discussion about memories of Science Olympiad, both the positive and negative memories. Additionally, the research question was answered through data analysis of individual interview questions about memories of why participants joined and participated in Science Olympiad and what helped participants get through negative experiences in Science Olympiad. The following is a discussion of the themes that emerged through data analysis.

The social component of Science Olympiad is imperative

Science Olympiad is a team-based competition, and all of the participants repeatedly explained that the team aspect of Science Olympiad made it so influential in their experiences. Each participant described the Science Olympiad community as supportive and caring. This community aspect is one of the critical ways to build support for the members to explore what may be new and risky because the members have a safety-net if something does not go as planned. The attribute is similar to other successful groups that have been documented, such as the Lange Institute and Herpetology Research Experience program (Adams et al., 2014; Carlone et al., 2015). The existence of a supportive community to minimize the risk of failure is a characteristic that can reduce the stress and fear of trying something unfamiliar (Carlone et al., 2015; Morton & Parsons, 2018). The support system established through the team allows for identity boundary work to take place and the development of a stronger STEM identity for the participants (Carlone et al., 2015; Hennessy Elliott, 2020; Hill et al., 2018). Additionally, due to the competitive nature of STEM, a collaborative environment, such as Science Olympiad, can provide a safe place for female participants to learn how to compete (Carlone & Johnson, 2007b). Camila, an alumna, specifically referenced the competition she saw in her STEM college major. The preparation she felt she had gained through her participation in Science Olympiad prepared her with the resilience to stay with her major.

Science Olympiad was related to a community of practice (Wade-Jaimes et al., 2019). The participants each explained the comfort they felt by being with others who were also doing similar things. Many participants recalled times when they were learning about a topic with other team members where they felt a connection to STEM that differed from what they had thought in a classroom.

When the participants responded about why they continued to participate in Science Olympiad, each one responded about the team. They talked about supporting their teammates and feeling supported by their teammates. While Steegh et al. (2020) claimed that most of the participants continued in STEM competitions due to their topic interest, I found that most of the participants in Science Olympiad talked more about their teammates as a heavy influence on their continuation in Science Olympiad. Part of this may be because the participants in this study are all female. While Steegh et al. (2020) also acknowledged that females tended to lean more toward collaboration than only competition, which would explain why the participants would be more inclined to cite the community as an important influence in their continued participation.

Mentorship opportunities are crucial

Mentorship was mentioned by many of the participants as one of the reasons they participated in Science Olympiad in the way that they did. However, the mentorship mentioned the most was not a traditional older role model. Instead, it was peer mentorship. The structure of the studied program allows for peer mentorship where the more experienced student teaches the less experienced students. This model enables the students to see how they can lead and reminds them they can do STEM well (Hennessy Elliott, 2020). Hennessy Elliott (2020) pointed out that when a program is student lead with adult support, the trajectory of the program changes, and students find they fit into STEM differently. Emma, an alumna, related a situation where she was given a chance to lead and came out of the experience with additional confidence.

Along with the peer role models, teacher involvement was an important component of Science Olympiad. Teachers have been said to have critical roles in developing STEM identity (Hill et al., 2018; Papadimitriou, 2004; C. A. Shapiro & Sax, 2011). The teachers in the studied program act in more of a supportive role, but the participants repeatedly related the importance they saw in having teachers as mentors. Specifically, Olivia, a current student, related that she feels more comfortable because teachers are the adult supervision instead of parents. Along with Olivia, other participants also shared that they felt the teachers were there to support and encourage them and gave them confidence in STEM. However, one challenge raised with the teachers' support was their expertise was not always in the specific areas where the participants needed help. Therefore, some participants felt they got less help than others because of the area of STEM they were interested in.

Gender representation is a key feature of the studied Science Olympiad team

Positive role models are integral for people to envision themselves in a STEM role (Grunert & Bodner, 2011; Milgram, 2011; J. R. Shapiro & Williams, 2012). Many participants related that interacting with others like them was encouraging and helped them feel they belonged. A current student, Claire, mentioned her comfort in seeing others like her participating in Science Olympiad. She related it gave her a confidence boost in knowing others like her were also pursuing similar interests. Another current student, Maria, also said that the way the female participants were seen on an equal platform as the male participants in the program gave her more confidence. Many of the participants related other situations in STEM, outside of Science Olympiad, where they felt they were assumed to step behind and had to prove themselves able to achieve at the same level as their male counterparts. Not only does Science Olympiad provide the safe space for female participants to develop STEM identity and build their confidence but it also provides a place for the participants' male counterparts to learn how to deconstruct the roadblocks that females often experience in STEM (Kim et al., 2018).

Research Question 4: Who belongs in STEM fields

Research question four, "What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?" was answered by analyzing the definitions of STEM people provided in the online selection survey and then expanded upon in the individual interviews. The participants described specific characteristics of STEM people that coincided with similar traits described in the literature, such as being smart, analytical, problem solvers, and ambitious (Archer et al., 2017; Cooper & Heaverlo, 2013; Farrell & McHugh, 2017; Fox & Cater, 2015). The participants related that STEM people are logical thinkers that stay with a challenge and work through it, but none of the participants associated that these characteristics made them feel less feminine as much of the literature expresses (Baram-Tsabari & Yarden, 2008; Farrell & McHugh, 2017; Grunert & Bodner, 2011; Papadimitriou, 2004). The participants did not express sentiments similar to those described in other studies because of the role models the participants are exposed to in the Bay Area High School and their families. While the participants did not specifically discuss the impact of the gender of the teachers that they saw as role models when asked about specific teachers, most of the STEM teachers mentioned were female teachers.

Additionally, many participants discussed their families' role in their views of STEM. They specifically mentioned female role models in their families, coinciding with the findings of Baram-Tsabari and Yarden (2008), who noted that the family belief system substantially influences whether young females will investigate and learn about STEM. Multiple participants also discussed the gender representation within the Science Olympiad program and its student leadership as significantly impacting their view of belonging. Levine et al. (2015) addressed the lack of female role models as a significant deterrent for females entering STEM fields. Due to these circumstances, most participants in the study felt they belonged in STEM and could achieve in STEM, unlike the claim made by Farrell and McHugh (2017).

Multiple participants described STEM people as humanitarians who helped the world. The data showed that the participants also wanted to help the world and impact the challenges of today. This idea of helping the world is one that studies have found is a desire for many females that tends to deter females from STEM fields (C. A. Shapiro & Sax, 2011). However, many participants specifically discussed how STEM could be their avenue to impact the world positively. Specifically, Claire, a twelfth-grade student, discussed her college major choice as one where she found STEM helping the world but also providing income possibilities that would support a comfortable lifestyle. This idea of helping the world is one of the reasons that the life science fields have essentially closed the gender gap, while computer science and engineering still have very pronounced gaps. The computer science and engineering fields are not readily recognizable as ones that can help society.

Conclusion

Science Olympiad is a program that provides a supportive environment that can positively influence STEM identity. Specifically for female participants, the team structure with a collaboration focus is a critical component that allows for the growth of a STEM identity. Females tend to thrive more in a collaborative environment than in a competitive one (Riegle-Crumb et al., 2019). Learning how to be successful in a competitive environment while being supported through collaboration is one of the biggest strengths of Science Olympiad (Carlone et al., 2015; Carlone & Johnson, 2007b; Riegle-Crumb, 2017).

The opportunities to experience various STEM fields afforded in Science Olympiad allow female participants to explore and dive deeply into topics to build personal specific STEM interests that can direct them to STEM college majors and careers. With long-term engagement in Science Olympiad, female participants can build their interest in developing a strong STEM identity (Adams et al., 2014; Levine et al., 2015).

Peer leadership changes the focus of a program (Hennessy Elliott, 2020). Peer leadership with teacher support is shown to be a recipe to help female participants feel they belong in STEM. However, it is imperative to have teachers available to support and help grow the student leaders to develop a community of practice that supports their peers and helps others learn what it means to belong in STEM.

Implications for Research

While the community and team were found to be a critical component of the Science Olympiad program, not all of the partnerships were positive. Several participants shared different times when a specific partnership was not uplifting. Therefore, another area that should be explored is what partnership attributes make it effective and a space where STEM identity can be enhanced. Specifically, looking at what male partners do that make their partnership one of inclusion instead of exclusion. Elliott (2020) explained that there must be intentional work to include females, and males need to be able to recognize what actions alienate females in partnership so that adjustments can be made. Since females are more inclined toward collaboration over competition and working with others is a reward for participating in activities, positive partnerships are imperative to enhancing STEM identity, especially in those with lower STEM identity (Abernathy & Vineyard, 2001; Riegle-Crumb, 2017). While same-gender friends have been shown to affect females' pursuit of STEM fields positively, the research does not thoroughly examine the opposite-gender effect on pursuing STEM fields (Riegle-Crumb et al., 2006). Therefore, the impact of opposite-gender partnerships would be another area of further research.

The models of STEM identity have all been developed based on studies of females who persisted in STEM (Carlone & Johnson, 2007b; Kim et al., 2018). Related to partnership research, further research is needed to understand the male perspective on what encourages the development of STEM identity in comparison to the female view. By examining how males develop STEM identity and then comparing and contrasting the models for female STEM identity, an understanding of the different needs can be developed. Through this understanding, program adjustments can be made to incorporate the needs of both groups.

Science capital, possession of skills and resources in the science community, has been shown to impact females in STEM significantly, specifically in underrepresented areas such as physics (Archer et al., 2017). One aspect of science capital is the location and what programs are available to students. This study occurred in the Bay Area of California, known for STEM opportunities, specifically technology. To investigate whether the program's success is due to the location and emphasis on STEM in the area, female participants in Science Olympiad programs should be studied in various areas, specifically areas where STEM is not the economy's driving force. Looking at Science Olympiad programs in these areas where Science Olympiad is one of a few STEM extracurricular activities available to students would allow for more robust conclusions about the effect of Science Olympiad on STEM identity (Papadimitriou, 2004).

Another aspect of science capital is family background. When multiple sources and the school support STEM, there is a higher probability that adolescents, specifically females, will enter STEM fields (Archer et al., 2017). The majority of the participants in this study had strong STEM family backgrounds, most likely due to the geographic region. While this study did have a few participants who did not have significant family backgrounds rooted in STEM, the study did not focus on family backgrounds. Therefore, more investigation on the effect of family background on STEM identity development is needed. Exploring family backgrounds and STEM identity outside of the boundaries of specific STEM programs is important to understand who is lacking the opportunities to explore and develop STEM identity by virtue of family background.

Lastly, the question that the data brings to the forefront regarding underrepresentation of females and other minoritized groups in STEM is whether STEM preparation should be described as a pipeline (Covert et al., 2019; Krogh & Andersen, 2013; LaCosse et al., 2020). Covert et al. (2019) and Krogh and Anderson (2013) both showed that K12 classrooms did not have a significant impact on female students continuing through the STEM pipeline. Additionally, LaCosse et al. (2020) showed that the mindset of STEM professors had a significant impact on whether female students continued in STEM coursework in college. All three of these studies were focused on classroom elements. Each of those classroom elements either had a negative or no impact on the retention of females students. However, in my study the participants repeatedly reported that the community of practice they were part of had a significant impact on their view of themselves in STEM. Therefore, research should turn the focus to how to build these communities of practice instead of repairing a leaky pipeline. The notion of a pipeline does not allow for the wide variance in females students. Since each person is different the pipeline imagery does not work to represent all of the experiences that female students have in STEM. Additionally, the ways people can be involved in STEM is very broad. The imagery of a pipeline does not help people understand how there are so many ways to be involved in STEM, not just where a pipeline points.

Implications for Practice

Although Science Olympiad is a national program, the variation in how the program is run differs from school to school. Based on the results of this study, student leadership with strong teacher involvement is crucial to developing a program where the students create a supportive community of which students are proud to be a member.

Active teacher support in helping manage the team and, more importantly, acting as role models and advisors to the students help them take risks and grow in their leadership abilities (Hennessy Elliott, 2020). Because teachers have a significant impact on building or dismantling STEM identity (Hill et al., 2018), it is imperative that teachers support the growth and development of a supportive environment. Additionally, with hands-on support, teachers must actively monitor situations and dismantle roadblocks with the students so that all students can participate. Teachers must be aware of how students are interacting with one another. Working with the older students on how to mentor and foster an inclusive environment is challenging in the beginning, but as the program's culture develops, the work turns to monitoring and checking in on the students. This means the teachers must be physically present and invest time and energy in order to build these relationships and monitor the interactions between the students.

In order to foster active teacher support, schools must provide support for the teachers. Funding a Science Olympiad program should be priority for the school. Additionally, compensating teachers for the time they put into developing a team and mentoring the students must be priority. While compensating teachers is commonly thought of being done through stipends and other monetary means, teachers can be compensated in other ways, such as counting the team supervision as an extracurricular duty that is required in most secondary schools.

Funding a Science Olympiad program should not fall solely on the school. Students and families should have some part in the funding; however, the student and family part of the funding should not limit a student from participating. Therefore, the way the students can help contribute to the funding of a Science Olympiad program can be through fundraising. Typically, schools use selling goods as fundraisers, but there are many more ways fundraising can take place. Developing the confidence of female students within the program was found to be a strength for Science Olympiad. Fundraising should be combined with confidence building activities. Hosting workshops and competitions for younger students can be lucrative and help all students, and specifically female students, develop their confidence in their STEM skills.

Building a strong community within the team was another key finding. One of the places that the participants pointed out as a time when they saw as one of the most crucial times of building their relationships of trust and strengthening their community was the travel time to and from competitions. While buses are expensive, the time the students spend on the bus with their team was shown to be one of the most memorable times for the participants during their competition day. Therefore, the program studied needs to keep securing team provided transportation to and from competitions as a priority for the program. Buses are the best type of transportation purely because the whole team can be in one vehicle. When the team is split into multiple vehicles, the cohesiveness of the entire team is put in jeopardy.

The focus of the program must encourage female participation. While some females are driven by competition, many are not (Riegle-Crumb, 2017). For this reason, the Science Olympiad structure allows for a focus on collaboration and team building. A concerted effort should be made for partnerships and teams to work together and collaborate in problem-solving and learning. Programs should make time for team bonding and allow the team members to have fun together and develop caring relationships with each other. Many of the participants in this study related the time spent traveling to competitions as a group. Additionally, the time they spent together after school and on Saturdays was where these types of relationships were developed. During this time, they were not solely focused on STEM work but developed enduring relationships that became their support system within STEM.

However, female students need to learn how to thrive in a competitive system due to the nature of many introductory STEM courses (C. A. Shapiro & Sax, 2011). The STEM world is still perceived as a group of competitive fields (Adams et al., 2014), so we must help female students develop a resilience that will help them through STEM systems they encounter outside of Science Olympiad. Through using an environment that is collaborative in nature but still has a competitive element, like Science Olympiad, female students can learn how to thrive in a competitive environment. However, the focus of the competition must be one where there is no pressure to perform. The pressure to perform at specific levels creates a fear of failure that can dissuade female students from continuing to pursue STEM (Carlone et al., 2015). Science Olympiad, and other extracurricular STEM activities, need to be a supportive environment focused on growth and development instead of winning a prize. With that being said, there must be external rewards for participants. The data from this study shows the need for physical rewards. However, some of those rewards come in the praise and recognition of the work being done within the group.

Additionally, with a focus on building a community of practice over the competition, identity boundary work is easier to do, and more students can explore the variety of options in STEM. Because Science Olympiad has 23 different events, many students can examine many STEM niches. While allowing students to select the topics that interest them, encouragement to explore other topics is essential. The participants in the study explained that many of their favorite topics came from being assigned an event they did not expect to enjoy. However, when events are given to a student, several ideas that coincide with Carlone et al.'s (2015) identity boundary work must be considered. First, social support is critical. Since Science Olympiad is partner and team-focused, having other team members who have experience should provide support in learning the knowledge and skills necessary to have some success.

Additionally, the team member in a new event needs the time and space to grow and develop. It cannot be expected that they can be experts immediately. Lastly, boundary objects are required. Boundary objects are physical items that can support growth and development. In Science Olympiad, a boundary object could be a few information resources, a skeleton of a notes page, or an experienced partner. The advantage of Science Olympiad is the variety of topics covered each year. While the students are often sad to see a favorite event be cycled out, they find new passions in new events and experiences.

While Carlone and Johnson (2007) claimed that STEM identity development is hard to operationalize and impossible to give a how-to guide on developing a STEM identity, I propose that giving female students opportunities to learn and grow in a supportive community-based STEM program is paramount to allowing female students the opportunity to build their STEM identity. The studied Science Olympiad program is one such program that will enable female students the space to develop their STEM identity and personal specific STEM interests.

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APPENDIX

Appendix A

Sample Rules for a Core Knowledge Science Olympiad Event

ANATOMY & PHYSIOLOGY

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION:** Participants will be assessed on their understanding of the anatomy and physiology for the human **Nervous, Sense Organs, and Endocrine** systems.
   A TEAM OF UP TO: 2 **APPROXIMATE TIME:** 50 minutes
2. **EVENT PARAMETERS:** Each team may bring one 8.5" x 11" sheet of paper, which may be in a sheet protector sealed by tape or laminated, that may contain information on both sides in any form and from any source without any annotations or labels affixed along with two stand-alone non-programmable, non-graphing calculators.
3. **THE COMPETITION:** This Event may be administered as a written test or as series of lab-practical stations which can include but are not limited to experiments, scientific apparatus, models, illustrations, specimens, data collection and analysis, and problems for students to solve. Content topics will include:
   a. **Nervous System:**
      i. The Brain - major regions and their functions
      ii. Identification of simple encephalographic wave forms and why they occur
      iii. Neural Impulses - cellular anatomy and physiology of neurons and supporting cells, synapses and neurotransmitters, action potential generation and propagation, ionic basis of the cellular membrane potential, types of neural synapses
      iv. Central Nervous System - organization of the spinal cord, brainstem and cranial nerves, purpose/functions of sleep
      v. Peripheral Nervous System – neural ganglia, action and physiology of sensory and motor neurons, action and physiology of sympathetic and parasympathetic neurons, understand differences in and purposes of parasympathetic, sympathetic, somatic, and sensory systems, reflex arcs and proprioception, nerve structure
      vi. Disorders: Epilepsy, Alzheimer's Disease, Multiple Sclerosis, Parkinson's Disease, Cerebral Palsy, Shingles (herpes zoster), Stroke, Amyotrophic Lateral Sclerosis (ALS)
      vii. Effects of the drugs: alcohol, caffeine, nicotine, and marijuana on the nervous system
      viii. **National Tournament Only:**
         (1) **The Brain - anatomy and physiology of brain function including function and role of specific nuclei clusters and tracts, theories of dreaming, neural impulses - retrograde signaling, purpose and principles of MRIs and EEGs**
         (2) **Treatments and/or prevention (e.g.; drugs, surgery) for all conditions listed above**
   b. **Sense Organs:**
      i. Types of sensory receptors, General Senses vs. Special Senses
      ii. Mechanisms for the General Senses of touch, pressure, pain, temperature, itch, and proprioception
      iii. Sense Organs – regions of each of the Special Sense Organs and their functions
      iv. Physiology of sight, hearing, balance, smell, and taste
      v. Disorders: myopia, hyperopia, presbyopia, nyctalopia, astigmatism, conjunctivitis, color blindness, otitis media, types of deafness, Anosmia/dysosmia, dysgeusia
      vi. National Tournament Only:
         (1) Neural pathways for vision, depth perception, and hearing
         (2) Additional Disorders: Diabetic Retinopathy, Macular Degeneration, Glaucoma, Otosclerosis, Presbycusis, Meniere's Disease, Pink Eye (conjunctivitis) plus treatments and/or prevention of all conditions listed above
   c. **Endocrine System:**
      i. The three classes of hormones – steroids, peptides, and amines
      ii. Mechanisms of hormone action – nuclear vs. cytoplasmic
      iii. Endocrine related problems – hypersecretion, hyposecretion
      iv. Hormone producing glands, their hormones and the function of each
      v. Disorders: diabetes mellitus, hypoglycemia, Graves' disease, Hashimoto's disease, goiter, cretinism
      vi. National Tournament Only:
         (1) Endocrine cycles and negative feedback
         (2) Autonomic nervous system control of endocrine function
         (3) Additional Disorders: Cushing's Syndrome, Addison's Disease, and Myxedema, acromegaly
         (4) Treatments and/or prevention for all conditions listed above (drugs, surgery, etc.)
4. **SCORING:**
   a. High score wins.
   b. Selected questions will be used to break ties.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries a variety of resources to purchase for this event; other resources are on the Event Pages at soinc.org

This event is sponsored by Hikma Pharmaceuticals

Appendix B

Sample Rules for a Building Science Olympiad Event

WRIGHT STUFF

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION**: Prior to the tournament teams design, construct, and test free flight rubber-powered monoplanes to achieve maximum time aloft.

   A TEAM OF UP TO: 2 **IMPOUND**: No **APPROXIMATE TIME**: 11 minutes

2. **EVENT PARAMETERS**:
   a. Teams may bring up to 2 airplanes, any tools, their flight log, and two stand-alone calculators of any type.
   b. Event Supervisors will provide all measurement tools and timing devices.
   c. Participants must be able to answer questions regarding the design, construction, and operation of the device per the Building Policy found on www.soinc.org.

3. **CONSTRUCTION PARAMETERS**:
   a. Airplanes may be constructed from published plans, commercial kits**, competitors' designs, and/or other sources of design.** Kits must not contain any pre-glued joints or pre-covered surfaces.
   b. Any materials except Boron filaments may be used in construction of the airplane.
   c. Total mass of the airplane throughout the flight, excluding the rubber motor, must be 8.00 g or more.
   d. **The wing must not exceed 45.0 cm horizontally projected wingspan and must not exceed 9.0 cm chord (straight line distance from leading edge of wing to trailing edge, parallel to the fuselage). The horizontal stabilizer must not exceed 28.0 cm horizontal projected span and must not exceed 7.0 cm chord.**
   e. The propeller assembly may be built by the participants or purchased pre-assembled. It may include a propeller, a shaft, a hanger, and/or a thrust bearing. The maximum diameter of the propeller is **24.0 cm**. Variable-pitch propellers that include mechanisms to actively change the blade diameter or angle must not be used.
   f. **A rubber motor not to exceed a mass of 1.50 g, including any attachments such as O-rings, must be the sole power for the airplanes after release. It will be massed separately from the airplane. Motors may be lubricated before and/or after check-in. Up to 6 motors may be checked in.**
   g. Participants may use any type of winder, but electricity may not be available.
   h. The airplane(s) must be labeled so that the Event Supervisor can easily identify to which team it belongs.

4. **FLIGHT LOG**:
   a. **Teams must submit a Flight Log along with their plane. The log must include the following:**
      i. **Materials used to construct the plane**
      ii. **A labeled diagram or picture that identifies and describes the parts**
      iii. **Appropriate metric units for all numerical values**
      iv. **A front cover labeled with the Team Name and the Team Number for the current tournament**
      v. **Team name, team number, and appropriate metric units for all numerical values**
   b. The submitted Flight Log should contain recorded data covering 6 or more parameters (3 required and at least 3 additional) for 10 or more test flights prior to the competition.
      i. The required parameters are:
         (1) Motor size before windup
         (2) Number of turns on the motor or torque at launch
         (3) Flight time
      ii. The team must choose 3 additional data parameters beyond those required (e.g.; turns remaining after landing, estimated/recorded peak flight height, the motor torque at landing, etc.).
   c. **If a 3-D printer, laser cutter, CNC machine or similar device was used as a tool to build the team's device, or any component thereof, the following information must also be supplied in the log.**
      i. **Information about the tool hardware, software, materials, and supplies used**
      ii. **Details of the source of any digital files (e.g.; CAD, STL, OBJ) utilized by the tool including but not limited to when and where the file was obtained, including the web address if downloaded from the internet**
      iii. **Descriptions of how the team constructed the final device from the tool created components**
   d. **All submitted logs will be returned to teams.**

5. **THE COMPETITION**:
   a. The event will be held indoors. Tournament officials will announce the room dimensions (approximate length, width and ceiling height) in advance of the competition. Tournament officials and the Event Supervisor are urged to minimize the effects of environmental factors such as air currents. Rooms with minimal ceiling obstructions are preferred over very high ceilings.

WRIGHT STUFF (CONT.)

b. Once participants enter the cordoned off competition area to trim, practice, or compete they must not receive outside assistance, materials, or communication. Only participants may handle aircraft components until the event ends. Teams violating this rule will be ranked below all other teams. Spectators will be in a separate area.
c. At the Event Supervisor's discretion:
   i. Multiple official flights may occur simultaneously according to the Event Supervisor's direction.
   ii. Test flights may occur throughout the contest but must yield to any official flight.
   iii. No test flights will occur in the final half-hour of the event's last period, except for teams that declare a trim flight during their 8-minute Flight Period.
d. A self-check inspection station may be made available to participants for checking their airplanes prior to check-in with the Event Supervisor.
e. Participants will present their event materials (airplanes, motors, and logs) for inspection immediately prior to their Preflight Period.
f. All motors will be collected at check-in and will be re-issued to the team only for their Preflight Period and 8-minute Flight Period. Time taken during the Preflight Period will impact a team's final score (see 6.b.). Timers will follow and observe teams as they are winding their motors. Event Supervisors will return flight logs after inspection.
g. A team's Preflight Period ends with their first flight, trim or official, which starts their 8-minute Flight Period or if 3 minutes passes after their motor has been returned, whichever comes first.
h. Any flight beginning within the 8-minute Flight Period will be permitted to fly to completion. Participants may make adjustments/repairs/trim flights during their official 8-minute Flight Period. Before their launches, participants must indicate to the Timers whether a flight is official or a trim flight. A flight is considered official if a team fails to notify a Timer(s) of the flight's status. Teams must not be given extra time to recover or repair their airplanes.
i. Teams may make up to a total of 2 official flights using 1 or 2 airplanes.
j. Time aloft for each flight starts when the airplane leaves the participant's hand and stops when any part of the airplane touches the floor, the lifting surfaces no longer support the weight of the airplane (such as the airplane landing on a girder or basketball hoop) or the Supervisors otherwise determine the flight to be over.
k. Event Supervisors are strongly encouraged to utilize three (3) timers on all flights. The median flight time in seconds to the precision of the device used is the official time aloft.
l. Participants must not steer the airplane during flight.
m. In the unlikely event of a collision with another airplane, a team may elect a re-flight. The decision to re-fly may be made after the airplane lands. Timers are allowed to delay a launch to avoid a possible collision. The 8-minute Flight Period does not apply to such a flight.
n. The Supervisor will verify with the team the data being recorded on their scoresheet.
o. Teams filing an appeal must leave their airplane(s) and Flight Log in the event area.

6. **SCORING**:
   a. The base score is the Team's longest single official flight time. Ties will be broken by the longest non-scored official flight time.
   b. Motors will be held by the Event Supervisor until they are returned to the team signaling the start of the Preflight Period. Once a team has been re-issued their motors, prior to their 8-minute Flight Period, a timing official will start a Preflight Period stopwatch. If their first airplane flight (powered or unpowered), trim or official, is launched within 3 minutes of the return of motors a 5% bonus will be added to the base score. After 3-minutes have passed since the return of motors, the 8-minute Flight Period will start and no bonus will be awarded.
   c. A bonus of 10% of the flight time will be added to the flight time of an airplane that has the entire surface of the wing between at least 2 ribs or at least one of the wingtip fences completely marked with black marker or black tissue. If no ribs are present, the whole surface must be black.
   d. Teams with incomplete flight logs will have 10% of their flight time deducted from each flight.
   e. Teams without flight logs will have 30% of their flight time deducted from each flight.
   f. Teams that violate a rule under "CONSTRUCTION" or "THE COMPETITION" that does not have a specific penalty will be ranked after all teams that do not violate those rules.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries a variety of resources to purchase for this event; other resources are on the Event Pages at soinc.org

This event is sponsored by the National Free Flight Society (NFFS)

Appendix C

Sample Rules for a Laboratory/Hands-On Science Olympiad Event

CHEMISTRY LAB

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION:** Teams will complete one or more tasks and answer a series of questions involving the science processes of chemistry focused in the areas of Aqueous Solutions and **Oxidation/Reduction**.

   A TEAM OF UP TO: 2 **EYE PROTECTION:** C **APPROXIMATE TIME:** 50 minutes
2. **EVENT PARAMETERS:**
   a. Each participant must bring safety equipment (e.g., goggles, lab coat, apron), a writing implement, and may bring a stand-alone calculator of any type.
   b. Each participant may bring one 8.5" x 11" sheet of paper, which may be in a sheet protector sealed by tape or laminated, with information on both sides in any form and from any source.
   c. Teams should bring any or all of the items listed as Recommended Lab Equipment for Division C Chemistry Events, posted on soinc.org. Teams not bringing these items will be at a disadvantage, as they are not provided.
   d. Participants must wear goggles, an apron or a lab coat and have skin covered from the neck down to the wrist and toes. Gloves are optional, but if the host requires a specific type they will notify teams. Pants should be loose fitting; if the host has more specific guidelines they will notify teams in advance of the tournament. Shoulder length or longer hair must be tied back. Participants removing safety clothing/ goggles or unsafely handling materials or equipment will be penalized or disqualified.
   e. Supervisors will provide any required reagents, additional glassware, and/or references that are needed for the tasks (e.g., Periodic Table, table of standard reduction potentials, any constants needed).
3. **THE COMPETITION:**
   a. The competition will consist of a series of tasks similar to those in first year high school courses. These tasks could include hands-on activities, questions on listed topics, interpretation of data (e.g., graphs, diagrams, tables), or observation of an established and running experiment.
   b. Teams may be asked to collect data using a probeware set-up demonstrated by the Supervisor(s). Following a demonstration of the sensors/probes, participants may be given data sets to interpret.
   c. **Given the data/watching a running Redox titration, students should be able to determine the endpoint of the titration and the number of moles of target ion in the titration.**
   d. Participants should understand the following **Oxidation/Reduction** Chemistry concepts:
      i. **Writing and balancing half reactions**
      ii. **Oxidation numbers**
      iii. **Balancing redox reactions in neutral, acidic, and basic solutions**
      iv. **Calculating standard cell potentials using a table of standard reduction potentials**
      v. **State and Nationals Only - knowledge of fuel cells, knowledge & application of the Nernst equation & common storage batteries may be included**
   e. Participants should understand the following about Aqueous Solutions:
      i. Principles, properties, terms, and definitions concerning aqueous solutions
      ii. Calculate solution concentration given quantities of solute and solvent
      iii. Calculate the amount of material needed to achieve a specific concentration
      iv. Different measurements of concentration (e.g., molarity, molality, mass percentage, and parts per million) and how to calculate each
      v. State and Nationals Only: conversions between concentration units
4. **SAMPLE QUESTIONS/ACTIVITIES:**
   a. Titrations to determine percent composition, molarity, and/or molecular mass.
   b. **Given an unbalanced Redox equation, students should be able to determine the 2 half reactions and balance the equation.**
   c. **Given the data/watching a running Redox titration, students should be able to determine the endpoint of the titration and the number of moles of target ion in the titration.**
   d. Use freezing point depression to determine the molar mass of a solute.
   e. Identify and explain factors that affect solution formation.
   f. Determine whether a solution is saturated, unsaturated, or supersaturated.
5. **SCORING:**
   a. High score wins. Points will be divided evenly between Aqueous Solutions and **Oxidation/Reduction**.
   b. Time may be limited at each task but will not be used as a tiebreaker or for scoring.
   c. Ties will be broken by pre-selected questions.
   d. A penalty of up to 10% may be given if the area is not cleaned up as instructed.
   e. A penalty of up to 10% may be given if a team brings prohibited lab equipment to the event.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries a variety of resources to purchase for this event; other resources are on the Event Pages at soinc.org

This event is sponsored by Ward's Science

Appendix D

Sample rules for a hybrid Science Olympiad event

IT'S ABOUT TIME

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION**: Teams will answer questions related to time and they may construct and bring one non-electrical device to measure time intervals between 10 and 300 seconds.

   A TEAM OF UP TO: 2 **EYE PROTECTION**: None **IMPOUND**: Yes **APPROX. TIME**: 50 minutes

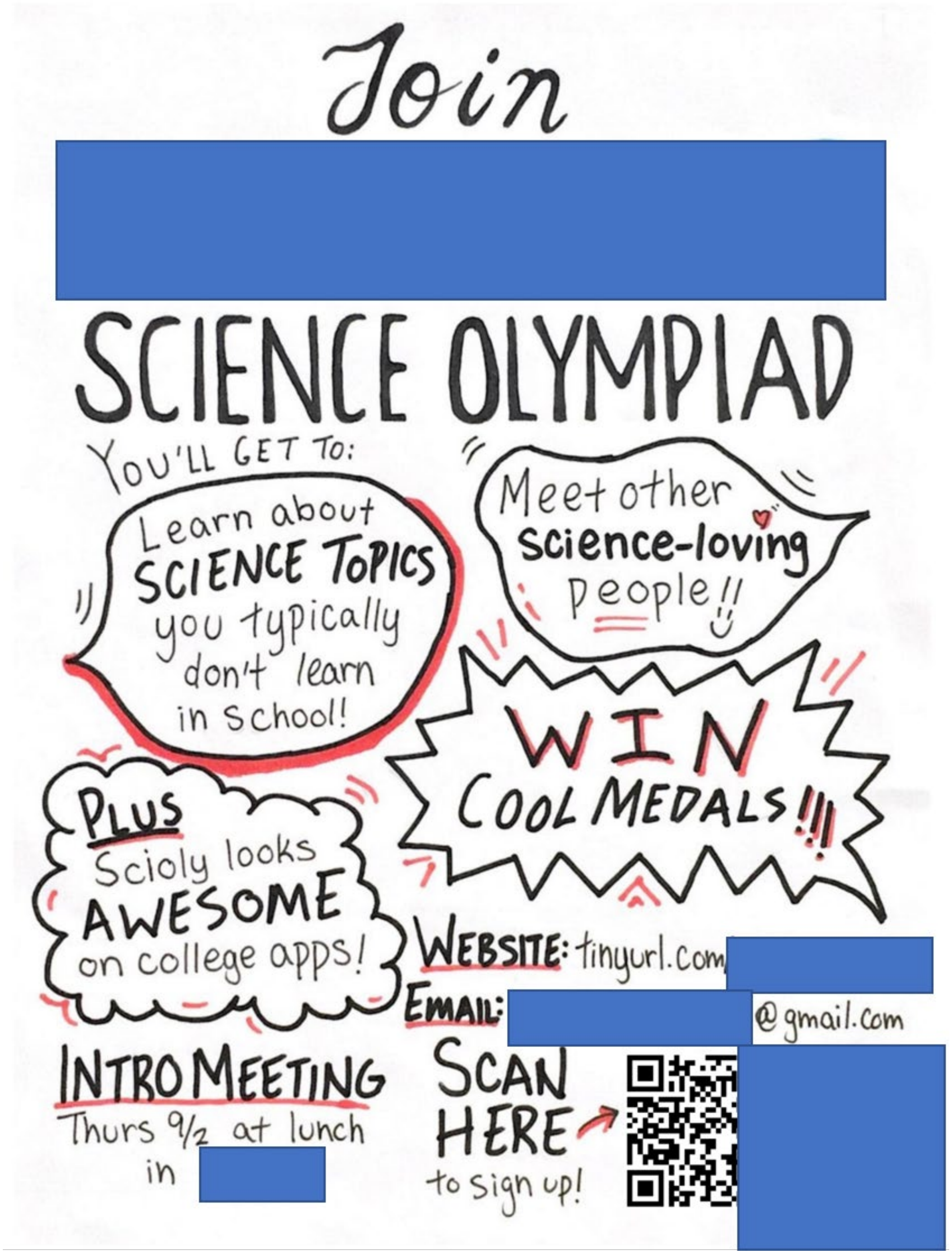
2. **EVENT PARAMETERS**:
   a. The event supervisor must hide from view any clocks present in the competition room.
   b. Each team may bring one three-ring binder of any size containing information in any form and from any source attached using the available rings. Sheet protectors, lamination, tabs and labels are permitted. Participants may remove information or pages for their use during any part of the event.
   c. Each team may also bring tools, supplies, writing utensils, and two stand-alone calculators of any type for use during any part of the event. These items need not be impounded.
   d. Each team must impound only one device and all components that are integral to its operation (e.g. water, sand, etc.), a device diagram, and copies of graphs and/or tables for scoring. Components needed to set up, calibrate, and clean up (e.g. tools, clean-up supplies, reference materials, other time keeping devices) need not be impounded.
   e. The impounded device and any storage boxes must be clearly marked with the team's school name and competition number. At impound, the device and all impounded components must be able to fit into an 80.0 cm x 80.0 cm x 80.0 cm cube and be moveable by the competing team members without outside assistance. The device may be larger after setting up for Part II.
   f. The device must be designed and operated in such a way that it does not damage or alter the competition area.
   g. Participants must be able to answer questions regarding the design, construction, and operation of the device per the Building Policy found on www.soinc.org.
   h. The device must be constructed to be able to provide a distinct audible and/or visual signal at the end of a time interval set by the competitor.
   i. Prior to competition, teams must calibrate devices by preparing graphs/tables showing the relationship between elapsed times and device configuration parameters. A labeled device diagram should be included.
      i. Any number of graphs and/or data tables may be submitted but the team must indicate up to four to be used for the Chart Score, otherwise the first four provided are scored.
      ii. Graphs and/or tables may be computer generated or drawn by hand on graph paper. Each data series counts as a separate graph. A template is available at www.soinc.org.
      iii. Teams are encouraged to have a duplicate set to use, as those submitted may not be returned.

3. **CONSTRUCTION PARAMETERS**:
   a. Examples of acceptable non-electrical devices include water or sand glasses, simple or torsional pendulums, or oscillating springs.
   b. Commercial counters, tally devices, timepieces or their parts are not allowed. Commercial balances, scales, test tubes, beakers, graduated cylinders, and burettes are not considered counters and are allowed.
   c. The device must be constructed to contain spillage.
   d. The device must be constructed to minimize possible impacts on other teams when running (e.g., as quiet as possible, occupies a reasonable amount of space when set up, etc.).

4. **DESIGN LOG**:
   a. **Teams must submit a Design Log along with their device. The log must include the following:**
      i. **Materials used to construct the device**
      ii. **A labeled diagram or picture that identifies and describes the parts of the device**
      iii. **Team name, team number, and appropriate metric units for all numerical values**
   b. **If a 3-D printer, laser cutter, CNC machine or similar device was used as a tool to build the team's device, or any component thereof, the following information must also be supplied in the log.**
      i. **Information about the tool hardware, software, materials, and supplies used**
      ii. **Details of the source of any digital files (e.g.; CAD, STL, OBJ) utilized by the tool including but not limited to when and where the file was obtained, including the web address if downloaded from the internet**
      iii. **Descriptions of how the team constructed the final device from the tool created components**
   c. **All submitted logs will be returned to teams.**

Appendix E

Recruitment Poster for Science Olympiad 2021-22



Appendix F

Principal and Superintendent permission letters

[redacted]

April 8, 2022

Institutional Review Board for the Protection of Human Subjects
University of San Francisco
2130 Fulton Street
San Francisco, CA 94117

Dear Members of the Committee:

On behalf of [redacted] I am writing to formally indicate our awareness of the research proposed by Ms. Letta Meyer, a student at USF. We are aware that Ms. Meyer intends to conduct her research by administering a survey to 76 of the Science Olympiad team members. Following the survey, she will conduct individual interviews with ten female students and a focus group interview with up to eight students.

I am responsible for all students at [redacted] and am the Principal of the institution. I give Ms. Meyer permission to conduct her research at our academic institution.

If you have any questions or concerns, please contact my office at [redacted]

Sincerely,

Francis Rojas
[redacted]

[redacted]

[redacted]

April 8, 2022

Institutional Review Board for the Protection of Human Subjects
University of San Francisco
2130 Fulton Street
San Francisco, CA 94117

Dear Members of the Committee:

On behalf of [redacted], I am writing to formally indicate our awareness of the research proposed by Ms. Letta Meyer, a student at USF. We are aware that Ms. Meyer intends to conduct her research by administering a survey to 76 of the Science Olympiad team members. Following the survey, she will conduct individual interviews with ten female students and a focus group interview with up to eight students.

I am responsible for all students in [redacted] and am the Superintendent of the institution. I give Ms. Meyer permission to conduct her research at our academic institution.

If you have any questions or concerns, please contact my office at [redacted]

Sincerely,

Cheryl Jordan
Superintendent
[redacted]

Appendix G

Informed consent forms for participants

April 9, 2022

Dear Parents:

My name is Letta Meyer and I am a graduate student in the Learning and Instruction Department in the School of Education at University of San Francisco. I am sending this letter to explain why I would like for your child to participate in my research project. I am studying STEM identity in females and would like to see how active participation in Science Olympiad influences female STEM identity.

With your permission, I will ask your child to complete a short questionnaire that would take about 15 minutes. Additionally, your child may be selected to participate in an interview and/or focus group that would each take about 45 minutes. Your child's participation in this study is completely voluntary and will not affect his or her grades or participation in the Science Olympiad program in any way. Your child may quit this study at any time by simply saying "Stop" or "I do not wish to participate."

The study will be conducted with an online questionnaire available between Friday May 20-25, 2022 to complete. Interviews and focus group discussions will be scheduled to take place the first 3 weeks of June 2022. There are no known risks involved in this study and your child will not receive any compensation for his or her participation. To protect your child's confidentiality, your child's name will not appear on any record sheets. The information obtained will not be shared with anyone, unless required by law. The records will be maintained by me and my faculty sponsor, Dr. Xornam Apedoe. If you have any questions, please contact me at (408) 250-1078 or via email at lmeyer@dons.usfca.edu.

This letter will serve as a consent form for your child's participation and will be kept in the Learning and Instruction Department at University of San Francisco. If you have any questions about this study, please contact Dr. Xornam Apedoe, the faculty sponsor of this project, at xapedoe@usfca.edu or at (415)422-6525. If you have any questions about your child's rights as a participant, you may contact the University of San Francisco IRB at IRBPHS@usfca.edu.

Please complete the statement of consent at <link to form> by Wednesday May 18, 2022.

Sincerely yours,

Statement of Consent
I read the above consent form for the project entitled A Case Study of Science Olympiad's Effect on Female STEM Identity conducted by Letta Meyer of University of San Francisco. The nature, demands, risk, and benefits of the project have been explained to me. I am aware that I have the opportunity to ask questions about this research. I understand that I may withdraw my consent and discontinue my child's participation at any time without penalty.

____

Child's Name (print clearly)

____

Signature of Legal Guardian *Date*

April 9, 2022

Dear Student:

My name is Letta Meyer and I am a graduate student in the Learning and Instruction Department in the School of Education at University of San Francisco. I am asking you to participate in a project that examines how active participation Science Olympiad influences female's STEM identity.

I am asking you to complete a short questionnaire that will take about 15 minutes. Your parents or legal guardians have already given permission for you to participate in this study, but you do not have to participate if you choose. You may quit this study at any time by simply telling me that you do not want to continue. You can skip any questions or tasks that you do not want to complete. Your participation in this study will not affect your grades in any way. There are no known risks involved in this study and you will receive nothing for your participation. To protect your confidentiality, your responses will not be shared with anyone unless required by law. The responses you make will be kept by my professor Dr. Apedoe and me. Neither your teacher nor your parents will know if you chose to participate in this project or will know the answers you provide.

If you have any question about this study, please contact me at lmeyer@musd.org.

Sincerely yours,

Agreement

I agree to participate in this research project and I have received a copy of this form.

____

Student's Name (Please Print) *Date*

____

Student's Signature

I have explained to the above named individual the nature and purpose, benefits and possible risks associated with participation in this research. I have answered all questions that have been raised and I have provided the participant with a copy of this form.

____

Researcher *Date*

UNIVERSITY OF SAN FRANCISCO

CHANGE THE WORLD FROM HERE

April 9, 2022

Dear Alumnus:

My name is Letta Meyer and I am a graduate student in the Learning and Instruction Department in the School of Education at University of San Francisco. I am sending this letter to explain why I would you to participate in my research project. I am studying STEM identity in females and would like to see how active participation in Science Olympiad influences female STEM identity.

With your permission, I will ask your child to complete a short questionnaire that would take about 15 minutes. Additionally, you may be selected to participate in an interview and/or focus group that would each take about 45 minutes. Your participation in this study is completely voluntary and will not have any specific personal benefits or risks. You may quit this study at any time by simply saying "Stop" or "I do not wish to participate."

The study will be conducted with an online questionnaire available between Friday May 20-25, 2022 to complete. Interviews and focus group discussions will be scheduled to take place the first 3 weeks of June 2022. There are no known risks involved in this study and you will not receive any compensation for your participation. To protect your confidentiality, your name will not appear on any record sheets. The information obtained will not be shared with anyone, unless required by law. The records will be maintained by me and my faculty sponsor, Dr. Xornam Apedoe. If you have any questions, please contact me at (408) 250-1078 or via email at lmeyer@dons.usfca.edu.

This letter will serve as a consent form for your participation and will be kept in the Learning and Instruction Department at University of San Francisco. If you have any questions about this study, please contact Dr. Xornam Apedoe, the faculty sponsor of this project, at xapedoe@usfca.edu or at (415)422-6525. If you have any questions about your child's rights as a participant, you may contact the University of San Francisco IRB at IRBPHS@usfca.edu.

Please complete the statement of consent at <link to form> by Wednesday May 18, 2022.

Sincerely yours,

Statement of Consent
I read the above consent form for the project entitled A Case Study of Science Olympiad's Effect on Female STEM Identity conducted by Letta Meyer of University of San Francisco. The nature, demands, risk, and benefits of the project have been explained to me. I am aware that I have the opportunity to ask questions about this research. I understand that I may withdraw my consent and discontinue my child's participation at any time without penalty.

____

Child's Name (print clearly)

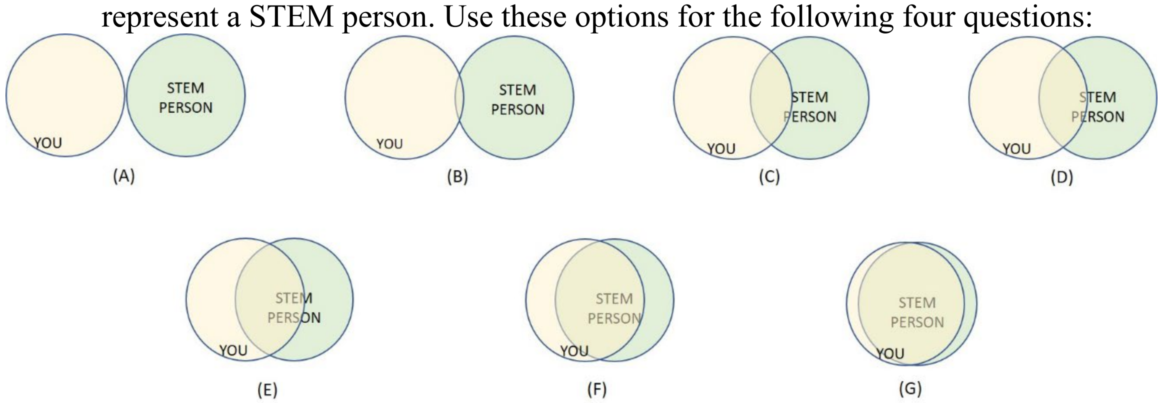
____

Signature of Legal Guardian *Date*

Appendix H

Survey Questions

1. Demographic information.
   a. Name
   b. Age
   c. Years of participation in Science Olympiad as a competitor.
   d. Years of hosting a competition as an alumni
   e. Overall, how would you classify your participation in Science Olympiad?
      A. Highly involved
      B. Involved
      C. Somewhat involved
      D. Not involved
   f. Schooling you are currently completing
      A. High School 9^{th} grade
      B. High School 10^{th} grade
      C. High School 11^{th} grade
      D. High School 12^{th} grade
      E. College 1^{st} year
      F. College 2^{nd} year
      G. College 3^{rd} year
      H. College 4^{th} year
      I. College Graduate
   g. Gender
   h. Would you be willing to participate in a 30 – 45 minute interview to share more about your experiences participating in Science Olymipaid?
   i. Would you be willing to participate in a 45-60 minute discussion with other current and former Science Olympiad participants to share more about your experiences participating in Science Olympiad?
2. In the diagrams below, let the yellow circle represent you and the green circles represent a STEM person. Use these options for the following four questions:



   a. Pick the graphic that you see yourself as.
   b. Pick the graphic that your family sees you as.
   c. Pick the graphic that your friends see you as.

   d. Pick the graphic that your teachers see you as. (Graphic shown below)
3. Describe a STEM person. Please be as specific as possible, describing multiple characteristics.
4. Check the top **three** rewards for participating in Science Olympiad:
   a. working with my coach
   b. working with my partners
   c. working with the rest of the team
   d. being part of a team
   e. competing against other students
   f. learning new things
   g. learning the scientific process
   h. having fun
   i. meeting students from other schools
   j. sharing my ideas with others
   k. preparing for my future
   l. pleasing my teachers
   m. pleasing my parents
   n. winning prizes
   o. getting my name in the paper or announcements
   p. working with my friends
   q. being on a team
   r. spending the day at a university
   s. looking better on my college application
5. Check the other rewards for participating in Science Olympiad. (Same list as above.)
6. What specific Science Olympiad events are/were your favorite? You may list up to five. Do not worry if you do not remember the exact name of the event, just describe the topic.

Appendix I

Interview Questions

1. In the background survey, you described a STEM person as: (READ participant's answer). Would you elaborate on what (a section of their answer) means to you?
2. In the initial background survey, you picked (show graphic) to represent how you see yourself and STEM. What made you pick that graphic?
3. In the initial background survey, you picked (show graphic) to represent how your family sees you and STEM. What made you pick that graphic? How important is it that your family sees you as a STEM person?
4. In the initial background survey, you picked (show graphic) to represent how your friends sees you and STEM. What made you pick that graphic? How important is it that your friends see you as a STEM person?
5. In the initial background survey, you picked (show graphic) to represent how your teachers sees you and STEM. What made you pick that graphic? How important is it that your teachers see you as a STEM person?
6. Let us use the same circle graphic again. When you just think about understanding STEM principles and how they work, which graphic do you think represents you? Why did you pick that graphic?
7. Let us use the same circle graphics again. When you just think about doing STEM (solving problems, explaining principles, etc.), which graphic do you think represents you? Why did you pick that graphic?
8. Let us use the same circle graphic again. When you just think about being interested in STEM topics in general, which graphic do you think represents you? Why did you pick that graphic?
9. Let us use the same circle graphic again. In the survey your told me ___ events were your favorites (insert from the survey). When you think about your interest in just the topics covered in those event, which graphic do you think represents you? Why did you pick that graphic?
10. What is your favorite Science Olympiad event? Tell me about how you found it and what intrigues you about it.
11. What is your least favorite thing about Science Olympiad? How do you deal with that so that you continue to participate?
12. Tell me about where you heard about Science Olympiad and why you decided to join and participate like you did.
13. As you chose your major, what part did your experience in Science Olympiad play?
14. Why do you continue to participate in Science Olympiad each year? (student)
15. Why did you continue to participate in Science Olympiad each year in HS and have continued to do Science Olympiad through alumni organizations?

Appendix J

Focus Group Questions

1. What stands out in your memory about Science Olympiad and what it meant/means to learn and do science?
2. Tell me about one of your memories of Science Olympiad that you think shaped you the most.
3. Tell me about one of your memories of Science Olympiad where you were ready to quit. What happened? And then why did you stay?
4. Share with me about a time when you were put into an event that you were not really interested in and then you found you actually liked it. What contributed to the change in interest?
5. In the initial background survey, none of you picked competing against other students as a main reward or reason to participate in Science Olympiad. When you think of the competition element of Science Olympiad, where does that fit on the continuum of what you like about Science Olympiad?

Appendix K

Codebook

RQ 1: How does participation in a Bay Area High School Science Olympiad program influence the STEM identity of female students and alumnae?

- Competition Performance
  - Achievement
  - after competition not as important
  - big ego
  - competition
  - consistent results
  - cram week
  - cramming the night before
  - Don't see everyone
  - external motivation
  - focus on how I did
  - hierarchy
  - hyper focused on something you didn't study
  - improvement
  - intense
- Confidence Building
  - confidence
- Depth of Learning
  - application
  - application of concepts important for understanding
  - apply knowledge to the real world
  - application of topics
  - basic understanding
  - depth of learning
  - expand knowledge
  - experience
  - explaining to others
  - grasp of concepts
  - guidance
  - hands on
  - knowledge is power
  - learn how I learn
  - learning
  - new information
  - new knowledge
  - new questions
  - new technologies

  - niche
  - not just studying
  - not just what but how
- Family, Cultural, Location Expectations of STEM
  - demographic expectation
  - environment
  - expectation
  - family emphasis
  - family example
  - family expectation
  - family support
  - family view of STEM confined
  - forced into music
  - like a family member
  - Location influence
  - parent encouragement
  - STEM always been there
  - STEM is the assumed default
- Growth Mindset
  - bigger picture
  - focus on learning
  - fun to learn
  - further knowledge
  - growth mindset
  - growth of learning
  - increase knowledge
  - learn for fun
  - learning
  - moments
  - reward of learning
- Identity Development
  - Activities growing up shapes identity
  - all encompassing
  - career
  - conceptual understanding
  - engagement
  - figure out what I want to do
  - identity
  - identity development
  - identity is career
  - increase STEM identity
  - influenced major
  - Inside Out analogy

  - main character
  - main character development
  - multi-dimensional
  - multiple identities
  - overall good at STEM
  - part of identity
  - self-development
  - sidekick
  - STEM influence grows
  - still developing
- People have multiple dimensions
  - more than just a STEM person
  - more than just my career
  - multi-dimensional
  - multiple identities
  - music with STEM
  - no combination
  - not defined by one thing
  - not just career path
  - other aspects of a person
  - other parts of me
- Problem Solving
  - Answer and solve like problems
  - asking questions
  - connecting ideas
  - critically think
  - curious
  - problem solving
- Skills Development
  - application of skill in other areas
  - application of skills in other STEM areas
  - better study skills
  - comfortable with asking questions of mentors
  - communication
  - critically think
  - curious
  - initiative
  - leadership opportunities
  - not comfortable
  - organized
  - preparing
  - problem solving
  - push yourself

    - questioning
    - skills
    - structure, lack of
    - test anxiety
    - test taking skills
- Teachers and Mentors
    - boss understands more aspects of my role
    - helping others
    - how boss sees me important
    - how close to teacher determines value
    - interaction with teachers
    - mentor
    - Mentoring
- What others see me doing
    - acquaintances
    - Activities growing up shapes identity
    - activities participating in
    - bias
    - family perception
    - family sees all interests
    - gravitate toward STEM
    - higher level classes in STEM
    - how close to teacher determines value
    - incomplete picture
    - interaction limited
    - others point out
    - outspoken
    - outward activities
    - perceptions by others
    - school emphasis
    - school options
    - Time spent in STEM activities
    - what classes taken
    - what I am involved in
    - what they see

RQ 2: How does participation in a Bay Area High School Science Olympiad contribute to the maintenance and growth of a personal specific STEM interest in female students and alumnae?

- Requirements to Build Interest
    - activity in fosters interest
    - activities participating in
    - exposure to some
    - introduction to topic

    - investigation
    - phases of life
    - Time
- Starting to Build interest
    - accidental events
    - assigned
    - doing things I hadn't thought of
    - interest development
    - interest in topic
    - other interests
    - random placement
    - Science interest
- Feelings of Interest
    - appreciation
    - build events intriguing
    - dual areas of interest
    - effort
    - engrossed
    - enjoyment
    - evolving interest
    - excitement
    - Exploration
    - fascination
    - focus
    - focus on my interests
    - happiness
    - interesting
    - levels of interest
    - passion
    - passion for topic
    - science was also pretty intriguing
    - think about it all the time
- Interest develops over time with increasing levels of exposure
    - enjoyed science
    - expanding interests
    - Exploration
    - events expose to different topics at a deeper level
    - fostered
    - not just career path
    - self-development
    - should be versus what is
    - still developing
- Interest helped me

  - exposure to a variety of areas
  - figure out what I want to do
  - future career
  - helped me find my major
  - informed
  - not just about what you like, but what you don't too
- Meaning of interest
  - interest and being good at it
  - interest levels
  - interest vs. STEM person
  - interest vs. using the knowledge
  - lack of interest
  - not all interconnected
  - variety types of events
- STEM is very broad
  - all fields of STEM
  - big world
  - broad
  - broadness of STEM
  - comprehensive of STEM
  - depends on STEM topic
  - diversity of topics
  - engineering
  - interconnectedness of STEM
  - intersection between topics
  - major/career choice
  - math and science together
  - not all interconnected
  - possibilities of STEM
  - section of STEM
  - see other areas
  - separation of STEM into different components
  - specific areas
  - STEM one dimensional
  - STEM variety
  - varied
  - variety types of events
  - vastness of STEM

RQ 3: What features of Science Olympiad encourage active, long-term participation in Science Olympiad for female members? What features hinder participation?

- Comfort in the familiar
  - continuation of experience
  - elementary experience

  - familiar
  - middle school experience
  - not comfortable
- Core memories
  - engaging experience
  - High School memories = Science Olympiad
  - longer lasting memories
  - memories
  - most defining experiences
- Friends in Science Olympiad
  - belonging
  - best friend
  - connection with people
  - different friends
  - friend
  - friend group
  - friendships created
  - invitation
  - knew the other people
  - new friends
  - relationships
  - social
  - social aspects
  - time with teammates
- Gender importance
  - all valued
  - females need to be at the top to be seen as equals
  - Gender balanced
  - gender specific role models
  - gender specific study times
  - hesitant
  - how treated by others
  - imposter syndrome
  - jokes cutting
  - male dominated in tech clubs
  - not male dominated
  - outside of Science Olympiad opinions not valued
  - representation
- Part of a caring community
  - all valued
  - behind the screen not the same
  - belonging
  - bond

- build others up
- bus rides back build community
- can just be themselves
- caring
- chaotic and fun
- collaboration
- comfortable space
- community
- Community can dissuade
- community helping each other
- community of scientists
- community to depend on
- connection with people
- contribution
- corny jokes
- COVID influence
- cram week
- culture of team
- doing the same thing
- excitement
- fun
- guidance
- help from others
- helpful
- ideas valued
- like-minded people
- motivation
- nerdy jokes
- no judgement
- outreach by current
- outreach by upperclassmen
- peer acknowledgement
- peer commitment
- peer leaders
- peer mentors
- peer role models
- peer support
- people helping each other
- relationships
- Safe
- that kind of atmosphere
- time with teammates
- travel community building

    - trust
    - value others contributions
    - working with other people
- School vs. Science Olympiad
    - change in perception of STEM jobs
    - different from school topics
    - different structure
    - digging deeper
    - doing science
    - expand knowledge
    - figure out what I want to do
    - higher level classes in STEM
    - influenced major
    - not just career path
    - not just what but how
    - not traditional
    - open mind
    - school emphasis
    - school options
- Teacher involvement
    - support from teachers
    - teacher introduction
    - teacher involvement
- Team Aspect
    - culture of team
    - ideas valued
    - intense
    - modification of ideas
    - not helpful
    - not solo
    - part of the team
    - partner participation
    - team contribution
    - teamwork
    - time with teammates
- Working Together
    - chaotic and fun
    - collaboration

RQ 4: What are Bay Area High School Science Olympiad female students and alumnae perceptions of who belongs in STEM fields?

- Different Way of Thinking
    - solution focused

  - STEM based approach
  - STEM influences how I think
- How Society see STEM
  - Ambitious
  - arts vs. STEM
  - confining
  - cuts off other areas
  - Definition
  - driven
  - dry sense of humor
  - dumb outside of like science
  - emotional intelligence
  - financial stability
  - in a box
  - income
  - job related
  - job title
  - lack emotional intelligence
  - lack of communication skills
  - lack of emotion
  - little bit of tech does not mean STEM
  - logic
  - media portrayals
  - methodical
  - not emotionally intelligent
  - others perception of STEM
  - science nerd
  - should be versus what is
  - societal frame
- Feelings Toward STEM
  - love science
- Innate Abilities
  - ability
  - be smart
  - capability
  - comes easily
  - good
  - good at
  - grasp of concepts
  - natural talent
  - not comfortable
  - overall good at STEM
  - quick grasp

  - self-comparison
  - should be versus what is
- STEM helps the world
  - advancements to help others
  - change to the world
  - helping others
  - humanitarian field
  - knowledge is power
  - service oriented
  - titles
- Willingness to stick with tough stuff
  - Ambitious
  - discipline
  - driven
  - dumb outside of like science
  - effort
  - initiative
  - push yourself
  - STEM competitive
  - stick with it
  - tenacity

Unclassified

- background
- balance
- college applications
- diagrams
- first influence
- friends think more capable
- help the family
- Hermione Granger parallel
- hobby
- home
- job fulling
- keep up
- lack of confidence
- love science
- major
- medals
- mentorship
- mindset towards competition
- moments

- motivation of competition
- multipurpose
- need to prove self
- Ok not to be the top if you learn and work hard
- opportunity
- outside actions
- outside variables effect placement
- planning
- positive reaction
- practice
- pressure
- pressure to medal
- randomness of test topics
- ranking
- recognition important
- rewards not coming
- see science all around me
- see what it was about
- self-esteem
- self-view
- showed me success
- skills
- slope of progression
- STEM part of society
- STEM person view
- STEM profession
- STEM stable income and future
- stress
- stronger attribute
- study group
- studying
- supportive
- surface level knowledge
- surrounding
- talent
- teacher interaction
- teacher view
- teacher vs. mentor
- teaching others
- technology-based
- time commitment

- title
- tough topics
- travel community building
- trust
- understanding depends on perspective
- understanding of other fields
- understanding the why behind it
- waste of talent
- welcoming
- work days
- work together
- world of science
- worth defined by achievements
- You're smart