Building Their Glass Slipper: Existing Challenges and Promising Approaches for Girls in Technology and Engineering Classrooms

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Over the past 20 years, a growing body of work examines why women are underrepresented in Science, Technology, Engineering, and Mathematics (STEM) fields and careers. However, research is lacking on work focused on how young girls form an identity in the disciplines of technology and engineering or the "T&E" of STEM. The purpose of this two-phased study was to explore perspectives and attitudes that influence girls' decisions to take high school technology and engineering courses and determine if a classroom environment focused on supportive and transformative norms can develop girls' positive technology and engineering identity. Three overarching research questions guided this study: What are girls' perspectives of and attitudes toward technology and engineering courses? How do girls' perspectives or attitudes toward technology and engineering influence their discussions about taking technology and engineering courses in high school? Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities? Using sequential exploratory mixed methods, qualitative data were first collected through semi-structured interviews. In addition, a survey was given to the participants to record their perceived technology and engineering attitudes, beliefs, and identities. The findings from this portion of the study informed the intervention for phase two. The second phase of the study gathered quantitative data that compared if girls exposed to human-centered design, recognition,

and belonging would form a more robust technology and engineering identity in the middle school technology and engineering classroom.

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Dedication

This dissertation is dedicated to my entire family. I would not have accomplished this milestone in my life without your unconditional love, support, and encouragement. To *my parents*- my first teachers. You instilled in me a love of learning and wonder from a young age. It has carried me through every personal and professional endeavor, and I will be forever grateful that God blessed me with the most amazing parents, teachers, and role models.

I want to dedicate this dissertation to the educators who have inspired, motivated, and mentored me from elementary to graduate school. I feel fortunate to have been educated by so many who teach from the heart, want to make a difference, and ask questions of the world. Each of you sparked a passion in me to want to do the same.

I want to dedicate this dissertation to anyone who thinks they do not belong, are not worthy, or will not make it in the world of technology and engineering. The world in which we live and teach still has such deep stereotypes. I hope this work will help open conversations to make your educational journey one that opens more doors and positively transforms your educational experience in technology and engineering education.

This dissertation is dedicated to my children – Harrison, Elin, and William. I hope you believe you can accomplish anything you set your mind toward. Thank you for allowing me to learn from and with you daily. You are my greatest gifts, and you are each so very loved.

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1.0 Introduction and Rationale

The push for a future workforce with an integrative science, technology, engineering, and mathematics (STEM) education is an urgent and highly focused initiative of many federal, state, and local groups (Honey et al., 2014). Having a STEM literate population makes us competitive in the global economy, especially since the U.S. Department of Labor Statistics projects that STEM occupations are "expected to grow 8.0 percent by 2029, compared with 3.7 percent for all occupations" (Zilberman & Ice, 2021). STEM literacy is also important for our national security. As the report, *Road Map for National Security: Imperative for Change* states, "the inadequacies of our systems of research and education pose a greater threat to U.S. national security over the next quarter-century than any potential conventional war we might imagine" (United States Commission on National Security/21st Century, 2001, p. ix). A demand of 2.4 million jobs in STEM go unfilled annually (Smithsonian Science Education Center, 2018), proving we are not producing enough graduates who pursue STEM careers. These statics show the importance of interest in STEM education and the need for people to pursue STEM careers.

One place to look to fill this gap in STEM careers is in the underrepresented population of women. Since the 1960s, women have increased their numbers in overall employment in the United States to 47% of all jobs. However, women represent less than a quarter in STEM careers (Noonan, 2017). The most significant gender gap in STEM careers can be found in engineering and computer science. Based on the data from the U.S. Census Bureau in 2020, even as the number of women in US jobs has risen to 48% of all workers, their representation in computer and engineering degrees lags far behind that of the overrepresentation of white and Asian men (Martinez & Christnacht, 2021).

A powerful TEDx talk by Jenni Buckley (2017) discusses the gender gap in science and engineering careers and argues, “we must engineer the diversity we want to see” (Buckley, 2017, 19:52). She reiterates that we can influence girls' decisions to go into engineering and science by simply showing them the possibilities. Importantly, it is not the case that girls and women simply do not have an interest science and engineering. Instead, girls’ interest starts high and declines as they move through their K-12 schooling, while boys’ interest remains high or even increases (Hand et al., 2017; Le & Robbins, 2016; Sadler et al., 2012). The report, *Why So Few?* by Hill, Corbett, St. Rose, and the American Association of University Women (2010) outlines the key factors that can also be attributed to this systemic decline of girls’ interest over time which includes gender stereotypes, male-dominated cultures, few like role models, and math/science anxiety (Hill et al., 2010). Their findings and numerous other studies since 2010 show a pattern that suggests a systemic problem with schooling—not with the girls and women —that must be interrupted.

As a technology and engineering educator, I have the unique ability to impact the students I teach. My content area offers an engaging and hands-on classroom setting that covers an integrative STEM curriculum and could introduce them to STEM career fields, especially technology and engineering. I am passionate about wanting girls in my classroom to understand that their epistemological beliefs and ontologies are valued and should be recognized as a needed addition to the STEM workforce. I also want other educators, specifically the men that dominate the technology and engineering education field, to come to value the lived experience and knowledge that girls bring to the classroom. During 12 years of teaching middle school technology and engineering, I’ve noticed a problem with girls choosing courses. The number of girls electing courses from my middle school technology and engineering courses to our high school technology and engineering courses and ultimately into careers in STEM, specifically technology and

engineering, is low. Records from three of our high school technology and engineering teachers' enrollment for the 2020-2021-year show that out of eight technology and engineering education courses offered at our high school that are practical in nature, only 21 out of the 148 students taking the courses were girls and young women. I want to know what can be done to increase these low numbers, energize girls' interest in the field and empower them with a positive identity in technology and engineering. The problem of my practice is girls choosing not to take technology and engineering courses at the high school level.

1.1 The System

Southern Hills School District (SHSD) is a public school system within the south-central region of Pennsylvania. It's located in a suburban area surrounding Hanover, PA covering approximately 56 square miles, and serves 4375 students in kindergarten through grade 12. Six schools make up the district, including one high school, one middle school, and four elementary buildings. The district vision reads, "Empowering and equipping all students to create their future and change the world" – *(Adopted by the Southern Hills Board of School Directors on November 14, 2018),* which emulates the blue-collar work ethic of the manufacturing rich tradition and history of the community in Hanover, PA. Students come from rural, urban, and suburban households within the district boundaries. The following table breaks down the "fast facts" of the district demographics from the PA Future Ready Index.

Table 1. Southern Hills SD Demographic

District Demographic			
District Enrollment	4375	Male	51.5%
Number of Schools	6	Female	48.5%
Percent Enrollment by Student Groups			
Economically Disadvantaged	35.1%	Special Education	11.3%
English Language Learner	.9%	Foster Care	0.8%
Gifted Students	3%	Homeless	0.7%
Percent Enrollment by Race/Ethnicity			
American Indian/Alaskan Native	0.1%	Hispanic	5.5%
Asian	1.6%	White	85.0%
Black	4.0%	2 or More Races	4.2%
Native Hawaiian or other Pacific Islander	0.1%		

The technology and engineering department (or technology education department/ tech ed as it is also referred) has been part of the district since its founding in 1959 and includes five high school and three middle school educators. At the district's founding, the technology and engineering department was better known as the industrial arts department. The foundational classes within the department included woodworking, metalworking, and graphic arts. Over the next 60 years, the industrial arts department grew and underwent name changes to reflect the profession's curriculum and standard trends. Even with changes to the more traditional name, course additions, and philosophy changes over time, there remains a stigma that our department perceives based on long-standing stereotypes that our classes are designed for boys or low-level learners who are only good working with their hands. Trying to break out of this stereotype remains

an issue even with changes and support to prove otherwise, as shown from the low enrollment of girls and students on higher academic paths.

Concerning my context and practice about my Problem of Practice (PoP) is my teaching assignment at Emory H. Markle Middle School (6-8th grades). As a technology and engineering educator, I have the privilege of teaching every student in the building at each grade level for approximately 25 days during the school year. This is a brief amount of time with each student, but the ability to have a negligible influence on each student is one for which I am thankful. I also need to consider my positionality and how that impacts my teaching and students. As a white middle-class woman, I understand and am aware of the roles and views that a woman is expected to hold and ways that women can be oppressed, especially in a field such as technology or engineering. However, I lack the understanding of what it is like to be a person of color or low socio-economic status and how they experience life and are oppressed in a colonialist-designed world. I want to understand more about what those who are oppressed, especially my students, experience and how their relationship with white or affluent teachers and fellow students changes over time.

As the middle school department head and curriculum leader, I am responsible for ensuring that my entire department is creating equitable environments for all students while also considering best practices in technology and engineering curriculum and instruction. It also is my responsibility to ensure that our middle school technology and engineering curriculum aligns with the high school technology and engineering curriculum. We have three middle school technology and engineering, and computational and design thinking courses which feed into five high school content areas that include a variety of courses including graphic design, woodworking, metal fabrication, introduction to engineering, computer-aided design, 3D modeling, aerospace

engineering, digital media, and power technologies to name a few. Southern Hills School District's (SHSD) current organizational system is positioned in a way that can either help promote my PoP or continue to push away the genuine reality that our current system is turning away hundreds of girls and young women from a potentially fulfilling path toward careers. This is occuring because we are not sparking their interest and helping them see their possible future could be in a career in technology and engineering. We may also be projecting our own bias through the content and instruction we offer in the technology and engineering classroom. Through ten empathy interviews conducted with various stakeholders connected to my PoP, each recognized that enrollment numbers for girls in SHSD high school technology and engineering courses are always low. It is unsettling to discover that the underrepresentation of girls in these courses is widely known and recognized but not seen as an urgent problem to try and address.

1.2 The Stakeholders

The organizational system at Southern Hills School District is much like that of other k-12 public institutions. The stakeholders who deeply impact my PoP each play a dynamic role. They include the secondary technology and engineering educators, the secondary guidance counselors, the school district administration, and the girls and young women students of the district. It will be essential to identify the stakeholders who are interested in or affected by my problem of practice and those that may be affected by the design and potential outcomes of my improvement science plan (Bryson et al., 2011). They have the power to inhibit or support the changes I am working to make within my classroom and district.

1.2.1 SHSD technology & engineering educators

The technology and engineering department teachers are primary stakeholders of my PoP. They provide the curriculum and opportunity for students to see and experience the worlds of technology and engineering in both middle and high school. The group demographics are eight educators and include five high school educators, all men, and three middle school educators, two men, and one woman. In discussions with the department, some see my PoP as a valid concern but are worried that no test of change will rectify the issue in the long run, and things will remain status quo; therefore, it is not important to them to be invested. The empathy interview findings revealed that three teachers are willing to invest time to tackle the inequities and gaps in the curriculum. This mindset is seen in the empathy interview conducted and represented in the final fishbone as part of the culture of the Tech Ed Department as SHSD.

1.2.2 SHSD middle & high school guidance departments

The SHSD Guidance Department at both the middle school and the high school are stakeholders in my PoP work. The guidance counselors lay the groundwork for students to transition from middle school to high school by helping them to select high school level courses and providing continuous academic support. Their perceptions of the Technology and Engineering Department, teachers, course offerings, and benefits for future career paths are vital to my PoP. While the guidance counselors play an influential role in helping girls select high school courses they need for credit and rank, they spend less time focusing on the girls' academic interests at this time. It will be critical to gain buy-in from these stakeholders due to the power they hold with

impacting every student within our district and the possible support they provide to helping girls to consider technology and engineering career paths.

1.2.3 Girls and young women of SHSD (current and alumni)

The girls and young women of the Southern Hills School District are at the heart of my PoP. For the purpose of my study, girls and young women are defined as those who identify as girls ranging from 6th through 12th grade plus those who have graduated from Southern Hills High School and are now in college or the workforce that I interviewed for empathy interviews. These self-identifying girls and young women are the central figures in cultivating a new culture of young women actively enrolling and pursuing careers in technology and engineering. Their perspectives, needs, and interests must be part of determining the plan for this improvement science journey. It is important to gather information from both current students and alumni of Southern Hills to fully see the broader scope of issues that support or deter girls and young women in our district from pursuing technology and engineering courses and the career fields in technology and engineering. Their positive and negative experiences have the power to enlighten the stakeholders identified earlier on the issues surrounding girls in our Technology and Engineering departments and district as a whole. Current students will also be affected either directly or indirectly by any potential tests of change associated with my PoP, and therefore understanding the whole gamut of their importance is needed.

1.2.4 SHSD administration/ leaders

The stakeholders included in this group are the Superintendent, the SHSD School Board, the Assistant Superintendent, the Director of Curriculum and Instruction, and building principals for the high school and middle school. They are all invested and work toward making SHSD a place where all students can grow and succeed as unique individuals academically and socially in grades K-12. Of this group of stakeholders listed, one who is closest and has the most influence on my PoP is the Director of Curriculum and Instruction. The Director of Curriculum and Instruction (DCI) oversees the curriculum, instruction, and extracurricular academic offerings we provide to our students. I believe the DCI values the importance of STEM education, integrating technology and engineering K-12, and giving all students equitable experiences in the classroom. The DCI is the most influential stakeholder that impacts my PoP. In conducting an empathy interview with him, I found that he believes greatly in the importance of supporting our K-12 students, especially those who may have experienced bias or been stereotyped. He also values career pathways, student mentoring, and greater STEM integration into the curriculum, especially at the elementary level. His perspective confirms that we have gaps and issues in our current system that do not foster a natural belonging for our girls in subject areas of technology, engineering, and computer science. He also believes there needs to be change, especially in the curriculum writing and assessment process, to help create this important systemic change.

1.3 Statement of the Problem of Practice

The problem of practice I looked to understand and change was that girls in the Southern Hills School District are choosing not to take high school technology and engineering courses at a disproportionate rate to that of their boy peers. This localized problem reflects the underrepresentation of girls and women on a national scale, as explained through the data from the United States Census Bureau and presented by Martinez and Christancht (2021). Although women working in engineering professions has increased to 15%, computer science occupations have decreased between 1990 and 2019 (Martinez & Christnacht, 2021). This broader problem is also occurring at the localized classroom level. Therefore, the change ideas, that became interventions within this study, considered this broader issue and looked for solutions that increased girls' interest and persistence in technology and engineering classrooms. As a department head, curriculum leader, and educator in the technology and engineering department, I am situated in a role that allows me to influence my department and classroom.

2.0 Review of Supporting Knowledge

2.1 Purpose of Review

The purpose of this literature review is to gain a better understanding of the persistent differential outcomes that cause so few girls and young women to enter careers in technology and engineering and enroll in technology and engineering courses in high school. I also want to learn about promising research-based approaches that disrupt these low outcomes and instead increase the rates of girls following the pipeline to a career in technology or engineering. In this literature review, I explore the following questions:

1. What explains the persistent differential outcomes and rates of women continuing through schooling into technology and engineering careers?
2. What promising approaches for secondary technology and engineering education classrooms have the potential to best support girls' technology and engineering identities?

2.2 Road Map

My literature review is organized as follows. I first will describe the main theories that contribute to the persistent differential outcomes and rates of women and girls on the path to careers in technology and engineering. I will summarize how the research from these persistent barriers intersects and highlight research from other scholars whose findings corroborate these

main ideas. I will summarize promising approaches that can be used to support girls' development of technology and engineering identity. Throughout, I anchor my review in a research report by Hill, Corbett, St. Rose, and the American Association of University Women (2010) that synthesizes significant studies conducted from 1980-2009. I offer additional work conducted since the 2010 report to represent the current state of research added to the field, especially culturally relevant pedagogy and identity formation frameworks done by numerous scholars, including Ladson-Billings (1995, 2014), Gee (2000), Carlone and Johnson, (2007), Godwin et al. (2016) and multiple works and contributions by Zahra Hazari, et al. (2010,(Godwin et al., 2016) 2020).

2.3 Review of Scholarship Question 1

What explains the gender disparities in girls' and women's STEM outcomes and persistence in technology and engineering careers?

Research on the factors that positively and negatively influence women on their path to attain a career in STEM and specifically technology and engineering careers is vast and can be traced back decades. Scholars have theorized many reasons that explain the persistent barriers that impact women in STEM fields and coursework, including social bias, learning environments, and self-perceptions (Hill et al., 2010; Cimpain, 2018; Kanny et al., 2014). Hill et al. (2010) provides evidence for social and environmental factors that contribute to the persistent barriers. Empirical understandings of these concepts have evolved slightly since the Hill (2010) report but are still centered around the impact and power that implicit bias and stereotypes have to promote or deter girls from pursuing technology and engineering careers.

The Hill et al. (2010) report sought to represent what is known about why so few women are becoming scientists and engineers. The team reviewed major studies and findings over 30 years and showed evidence that specific social and environmental factors illustrate the relationship between the persistent differential outcomes and the low rates of women specifically entering science and engineering careers. One common theme linked between the Hill et al. (2010) report and the additional literature review is the immense weight that bias and stereotypes hold at each point along the pipeline of a girl's adolescent development, into adulthood, and eventually the workplace.

2.3.1 Societal beliefs

Implicit bias is a person's automatic response to link certain things to different groups. Unlike explicit bias, when a response is purposeful, and the person is fully aware of their perception or action, implicit bias is automatic. It is a result of social stereotypes formed throughout lived experiences (Alderson, 2017). Girls grow up in homes where their parents, siblings, and friends can project biases onto them. A study by Haines et al. (2016) shows how deep-seated and persistent implicit gender bias can be. Their research compared data gathered initially in 1983 and then replicated in 2014 on gender stereotypes and how those stereotypes have changed over time. The study's goal was to understand the extent of gender stereotyping today and assess if beliefs between the genders have changed. In the study, participants had to rate the likelihood of certain gendered characteristics as being more likely for a typical man or woman. The results remained constant across the 30-year timeframe and the area of female gender roles increased in the amount of gender stereotyping recorded. They found that from 1983 and 2014,

there was a large differentiation in gender roles with little change in what the participants deemed a female-typed and male-typed occupation.

Bias held by family members and passed to girls can also lead to negative influences for girls. Research by Murcia et al. (2020) explored parents' attitudes toward STEM and engagement and how that influences their children. The study conducted short interviews with United States students at the high school level and focus group sessions with those students' parents. The interview questions involved attitudes, interests, perceived influencers, and parental perceptions. The researchers found that students described their parents and siblings as most influential in career thinking based on the sorted interview data.

Interestingly, parents didn't think gender was an issue for their children in a future STEM career and regarded future careers as open to either gender. This contradicts the clear statistics that show the gender disparity between men and women in STEM jobs (Noonan, 2017). This finding may indicate that parents in this study held slight gender bias themselves, or they were blind to the implicit biases they may have and could project onto their children.

These pieces of literature and their findings show that there is still a strong bias toward what careers girls and boys should aspire to, and the influences society and home life can hold. These same gender biases have been found to appear in girls' social circles and in their learning environments.

2.3.2 Education systems

In addition to society's beliefs, the bias and stereotypes that girls face within learning environments show a systemic problem of our education system devaluing girls' abilities and contributions in STEM content areas. Hill et al. (2010) emphasize the stereotype threat schools

create for girls with the passing of bias onto students, the lack of female role models, and the closed mindset regarding STEM abilities. The literature reviewed reinforces these findings and points to educators, the school curriculum, and school experience in encouraging or discouraging gender bias and stereotypes toward girls in STEM subjects.

Educators can also create an environment that discourages girls. In one study, a team of researchers examined the biases of high school teachers and students in math and science classrooms (Hand et al., 2017). Surveys of 44 teachers and 121 grade eleven students were conducted and analyzed, examining gender role biases and perceptions of STEM subjects. The study results showed an innate bias in both teachers and students that rank masculine traits higher to those professions that are scientific and feminine traits to those professions associated with the humanities. Also, one portion of the study looked at gender biases based on performance and found that teachers tended to report boys' superior in STEM disciplines, thus creating a disparity for girls and possibly discouraging their self-efficacy in STEM courses (Hand et al., 2017).

In addition to educators' and students' biased beliefs, a study conducted by Legewie and Diprete (2014) suggests that high school environments play an essential role in either weakening or strengthening gender stereotypes and the gender gap in STEM fields of study. Their study focused on how gender beliefs manifest differently based on various high school environments. In their longitudinal study of 9,120 high school students at 230 schools across the United States, they examined two questions: (a) how high school context plays a role in students' orientation toward STEM fields, and (b) the power gender segregation in extracurricular activities Legewie and Diprete (2014). Based on survey data collected from the various schools and students, their findings suggest that providing a more intensive curriculum of math and science and reducing gender segregation in extracurricular experiences plays a massive role in lessening the gender gap

in STEM orientation, especially for girls. In addition, schools that do not provide adequate information and exposure to STEM careers in curriculum and experiences can increase gender stereotypes in students (Legewie & Diprete, 2014). Their results found that the curricular and social environment in high school's curricular and social environment have a lasting impact on both boys' and girls' orientations toward gender stereotypes of STEM degrees, which then leads to gender gaps in STEM fields.

Gender bias influences gender gaps in STEM engagement as well. A study done by Moss-Racusin et al. (2018) explored the relationship between gender bias and gender gaps in STEM engagement. Two experiments were conducted in the study. The first experiment looked at the causal impact of existing gender bias. The results from the first experiment suggest that gender differences in STEM aspirations were only observed in the presence of a gender bias. The second experiment explored the impact of gender bias on STEM outcomes but in the specific context of a STEM school department. In the second experiment, when gender bias was present, women believed they will encounter more discrimination than men, but only when bias was presented. This perception was eliminated in the equality group that experienced gender equality conditions. Therefore, if the environment presents gender bias, there will, in fact be a persistent negative outcome in women working toward a career in technology or engineering. This finding holds true based on my experience in technology and engineering classrooms, which hold a gender bias of being a masculine subject.

These studies support the literature on the power of gender biases and their influence on girls' learning environments. The biases and stereotypes formed from society's beliefs and shaped through learning environments can negatively reduce self-perceptions and self-efficacy for girls.

2.3.3 Self-perceptions

Cognitive gender differences and gender bias play a pivotal role in impacting girls. But to what extent does a young girl's self-perception of her interests, self-efficacy, and view of technology and engineering or STEM craft her story?

A finding of the Hill et al. (2010) report is that girls need support in self-efficacy to create a positive self-perception in STEM subjects. Girls feel they have to work harder and receive better grades in STEM school subjects, often because teachers, parents, and friends tell them that boys are better at math. They believe they are less likely to succeed in a STEM career and ultimately express less interest because of this self-perceived belief. This perception can be sourced from many different places, but as the literature shows, it mostly stems from parents, educators, and the learning environment.

Since the Hill et al. (2010) report, researchers have continued to study self-efficacy about girls and STEM. One such study suggests self-efficacy is the most critical factor in moderating the differences in the interest of STEM careers based on gender (Tellhed et al., 2017). The study explored high school students' self-efficacy beliefs and social belonging beliefs interested in STEM and HEED majors. HEED majors include those more commonly associated with women (Health care, Elementary Ed, and Domestic fields). The study used a questionnaire given to Swedish high school seniors that tested their self-efficacy beliefs and social belonging beliefs through a variety of targeted questions. Their study found that students of both genders felt a social belonging more often in majors that were dominated by same-gender peers, thus confirming that, for young people, social belonging impacts career interests. They also found that self-efficacy is more important to equalize gender difference for STEM majors than for HEED majors. This finding can translate to the American educational model and reflects the importance for a girl's

self-efficacy and interest in STEM in giving her a self-perception that she can achieve success in STEM, the same as her male peers.

These recent studies suggest that negative self-perceptions based on gender stereotypes and gender bias have the power to reduce girls' confidence in themselves and therefore reduce their drive for believing they can attain achievement in technology and engineering fields. This factor cannot be overlooked when searching for persistent barriers on a girl's path to technology and engineering careers.

2.3.4 In sum

The reviewed literature reveals consensus that, rooted in systemic societal bias and stereotypes, a girl's exposure to gender biased societal beliefs and learning environments leads to a negative self-perception and lack of resiliency to continue a path toward a career in technology or engineering. Recognizing that there are several factors that influence women and girls in technology and engineering directs attention to the importance of exploring different approaches to support them on the pipeline to technology and engineering careers.

2.4 Review of Scholarship Question 2

What Promising Approaches for Secondary Technology and Engineering Education Classrooms Have the Potential to Best Support Girls' Technology and Engineering Identities?

The literature reviewed to answer this second question examines ways that teachers and school systems transform to support girls in technology engineering classrooms and in the

formation of their identities. A bias or unbiased classroom learning environment and one that is rooted in cultural relevance as many scholars have noted (Silverman & Pritchard, 1997; Weisgram & Bigler, 2007; Lagesse & Marshall, 2019; Ladson-Billings, 1995, 2014), can play a huge role in disrupting the gender and cultural bias young girls may experience. The curriculum presentation to include a more human-centered approach has shown promising in appealing more to young girls and helping them see their connection to technology and engineering (Burks & Amos, 2019; Virtanen et al., 2015; Silverman & Pritchard, 1997). In addition, the notion of identity formation in the disciplines of mathematics, science, and computer science has begun to inform a new body of research focused on how girls' identity formation toward a discipline can allow them to persist toward a field in that discipline.

2.4.1 Technology & engineering classrooms

A consideration for technology and engineering classrooms is transforming the learning environment for girls. The system in which we educate and provide opportunities for girls is flawed. Systemically male-dominated technology and engineering classrooms can discourage girls from continuing in courses and negatively influence their perceptions and attitudes. A study by Silverman and Pritchard (1997) looked specifically at the technology education classroom environment and what factors discouraged girls from continuing to take HS technology education classes or pursue STEM careers. Data collected in the study included surveys, classroom observations, and focus group sessions. Researchers found that even though most girls enjoyed technology education classes and had a positive experience in middle school, that perceived positive experience wasn't enough for most of them to enroll in a Tech Ed course in high school. The study also found that some teaching methods and classroom environments allowed sexist

behavior and lacked project design aspects girls showed to be more enthusiastic about. These environments and project methods may have discouraged some girls from further enrollment in technology education courses. A finding from their observations of middle school technology and education classroom found boys monopolizing tools, and in the study's focus group interviews, girls complained that "boys would sometimes criticize girls, resorting to stereotypes about girls' lack of technological skills" (p. 47). Suppose the environment is skewed against girls and allows for behaviors that perpetuate stereotypical beliefs that technology and engineering courses are for boys. How can we expect girls to feel that they belong? The classroom environment has and continues to systemically make girls feel like "the other" in technology and engineering classrooms.

2.4.1.1 Transforming classroom environment and pedagogy

Gender bias and career stereotypes are deep-seated in teachers and students (Haines et al., 2016; Cimpains, 2018). However, teachers can combat these by creating a classroom culture that addresses these obstacles head-on and creates an environment that is not just inclusive but transformative for all students. The literature reviewed in this section reveals the need for culturally relevant teaching and developing students' critical consciousness. These are crucial pieces in showing all girls that they do belong, but their experience and knowledge are valued in the classroom because they are girls.

Pinar (1992) states, "teachers still face the challenge to become more than they have been conceived and conditioned to be" (p. 232). This statement references how teachers are submerged in identities formed by others, and so often, they teach how they were taught through the lens of someone else's identity. In the day-to-day routine of classroom demands, we can lose sight of what our students bring to the classroom in the form of their own lived experience, culture, and identity

and instead stick with what we know. As educators, we face state and federal mandates, district initiatives, curriculum programs, etc., that steer our classroom and curriculum. However, our position as educators and our position in relation to our students is governed by more parts than what we may see on the surface. As Johnson-Bailey (2012) states, there is much we must be attentive to:

> More often than not, the mechanisms that help us to sort and categorize our world are shaped by our social positions or societal locations: race, gender, class, sexual orientation, age, physical and mental abilities. Such factors affect how we view the world and influence how the world sees us. So, an integral and often unexplored part of this positional existence is the consciousness of one's position. (p. 263)

Technology and engineering careers are dominated by white and Asian men (Fry et al., 2021), and it is no surprise that technology and engineering classrooms mirror the national statistics. While the focus of the literature reviewed in this section is of the underrepresentation of girls, the same promising approaches can *and should* be part of the technology and engineering classroom for our indigenous students and students of color as well. The foundational work by Gloria Ladson-Billings (1995) addresses the position of teachers and students and, ultimately the need for "culturally relevant pedagogy." This pedagogy focuses on the achievement of knowledge and skills in the classroom that use a cultural basis to empower students academically and emotionally. Her 1995 four-phase study looked at eight exemplary teachers of African American students, and from the findings of her observations and ethnographic interviews, she developed a framework. This culturally relevant pedagogical framework encompasses three components: academic success– the belief that all students of different ethnic, gender, and socioeconomic backgrounds can achieve academic success; cultural competence – the idea that knowledge is

shared and built from many viewpoints and cultural experiences and should be bridged; and sociopolitical consciousness – both the educator and students are aware and willing to critique the social injustices in our society and where they fit.

A later work of Ladson-Billings (2014) discusses the "remix" or "update" of her original work to that of *culturally sustaining pedagogy*. She pushes for "those in the mainstream to develop the kinds of skills that will allow them to critique the very basis of their privilege and advantage" (p. 83). In addition, Ladson-Billings (2014) states that we need powerful pedagogical models grounded in theory to help teachers with their classroom philosophy and practice. She also asserts culturally sustaining pedagogy that teachers create must be balanced in assuring students perform well in skill-focused curriculum and external assessments *AND* meet the culturally relevant needs and backgrounds of our students and their communities. For technology and engineering classrooms, this pedagogical position stands to help break down the barriers that we see in a low enrollment of girls and students of color in our programs and in the pipeline toward technology and engineering careers. As Ladson-Billings (2014) states, "If we want to help[…]experienced teachers to become better, we need to help them understand, reflect on, and improve their philosophy and teaching practice" (p. 83). She also reminds us that not all pedagogy should solely be relevant; it should also be revitalizing for our Indigenous students. Our Indigenous students have been forced to assimilate all parts of their culture and identity to the European-American education system. Abrams et al. (2014) and Brayboy and Maughan (2009) assert in their work that we should be looking to revitalize their ways of knowing and being in our classrooms and use their cultural knowledge to make our classroom knowledge base that much richer.

Quigley (2011) provides a rationale for a "third space" in the science classroom that is built on the frameworks and theory of Third Space (Gutiérrez, 2008), cultural congruence (Meyer &

Crawford, 2011), and funds of knowledge (Vélez-Ibáñez & Greenberg, 1992) in science education. Taking a deeper look at the theory of Third Space, it can be viewed as a purposefully created space in the classroom where students' everyday cultural world and language (first space) and subject-specific instruction in school (second space) are supported as mutually beneficial and valued in the school setting (third space), not in competition (Quigley, 2011). Although Quigley's rationale addresses the science field within her work, I argue that her idea and posit for third spaces should be applied in all classrooms, especially in technology and engineering classrooms. Quigley (2011) states:

> By suggesting it is the student who needs to conform to the cultural norms of science, the student is forced to leave their funds of knowledge out of science. I am reminded that if science educators continue to ask students to leave their funds at the door, what knowledge is science omitting. (p. 552)

For girls in our classrooms and students with various cultural backgrounds, what knowledge are we asking them to leave at the door when they enter our technology and engineering classrooms because we aren't even giving them the chance or ability to understand that they can have both? They can bring their lived experience, cultural dialogue, and gender-based knowledge and add to the knowledge base of our technology and engineering classrooms. This notion of "third space" may be one of the most promising applications the technology and engineering education profession should investigate if we hope to help the underrepresented women and people of color persist in the pipeline to technology and engineering careers. The problem I see is that there is no research base yet established for this within the literature specific to K-12 technology and engineering classrooms, which are rich in inquiry, problem-based learning, and application of real-world challenges.

Adopting this orientation and application of classroom spaces will benefit not only the girls in our technology and engineering departments, but all students. However, we mustn't lose sight of the students who already benefit from the current educational system. We must be sure their education affords them a civic opportunity to see how their identity and position grant them the privilege.

2.4.1.2 Sociopolitical consciousness

Teaching students about gender stereotypes and discrimination is an instructional strategy that promises a transformed classroom. A study done by Weisgram and Bigler (2007) indicates the positive impact of incorporating some form of gender discrimination awareness within the curriculum of technology and engineering courses. The experiment measured the perceived attitudes of 158 middle school girls who attended a science intervention conference. The girls were divided into two groups: a discrimination condition and a standard condition. All participants learned about scientific careers and did hands-on activities. The discrimination condition attended a session that defined gender discrimination, gave examples, and showed biographies of women scientists who overcame discrimination. Surveys looked at attitudes toward science, perceptions of science and discrimination, interest in science, and estimated proportion of women in science fields. The results from the study indicated that "learning about discrimination was associated with positive outcomes, including the belief that gender discrimination can be overcome by increasing the number of women who work in scientific fields" (p. 266).

Taking discrimination awareness or "critical consciousness" a step further, Kokka (2020) approaches the need to develop students' critical consciousness with clarity and depth and, like Ladson-Billings (2014), focus on those who are privileged. She proves that due to the lack of a literature base, more needs to be done to raise the critical consciousness of privileged students

(white and affluent) in mathematics classrooms. Her literature review points out that most privileged students are resistant to learning about their privilege and shares an example of how social justice pedagogy solidified negative stereotypes in students (Kokka, 2020). She discusses and cites Gutstein's (2007) definition for clarity in defining her social justice pedagogy in mathematics term coined “Social Justice Mathematics" (p. 781). However, Kokka (2020) takes the pedagogical approach a step further by stating that most critical consciousness goals are intended more for students who are not part of the white dominant culture, and therefore she proposes developing “critical mathematics consciousness” (p. 782) in students of dominant backgrounds. The crux of her goal is that students of privilege develop sociopolitical understanding, take action, and develop critical civic empathy to create social transformation within the mathematics classroom through their work in well-planned, fluid mathematical tasks. She points out that mathematics teachers also need outside support from other subject areas and community partners to be aware of their critical consciousness as well as the research and design of the social justice mathematics tasks. Although her work is based on mathematics tasks, the technology and engineering educator should adopt this type of transformative classroom view where tasks can be developed by women and people of color in the community to help support technology and engineering educators make social transformations in their classrooms.

As the findings from these studies show, students who have teachers who embrace culturally relevant pedagogy will benefit deeply. This means that educators, and for this paper, technology and engineering teachers who hope to help our students persist in the STEM pipeline, adopt this orientation towards teaching. Culturally relevant teaching is not just a program but instead a position towards teaching that helps students become interested and invested in the

content we are instructing while simultaneously having a personal and cultural relevance to the student.

2.4.2 Human-centered curriculum

A curricular design approach that has shown positive results for improving girls' interest in engineering and technology is to design technology and engineering curriculum with a human-centered approach. Scholars in multiple pieces of literature highlighted the benefits of using human-centered, social purpose, or human design-focused instruction, especially for girls (Burks & Amos, 2019; Virtanen et al., 2015; Silverman & Pritchard, 1997). Based on several empirical pieces and to clarify for the reader, human-centered design (HDC) is defined as "accounting for and reflecting shared human values in the creation of the technologies, artifacts, and systems that humanity shares in the collective pursuit of life" (Zachry & Spyridakis, 2016, p. 394).

Incorporating ethics and humanities-based topics in the engineering curriculum can positively impact girls' perceptions and identities, as found in a study by Burks and Amos (2019). They studied the impact of the engineering design curriculum enhanced with socio-ethics, and holistic engineering practices on the engineering identity of 9-12th grade girls. This study was conducted specifically with a group of girls at a weeklong summer engineering camp. Therefore, the results need to be reviewed carefully since the girls' interest in the camp may already have been high. There were no boys at the camp to create a gender bias situation or gender biases from the counselors. This may have decreased opportunities for girls to feel unequal in any situation. However, the study results found that when the engineering curriculum incorporates humanities into a traditional STEM curriculum, there is a diversifying lens of a social and emotional connection added and thus more likely to engage young women.

This human-centered approach can be contrasted with the typical engineering instruction, which tends to cater to the interests and preferences of boys. For instance, in a study conducted by (Weber, 2012) boys indicated a greater interest in mechanical or technical activities and greater levels of cognitive interest and perceived personal capacity compared to the girls in technology and engineering-related activities. Weber (2012) focused on the effectiveness of using the components of a framework called the Engagement, Capacity, and Continuity (ECC) Trilogy for technology and engineering teachers to determine their students' interest, perceived personal capacity, and participation in technology and engineering activities. A survey was implemented and coded using the ECC framework components and administered to both middle and high school boys and girls enrolled in technology and engineering courses. The results compared girls' and boys' responses to identify where a lack of interest may occur and complemented the notion that technology and engineering instruction cater to boys' interest over the human-centered approach that appeals to girls.

One framework that could be referenced to guide this incorporation of a human-centered approach in engineering design comes from a study by Capobianco and Yu (2014). They crafted a framework that takes each phase of the engineering design process and applies empathy or "caring" into guiding questions. The instructor then uses these questions to point out and frame engineering as a caring profession, creating more interest in girls (Capobianco & Yu, 2014). The implications of using this model in their study showed that girls introduced to engineering as a caring profession may give them a more informed perspective of the field and promote high interest in engineering. This body of literature substantiates the arguments that developing a more human-centered approach to engineering design curriculum that utilizes empathy is significantly warranted.

2.4.3 Identity formation

A newer body of scholarly work has begun to look at how we can form and hold multiple influencing identities as people (Gee, 2000) and how that identity is viewed regarding disciplines (Kane, 2012; Carlone & Johnson, 2007; Hazari et al., 2010; Hughes, Schellinger & Roberts, 2021).

2.4.3.1 Constructing identity

How we view the world can be attributed to our sense of identity. Gee (2000) provides four possible ways in which we can view our identity: natural – developed from, institutional – authorized by, discourse – recognized in, or affinity – shared in. He also posits that "these four strands may very well all be present and woven together as a given person acts within a given context" (Gee, 2000, p. 101). This founding work of Gee has led to the notion that identity is not a single influence that developed from or is authorized by a singular experience or environment, but can adapt, change, and hold multiple perspectives depending on the environment.

Kane (2012) refers to identity as, "a person's understanding of self in relationship to the world, including people, places, events, material objects, and semiotic systems" (p. 458). The way in which students develop identities and how those identities impact their experiences in the classroom and view of others is beginning to form an important analytical lens for educators and researchers. One study to explore academic and disciplinary identities was done by Kane (2012). Her study looked at third-grade African American science students' formed academic and discipline identities in an urban school. She collected data from field notes, videotaped lessons, evaluated student artifacts, and moderated interviews to see how the students perceived or narrated identity in their interviews, compared to what was observed in other contexts. She found that the way in which these students constructed a science identity was different for each of them, and they

were pulled to the discipline and engaged with it in different ways. Each student was creating an identity as a science student via different paths or narratives. Through this formation of identity, they believed they were competent or could perform in a way that helped their classmates or were supported by their teacher to develop self-efficacy.

The work of Kane (2012) and Hazari et al. (2010) point to an initial science identity framework developed by Carlone and Johnson (2007). Their conceptual framework was built on a founding belief that using an identity lens with education "allows us to ask questions about the kinds of people promoted and marginalized by science teaching and learning practices" (p. 1189). Based on the literature reviewed thus far and the environments that technology and engineering classrooms show systemically gendered bias, I argue against providing a similar posture to Carlone and Johnson's (2007) statement. This needed understanding that is looking through the lens of identity formation must be emphasized so that girls in the technology and engineering classroom aren't marginalized because of their gender identity but instead should be valued because of their identity. The conceptual framework by Carlone and Johnson (2007) introduced three interrelated dimensions of science identity in competence, performance, and recognition. They define each further as *"competence*: knowledge and understanding of science content; *performance*: social performance of relevant science practices; *recognition*: recognizing oneself and getting recognized by others as a science person" (p. 1191). Carlone and Johnson posit in their study that these dimensions are interrelated and, as Gee (2000) also explained, merge, depending on the context of a situation. They also include in their framework that racial, ethnic, and gender identities also impact the formed science identity and should not be overlooked.

Since 2010, the work of Zahra Hazari and colleagues has begun to deepen our understanding of discipline-developed identities, especially in physics, engineering, and STEM

(Dou & Sadler, 2019; Hazari et al., 2020; Hazari et al., 2010). The framework that has built and expanded this body of research is rooted in students' identification with physics. Hazari et al. (2010), in comparison to Carlone and Johnson (2007), embedded their model in the social cognitive career model (Fouad & Smith, 1996; Fouad et al., 2002; Lent et al., 1994; as cited by Hazari et al., 2010) and also includes *interest* - a student's desire to think and understand content - as a fourth dimension in identity formation in physics (Hazari et al., 2010, p. 982). This study looked primarily at the quantitative data collected from over 3,000 randomly selected college students across the United States enrolled in an introductory college English course. These data were gathered from a survey that collected information about students' backgrounds, experiences in high school, and attitudes toward physics. The survey was tested for reliability and validity and is known as the PRiSE (Persistence Research in Science and Engineering) survey. The findings from this study led to the development of the interest, recognition, and competence/performance framework that attempts to describe how these constructs impact the creation of students' physics identities (Hazari et al., 2010). In addition, they found that the stronger the physics identity, the stronger the prediction for a student to choose a career in physics. These research findings highlight the importance of identity formation in STEM disciplines and the body of scholarly work produced to expand on the initial findings.

Expanding on the work of Carlone and Jonhson (2007) and Hazari et al. (2010) with a focus on a specific discipline identity for girls is a study by Hughes, Schellinger, and Roberts (2021). They investigated the role of performance and recognition on middle school girls' coding identity development. The illustrative case study involved three middle school-aged girls at a Girls Code camp. Researchers collected and analyzed the girls doing different types of identity work using video observations, surveys, and interviews. The girls participated in various activities at the

camp. Still, the focus was placed on activities that engaged the girls as coders or "doing the work of a coder" (Hughes et al., 2021, p. 432), which they proposed helped with the development of the girls' coding identities. The investigators reviewed the video recordings of the girls doing these activities. They looked for moments when girls demonstrated their skills as coders and then were recognized positively for these moments or were never recognized by their educators or peers. The observations, pre-and post-camp coding identity surveys, and focus group interviews were operationalized by the researchers, who created an identity trajectory story for each case. The study found that although the girls sometimes exhibited similar competence in coding activities, they received different forms of recognition. Each girl indicated that they acquired an improved coding identity and one day may want to be a coder. The various types of recognition the girls received included: public performance recognition by the educator as being an expert and someone others could go to for help, public educator recognition and praise for persevering through a difficult coding challenge, or unacknowledged competence and perseverance by the educators or peers, even after the student sought out the educators and proved competent and the ability to persevere. In addition, Hughes et al. (2021) discuss the idea that differing recognitions may have been based on the racial stereotypes of a "good" or "bad" student as explained by Calabrese Barton et al. (2013), cited by Hughes et al. (2021) where girls of color are not fully recognized as strong science students because of the stereotype that good students are white girls or boys. Hughes et al. (2021) concede that while the study did show an overall increase in the girls' coding identities due to some form of recognition toward coding competence or coding perseverance, it was only studied in a week and did not explore school, home, or other out-of-school experiences. A long-range study would improve their overall framework.

2.4.4 In sum

The literature reviewed in exploring promising strategies fell into two constructs of possible areas to develop a girls' positive technology and engineering identity. These constructs create more transformative technology and engineering environments and specifically address technology and engineering identity through recognition and belonging. Developing a classroom that transforms toward a culturally and gender-relevant space will require training both the educator and students, which will provide gains for reducing the traditional stereotypes associated with technology education classrooms. The educator's role in the development of girls' technology and engineering identities will need to be addressed. This may include training K12 technology and engineering educators specifically on how to incorporate recognition and create environments for belonging for all girls in their classrooms.

2.5 Synthesis

The literature reviewed reveals a multi-faceted web of influences that can either propel forward or create deterrents for girls and women on the journey to technology and engineering careers. What is clear from the literature is that there is no magic glass slipper or silver bullet approach to rectify the persistent differential outcomes that place girls at a disadvantage. Instead of this, research does reveal multiple promising strategies to address instruction, identity formation, and transformed learning environments for girls.

Gender bias and gender stereotypes are deeply seated in society, which directly influences the way boys and girls form positive or negative technology and engineering identities and

ultimately impacts their pursuit of careers in those fields. We all grow up in different environments with personal experiences and cultural implications shaping our beliefs, biases, and identities. Family, societal, and learning environments create and transmit biases, especially gendered careers that can have lasting impacts on youth and especially girls. In reflecting on much of the findings from the literature, I wonder how many parents, teachers, and counselors within our school systems have those same stereotypes and biases that can unintentionally guiding their students in more traditional gendered occupations. A true aha moment for me is reconciling that as teachers, we hold such an influence in the lives of our students, and anyone considered an influencer in a young girl's life needs to understand that "Biology is not destiny" (Hill et al., 2010, p. 20).

The literature also indicates that educators need to recognize and adopt strategies that will empower, encourage, and encompass the development of technological fluency and engineering identity in their students, especially young girls. Existing research grants a glimpse into how teachers and school systems need to change their systems to bridge better the gap between girls in technology and engineering classrooms and their pursuit of careers in technology and engineering fields. This requires getting to know your students, which I argue can be a key piece in helping to develop their engineering identities and interests in the classroom. I also feel that based on the literature review, some of the biggest hurdles for technology and engineering educators are the stereotypes and biases of teaching in a traditional career and technical context, formed and forged by the industrial revolution and preparing citizens for jobs in an industrial society (Pinar, 1992). Suppose students believe your class is not for them because of the way society and their environments portray them. In that case, you must address that stereotype from day one and prove to your students through relationships, dialogue, and instructional approaches that technology and engineering are for everyone. I have discovered the most promising approaches presented by the

literature require technology and engineering classroom teachers to focus on culturally relevant teaching (Ladson-Billings, 1995), building a sense of belonging, and tailoring curriculum to include the lived experience of the girls and students of color to the knowledge base of the classroom. To make technology and engineering classrooms more culturally relevant, the educator must be willing to move away from the status quo and embody technology and engineering growth mindset for students, society, and the knowledge they are being asked to convey in their classroom. This moves away from the status quo of assimilation-type teaching and instead questions the structures of our educational systems and society.

While the idea of orienting toward a culturally relevant teaching practice and investigating how a third space could be applied in the technology and engineering classroom is critically important in my opinion, I also believe this requires a systemic, district-wide approach to generate the most impactful change. Therefore, I looked to begin my path as a change agent with two specific strategies that I believed would fit within my locus of control and practice in developing a positive technology and engineering identity through recognition and belonging. Similarly, I wanted to explore more options in exposing my students to a variety of careers and showing them role models in those careers that do not fit the standard dominant culture stereotype of a middle-aged white man. Suppose the decision to pursue an engineering degree occurs in high school and is inspired in the middle school years. Yet, girls do not know or believe that they belong, and their knowledge is important because of their own experiences. In that case, we are missing out on a huge population that could help make great contributions to technology and engineering.

Suppose our classrooms, especially technology and engineering classrooms, are designed to cater to the dominant group of white boys. In that case, we are doing a disservice not to just girls but also to the boys and educators in those classrooms. Keeping the same environments we

have always had and just trying to recruit more girls into a classroom is saying that our classrooms are just fine and it's the girls that are the issue, which is furthest from the truth. A true comparable educational situation between science and technology classrooms can be found in Sandra Harding's (2016) explanation of science education.

> Conventional scientific education available to boys is woefully flawed in that it is structured by unrealistic and politically damaging images of and goals for scientific activity. Such a view offers opportunities for radical thought about what science education should look like for everyone. (p. 30)

Just because it has always been done this way is one of the worst reasons to continue to do something in education and yet it is repeated and systemically done all the time. We should instead follow the lead of the Sensoy and DiAngelo (2017) statement and, "Teach from a critical perspective and understand that knowledge and all means of knowing are connected to a social context" (p. 29). As educators and researchers, we need to see the knowledge our girls bring to the classroom as a valued asset that can deepen and enrich our constructs and our classrooms' constructs of knowing and being.

3.0 Methodology

Due to the multifaceted nature of studying the phenomenon of girls' attitudes, perceptions, and experiences in technology and engineering classes, it was necessary to use a mixed method, two-phase approach to understand the complexity of my problem of practice fully. The study followed mixed-methods sequential exploratory approach as explained by Creswell (2009), with Figure 1 visually showing this process.

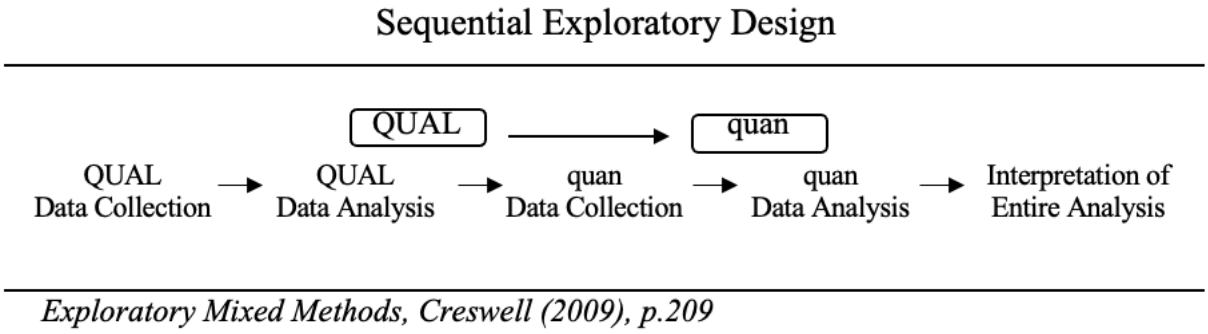


Figure 1. Sequential Exploratory Mixed Method Design

Two data collection phases, one subsequently following the other, occurred. By structuring the study in this way, the qualitative results were used to understand and interpret the quantitative findings. In addition, the quantitative results were used to help build on the analysis of the qualitative phase (Creswell, 2009). The study explored the attitudes, perceptions, and experiences of girls in technology and engineering courses and was guided by the following research questions:

Qualitative Research Questions:

1. What are girls' perspectives of and attitudes toward technology and engineering courses?
2. How do girls' perspectives or attitudes toward technology and engineering influence their decisions about taking technology and engineering courses in high school?

Quantitative Research Question: Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities?

3.1 Positionality of Researcher

As each of the learners in my classroom brings a unique experience and background, so do I as the researcher of this study. Reflecting on my positionality, it is important to bring to the reader my experience and perceived identity and to acknowledge its potential impacts on this research. As both a practitioner and a scholar within this research study, Perry, Zambo, and Crow (2020) discuss needing to recognize both the insider and outsider role I bring to the study. They further state "how their identity affects their research process about their research subjects and systems of power" (Perry et al., 2020, p. 112). I identify as a heterosexual white woman raised in a predominately middle-class suburban neighborhood with very little diversity. I grew up the oldest daughter in my family and strived for perfection in all I did from a young age. I was privileged to attend a Catholic school for my K-12 academic experience. Throughout my academic career, I was drawn to pushing boundaries set in place by society, precisely those traditional ideals of gender. I always had a voice in my mind saying, "I can do everything they [boys] can do, if not better."

When I reached the undergraduate level and was pushed into the world of technology and engineering, I began to recognize more clearly, as I interacted with professors and peers, that my experiences in the world were different from theirs. As a young white woman, I was entering into a field of all white men, and this awareness almost created a heightened sense of determination and pressure to succeed. Once in the educational workforce, my experience and identity that I brought to my teaching were different than the men I worked with. However, it is important to bring awareness and recognize that my identity is positioned differently in a more privileged experience than those women and men of color who are also members of the technology and engineering profession.

It is my position that the personal struggles and gendered stereotypes I witnessed in my journey are what has driven my perusal of this problem of practice. My shared common experience with the girls in my research links my choice to pursue the problem and my ability to relate to their perspectives shared in this study. It is also important to recognize my position as an educator or former educator of many girls in this study. Not only did I have the role of researcher, but also an educator. In the interviews, I could not assume I knew what each girl experienced or would experience based on my life journey, therefore I had to take a focused role of active listening and allow the girls to be the expert of their own narrative experience. As the educator implementing change in my practice, I had to be aware that as their educator, I am in a position of power and that power can impact their responses. It was important to recognize, especially when students were participating in the surveys, that no influence of power was pushed on them to answer questions in a specific manner but rather generated from their own perceived attitude, position, and experience.

3.2 Phase One

3.2.1 Study sample

The targeted participants were a "purposive sample" as defined by Menter (2011), as the participants were selected specifically because of their self-identified gender and enrollment in 9th-12th grade technology and engineering education courses at Southern Hills High School. Recruitment of the girls began upon IRB approval and after obtaining parental consent and finally student assent. All self-identifying girls enrolled in technology and engineering and physics courses were invited to participate. A potential 34 participants were available from the physics and technology engineering course enrollment in the spring of 2021 and invited for this part of the study. Of the 34 invited, 14 girls responded with initial interest to participate in this phase of the study. In the end, parental consent and student assent were obtained for six (n = 6). Six young women participated in the study representing four different technology and engineering courses offered at Southern Hills High School. Participants ranged in grade levels from sophomore to senior. The participants' expressed experiences were referring to the prior year, as interviews took place after the school year commenced. Of the six participants, only one had taken more than one technology and engineering course as of the interview date, and two scheduled for enrollment in technology and engineering courses in future semesters. The six participants are Ashley, Jennifer, Julia, Lauren, Natalie, and Sarah.

Table 2. Participant Information

Name	Grade	Courses	Total Tech/Eng Courses Taken
Ashley	Sophomore	Metal Technology 1	1
Jennifer	Sophomore	Wood and Manufacturing 1	1
Lauren	Sophomore	Digital Media 1	1
Sarah	Sophomore	Wood and Manufacturing 1	1
Julia	Junior	Digital Media I & Digital Media 2	2
Natalie	Senior	Wood and Manufacturing 1	1

3.2.2 Methods and data collection

Following the sequential exploratory strategy, the qualitative exploration of high school girls' perspectives and attitudes of why they chose to enroll in technology and engineering courses occurred through semi-structured interviews. The qualitative methodology was important to deeply comprehend why and what is specifically influencing girls within the Southern Hills School District to enroll or not enroll in technology and engineering courses. In educational research, Menter et al. (2011) discuss the advantage of conducting interviews, as "Interviews allow people to provide their views in their terminology. This allows us to understand better the meanings underpinning people's actions and illuminates their attitudes, motivation, and rationale." (p. 127) Before data collection, permission was received from the Institutional Review Board (IRB) to conduct this research on human subjects. Interview questions (see Appendix B) were purposefully designed to frame questions broadly (Saldaña, 2015) to allow for reflective, individual answers from the participants. The interview questions included topics of interest, course choices,

classroom experiences, perceptions of gender, and recommendations. Under the topic of choices in the course, a sample question included, "Because technology and engineering courses are electives, I am curious about the reasons you did or did not participate in these courses. What are some of the reasons you decided to take (not take) technology and engineering (tech ed) courses at the high school?" Due to the continued uncertainty of the COVID-19 pandemic and the potential for virtual learning environments, all interviews were conducted via the online video conference software Zoom and lasted between 25-40 minutes.

Additionally, a quantitative survey (see Figure 2 for a survey and Appendix C.1) was administered to help "promote the robustness of the research findings" (Menter et al., 2011, p. 127) with a way to connect the differences and build on the similarities of the data findings from the interviews. The survey instrument was based on the adapted scholarly work of physics/STEM/engineering identity surveys by Hazari et al. (2010), Dou and Cian, (2020) and Godwin et al. (2016). The survey instrument was used to assess the technology and engineering identity attitudes and beliefs that the girls held. Specifically, the questions within the survey fell into the constructs of the physics identity framework (Hazari et al. 2010) and included: interest, recognition, performance/competence. Additionally, another section included perceived belonging as described by Hazari et al., (2020), as it is discussed as being important for feeling part of a community or career. The survey included perceived interest in a technology or engineering future career and an overall technology and engineering identity construct. The survey asked the girls to rate their level of agreement regarding statements in five areas using a 4-point Likert scale. They were: interest, recognition, performance, belonging, and identity. The Likert scale ratings consisted of 4 = *Strongly Agree*, 3= *Somewhat Agree*, 2= *Somewhat Disagree*, and 1= *Strongly Disagree*. These responses were used to help elaborate similarities and differences between

participant beliefs and experiences. They were pulled into the analysis and portraiture of the participants as described later in this chapter.

After conducting and transcribing all interviews and reviewing the survey responses, I began analyzing the qualitative data using multiple coding cycles. The first cycle of coding utilized the elemental method of In Vivo coding, which, "is particularly useful in educational ethnographies with youth... their actual words enhances and deepens an adult's understanding of their cultures and worldviews" (Saldaña, 2016, p. 106; see also Stringer, 2014). In this coding process, I read through the transcripts several times and grouped each set of participants' words into a code every few sentences or lines that seemed to call for highlighting. Their actual words became initial codes (see Table 3).

Table 3. Example of In Vivo Coding

Transcript	Code
I think they [Tech Ed classes} can sometimes feel intimidating. I don't know. Personally, the thought of being in a room with a ton of males it's, just like "eww, yikes." Personally, if I was in class and I needed help, I think I'd feel more comfortable asking one of my friends or just asking a girl in general, which is maybe just a me thing. I think it's just intimidating	Feel intimidating Too many males Comfortable with girls Intimidating

Coding in this way allowed me to stay true to the participants' voices. Once these initial codes were pulled from each interview, I moved into the second cycle of Pattern Coding to pull material from the first In Vivo cycle into more meaningful units of analysis (Saldaña, 2016, p. 236). Because Pattern codes are inferential codes, they helped lay the groundwork for cross-

participant analysis. I began to take additional memos, leave comments within the transcribed interviews, and revisit the initial codes. From these notes and clusters, several pattern codes emerged into both commonalities and some outliers from each of my participants. Saldaña (2016) also discusses that Pattern Codes can cycle across several participants' data, and categories can still emerge, reorganize, and be categorized further.

As I continued the analysis, I became aware that I may be losing the unique perspective that each of my participants was trying to share with me about her experiences in technology and engineering. As I mentioned in my literature review, there is no one-size-fits-all magic glass slipper that can be given to these girls to get them to the technology and engineering "dream castle." Instead, their slippers are built. They are made by their own experiences and constructed with the tools given to them by their family, friends, society, and educational systems. I recognized that, as the researcher, not fully to acknowledge and share their individual story would be unfair to them. I returned to their transcripts and began creating portraits of each participant.

Utilizing portraiture to show the descriptive experiences of my participants was necessary for this portion of my study. As a research method for the qualitative portion of my study, Lawrence-Lightfoot and Davis (1997) described portraiture as both art and science:

> Portraiture is a method of qualitative research that blurs the boundaries of aesthetics and empiricism to capture the complexity, dynamics, and subtlety of human experience and organizational life. Portraitists seek to record and interpret the perspectives and experiences of the people they are studying, documenting their voices and visions – their authority, knowledge, and wisdom. (p. xv)

Portraiture methodology was developed by Lawrence-Lightfoot in 1983 and has since gained importance in social sciences research as an essential method to consider in qualitative

studies. As the researcher trying to understand the attitudes, perceptions, and beliefs of my participants regarding technology and engineering education, I must also be aware of how each of my participants may have been influenced by her own lived experiences. This includes their culture, societal influence, and environment. The power of portraiture lies in the creation of the narrative that is "complex, provocative, and inviting that attempts to be holistic, revealing the dynamic interaction of values, personality, structure, and history" (Lawrence-Lightfoot & Davis, 1997, p. 11). As I constructed and then analyzed each portrait with the reflective look back at my In Vivo and Pattern Coding, I was able to understand more clearly my participants' perspectives, while also seeing shared experiences between the entire group as themes. As Saldaña (2016) recommended with multiple coding cycles, code charting can be helpful, "particularly when there are multiple participants in a study" (p. 229). I utilized this approach and found it to help visualize the pattern codes and emerging themes, especially once the portraits were used. (See Appendix D for a breakdown of codes). Once the portraits were complete, I asked each participant to review the portraiture I had written of them to ensure I accurately represented their shared experiences. I requested that they let me know if any adjustments or corrections should be made. Five of the six participants responded to this request with no discrepancies found or corrections asked to be made.

3.3 Phase Two

3.3.1 Theory of improvement

Girls in Southern Hills School District choose not to take high school technology and engineering (T&E) courses at a disproportionate rate to that of their boy peers. My improvement

theory aims to increase girls' technology and engineering identities through changes to the technology and engineering classroom environment focused on supportive and inclusive norms. This targeted classroom environment change warrants the theory of improvement. If girls have a more robust technology and engineering identity, they will enroll in more technology and engineering classes at the high school. The hypothesis that this theory of improvement would work was based on research that shows girls who form identities toward disciplines and content retain and persist in STEM courses at a higher rate (Blackburn, 2017; Hazari et al., 2010; Godwin et al., 2016).

3.3.2 Drivers and driver diagram

I aimed to foster technology and engineering identities for the girls in my 8th grade classes through supportive and transformative classroom adaptations. Although initial changes were anticipated with interventions in my classroom, a larger aim for the future of this improvement plan is that by August 2023, 10% more 9th grade girls will enroll in technology and engineering courses. The baseline comparison to show a 10% increase will be enrolment numbers from 2020-2023. The drive diagram in Figure 2 below operationalizes my theory of improvement while summarizing the aim, the measures, and interventions I implemented within my study.

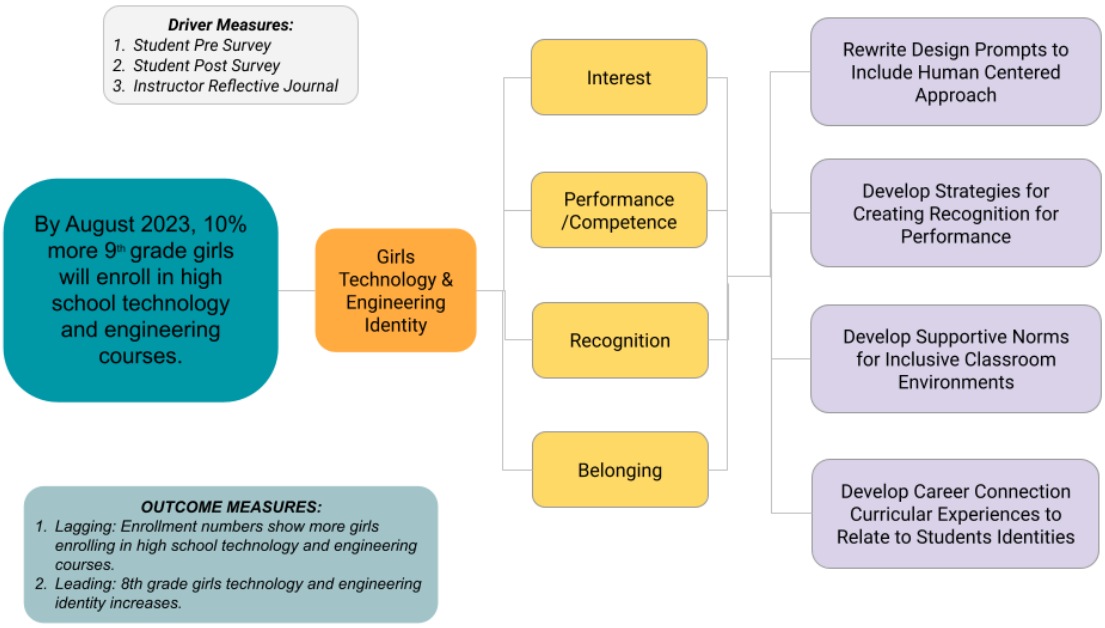


Figure 2. Driver Diagram

3.3.2.1 Driver descriptions

The primary driver of the system in my problem of practice was girls' technology and engineering identity. Within Southern Hills School District, no work has been done to cultivate this identity formation. As the literature also revealed, girls' identity formation toward technology and engineering as a discipline can provide them the tools for persisting through courses and into fields within technology and engineering (Kane, 2012; Carlone & Johnson, 2007; Hazari et al., 2010; Hughes, Schellinger & Roberts, 2021). This driver was also clearly concluded as an area of need through empathy interviews of several stakeholders and the developed fishbone diagram (see Appendix A).

The identified primary driver of girls' technology and engineering identity was unpacked further to include a sub-section of secondary drivers that could impact change. This included girls'

identity formation constructs of interest, performance, recognition, and belonging as defined through scholarly work in physics, STEM, and computer science (Hazari et al., 2010; Hazari et al., 2020; Dou & Cian, 2020; Godwin et al., 2016). This study focused on the hypothesis that if girls can form a positive identity in feeling belonging, worth, interest, and success in the technology and engineering classroom, they would begin to perceive and feel technology and engineering courses are more inclusive for all students.

Addressing the need of the secondary drivers required investigating several possible change ideas or interventions. The initial ideas for intervention included: developing supportive norms in the classroom environment that are more transformative for girls, purposeful exposure to role models when investigating careers in the classroom, recognition for performance and competence with content, and rewriting course performance tasks to include human-centered approaches. These initially proposed interventions were adjusted further once phase one of the studies produced findings. Additionally, small adjustments were made within the improvement science Plan, Do, Study, Act (PDSA) cycles of the intervention.

3.3.3 Phase 2 change idea and intervention overview

As Creswell (2009) explains in sequential exploratory strategies, "the second phase of quantitative data collection and analysis *builds* on the results of the first qualitative phase" (p. 211). After themes emerged in the initial analysis of phase one, phase two, Plan, Do, Study, Act's (PDSA) improvement science cycle was put into motion. It is important to note that a goal of improvement science research recognizes how local organization features can shape the interventions, and one must integrate this insight into iterative solutions (Bryk et al., 2015). The understanding of my local problem as a practitioner was gathered from stakeholder empathy

interviews, a review of literature, the driver diagram, *and* the findings from phase one of my study. This gave me further insight to develop the initial intervention and iterative changes within my classroom. Within phase two of my study, the guiding research question was: Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities? To address this question and utilize the PDSA cycle, additional inquiry questions were developed to break down and guide the tests of change/interventions that would occur within my practice.

These inquiry questions were:

1. Do human-centered design approaches increase girls' interest in technology and engineering courses?
2. How does being recognized for competence or perseverance improve girls' technology and engineering identity?
3. How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?

These supportive and transformative changes to the classroom environment included determining specific engineering tasks that students completed, including human-centered design, creativity, and freedom in project work. Purposeful changes also included specific times I recognized girls for their competence or perseverance on a task independently and in front of their peers. As Osterman (2010) discusses, "research also indicates that academic support directly affects students' sense of belonging and identifies specific dimensions of teacher practice" (p. 257). Recognizing girls and academically supporting their performance should have helped their sense of belonging. In addition to building a sense that the girls "belong," additional opportunities were developed with additions to the curriculum to include role models in technology and

engineering and setting classroom norms. After each of the initial PDSA or "intervention cycles" it was necessary to reflect, adjust, and prepare for small tests of change that I had learned from. As Hinnant-Crawford (2020) explains, "You begin with a theory and test it, and you end with developing or revising the theory in preparation to test again" (p. 162). This revision was critical to the interventions' results and goal of improvement.

3.3.3.1 Phase 2 study sample

Specific to phase one of the study a new sample of participants was targeted, separate from those participants involved in phase one. The targeted participants were a "purposive sample" as defined by Menter (2011) and considered convenient to the study. They were all part of the same course enrollment for all interventions and data collection within the study. The participant data were selected specifically because of their self-identified gender. The sample was self-identifying girls enrolled in 8th-grade technology and engineering education at Emory H. Markle Middle School. Middle school girls were selected as the participants for this study because they are the central feature of my problem of practice. Therefore, to address the stated problem of practice, girls in the middle school were the focus to create this needed change. The test of change was enacted on two different 8th grade rotations of students in the *Exploring Technology and Engineering* course. A total of 103 students were enrolled in the Exploring Technology and Engineering course rotations. Regardless of identified gender, all students that participated in phase two of the study were invited to take the pre-course and post-course survey—only the data collected from those self-identifying as a *girl* were used in the analysis. Of the 103 students enrolled in the course, 84 assenting and reliable responses to the survey were analyzed, and 34 of them identified as girls.

3.3.3.2 Phase 2 methods and data collection

The survey instrument (see Appendix C.2) was developed and adapted based on the validated and reliable instruments of student identity in physics, engineering, and STEM students by Hazari et al. (2010), Dou and Cian (2020), and Godwin et al. (2016). The survey was the same instrument administered in phase one of this study. The Qualtrics constructed pre-survey and post-survey utilized 14 Likert-scale questions and was given to the 8th- grade students in the Exploring Technology and Engineering course and at the beginning and end of the course (see Figure 3).

Survey on Girls' Perceived Technology and Engineering Identity				
Scale:	4 Strongly Agree	3 Somewhat Agree	2 Somewhat Disagree	1 Strongly Disagree

Questions:

1. I enjoy learning about technology and engineering.
2. I am interested in learning more about technology and engineering.
3. My teachers see me as a technology and engineering person.
4. My friends/classmates see me as a technology and engineering person.
5. My family sees me as a technology and engineering person.
6. I understand concepts I have studied in technology and engineering.
7. Others ask me for help in technology and engineering.
8. I am confident about my work in my technology and engineering course.
9. I can do well on tests and performance tasks in technology and engineering.
10. I feel different than other students in my technology and engineering course. (reverse coded)
11. There are times in my technology and engineering course I feel alone or isolated. (reverse coded)
12. Sometimes I feel that I have to prove I belong in my technology and engineering course. (reverse coded)
13. I see myself in a future career in technology or engineering.
14. I am a technology and engineering person.

Figure 3. Technology & Engineering Identity Survey

The data were collected and analyzed using descriptive statistics to show girls' technology and engineering identity. Although the survey was given to all 8th-grade students, the data for the girls alone was used for this phase of the study. The same survey was given at the end of the course, and the data were compared to the pre-survey data to see if the improvement cycle worked and what future iterations were needed.

Quantitative data, via the pre/post-course survey, was used to show the number of participants, specifically the girls' perceived interest, performance, recognition, belonging, and technology and engineering identity. These data were imperative to the study because if girls showed an increase in their sense of interest, performance, belonging, or recognition after the change was implemented, there should have also been improved overall sense of technology and engineering identity.

These data were collected via the developed survey using the online Qualtrics program. The data were archived and coded for analysis and checked for accuracy as it was collected. The survey data were coded into the constructs of the Physics and STEM identity frameworks by Hazari et al. (2010, 2020), Dou and Cian (2020), and Godwin et al. (2016). These codes included interest, performance, recognition, belonging, and identity. The survey asked the girls to rate their level of agreement regarding statements in these five areas using a 4-point Likert scale. The Likert scale ratings consisted of 4 = *Strongly Agree*, 3= *Somewhat Agree*, 2= *Somewhat Disagree*, and 1= *Strongly Disagree.* The survey can be referenced in Figure 2 and Appendix A. IBM's Statistical Package for the Social Sciences (SPSS v. 28) was utilized as the analytics platform to analyze the survey data.

The use of an educator reflection journal was also used to track the implementation process of both PDSA cycles. This weekly reflection journal included the prompts: *Things that went well,*

Things I noticed, Things to improve. The journal entries guided the second intervention change idea iterations. They were a source of reflection on what I could improve in my instruction and what I noticed my students were experiencing (see Appendix H for a small excerpt).

Systems Measures. Within the PDSA cycle of improvement, it is important to ask, "how will we know if the change is working?" To do this, it is important to define the types of measures referenced throughout the implementation of phase two of the study.

Outcome Measures. There were two potential outcome measures used to determine if the change was working. The first was the lagging outcome measure: *Enrollment numbers show more 9th grade girls enrolling in high school technology and engineering courses.* This outcome speaks directly to the aim's goal of 10% more girls enrolling by 2023 in technology and engineering courses. It was also lagging because it may take a longer time than the aim timeframe for this outcome to occur, as it is not focused on only 9th grade girls but all girls in the high school. As the tests of change continue to iterate over time, a greater impact should be felt through all high school grade levels and technology and engineering courses.

The second outcome measure tells more about the change that occurred immediately and is considered a leading measure. This measure should have resulted from the intervention and was defined as *8th grade girls' technology and engineering identity increases*. This measure should have been more readily achieved as each intervention was applied as an improvement cycle, analyzed, and iterated faster than the overall lagging measure.

Driver Measures. To see the technology and engineering classroom changing, driver measures also were included. These measures were included to give feedback throughout the intervention process occurring within the two PDSA cycles to determine if progress was made in improving the problem.

Process Measures. Process measures were put into place to determine if the driver measures and outcomes measures were working and progress was made. In addition to the pre-and-post course survey, a reflective weekly journal was recorded throughout the PDSA cycles. These were used to inform and adjust instructional practice. The journal was used as a source of what was personally working within the interventions and what the students or I seemed to be struggling with. The reflections were one of the primary sources used to adapt my intervention from one intervention cycle to the next.

Balancing Measures. Pushing for a change in a very male-oriented, traditional environment may be challenging for the SW technology and engineering department members. It will be important for me to consider balancing measures to push for systemic changes within the department, even though they may feel uncomfortable for the male teachers. Destabilizing the department may be temporarily necessary to create more positive outcomes for everyone, especially our girls.

4.0 Results

4.1 Phase One

In this first phase of the study, I sought to understand the perspectives and attitudes the participants had of their technology and engineering courses through research question one. I also pursued understanding how their perspectives and attitudes toward technology and engineering influenced their decisions to take their high school courses through research question two. To begin, the quantitative survey on technology and engineering identity (see Figure 3 for survey and Appendix C.1) was administered to help "promote the robustness of the research findings" (Menter et al., 2011, p.127) with a way to connect the differences and build on the similarities of the data findings from the interviews. Although the survey administered in this initial phase was not used for quantitative data analysis, it did help to show connections between perceptions and attitudes the girls shared in their interviews and reported in their survey responses. An overall summary of the data from the survey can be seen in Figure 4.

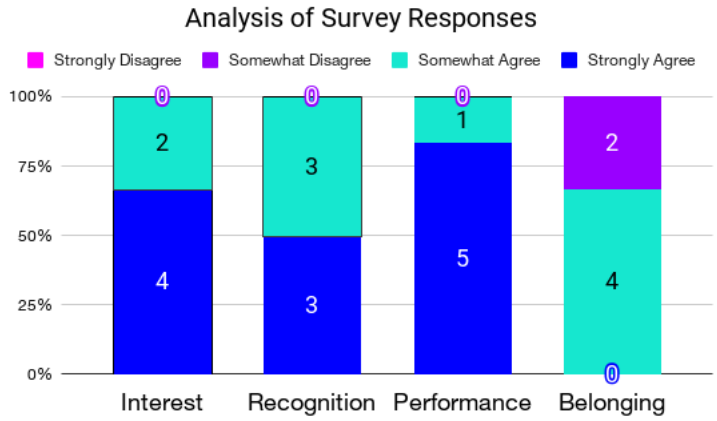


Figure 4. Analysis of Survey Responses in Phase 1

Combining the survey items based on the constructs of interest, recognition, performance, and belonging, you can see overall the girls responded positively in most areas. Of the technology and engineering identity constructs, within three constructs, all six girls agreed or strongly agreed with the statements. The high agreement was found with the questions about interest in the content. There was also a positive attitude toward the construct of recognition in others seeing them as technology and engineering people. The highest strength fell in their own attitudes of their ability and performance with five of the six girls strongly agreeing in their abilities to know and perform the content in technology and engineering. The one construct that showed negativity was within their attitude toward belonging. With two of the four girls somewhat disagreeing to this attitude. The final two questions of the survey asked the girls agreement of their interest for a future career in technology or engineering and if they felt they were technology and engineering people (a belief in a technology/engineering identity). The results for both questions were the same with four of the girls somewhat agreeing, one strongly agreeing, and one somewhat disagreeing as seen in Figure 5.

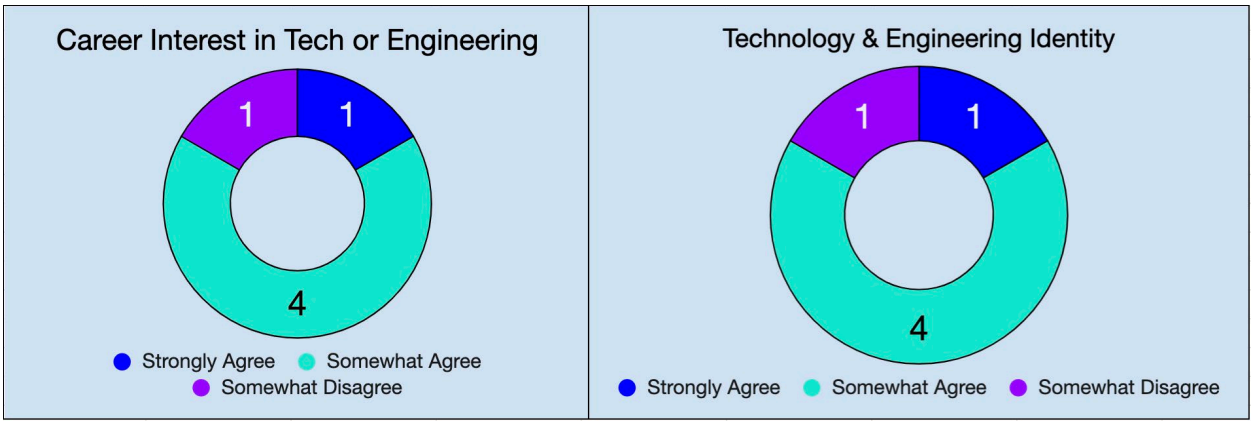


Figure 5. Career Interest and Technology & Engineering Identity in Phase 1

These results provided the baseline to compare and make connections to the girls' statements throughout the interview and qualitative analysis portion of the first phase of the study.

4.1.1 Building their glass slipper – Portraits

4.1.1.1 Ashley's slipper

Ashley is a sophomore whose experience in the technology and engineering department was reflected in the *Metal Technology 1* course. Her positive experience has influenced her to schedule the *Wood and Manufacturing 1* course in a future semester. Ashley's attitudes and perspectives of the technology and engineering course showcase that despite feeling awkward and doubting her belonging, she knows there is room to grow. Overall, Ashley sees herself as a technology and engineering person. This strong identity toward technology and engineering stemmed in part from the early adolescent experiences that sparked her interest and the confidence she built in her skills during the hands-on project work in her classes.

Influences. Ashley has always liked learning about how things work. When putting things together, she likes how she can create something worthwhile. Explaining what sparked her interest in technology and engineering, Ashley attributed her grandfather and her desire to help others as influences.

> *My grandfather does woodworking for a job, and he has a woodworking shop above their garage. I would go up there sometimes. I go up there more frequently now. [When] I would go up there, I would see the stuff he did, and I think that probably started something.*

Ashley also referred to her viewpoint of seeing the constructed world around her, even at a young age. She recalled being drawn to how things are made and how that could help others as early exposure to understanding the power of technology and engineering.

> *I think it was seeing the different things that people could do. Things in everyday life like bridges or even houses that we look at as kind of like, "oh, that's there." I just think it's cool that if I did see [technology/engineering] as something in my future that I could be someone to help make one of those someday.*

Ashley's middle school experience was also an important part of building her interest in technology and engineering, considering it a career choice and helping her schedule high school courses within the Tech Ed department.

> *I know that in middle school, when we would have our tech classes, I really enjoyed them, and that was the one class that I always looked forward to going to. I thought about it and thought this could be something that I could see myself doing as a career later in life, so I was like, "I'm going to try it."*

Ashley's remarks show that the influence of her grandfather, her innate wondering of how the built world can help others, and her middle school technology courses all played an influential role in her decision to take technology and engineering courses at the high school level.

Overcoming intimidation. Ashley's positive influences helped her decide to take *Metal Technology 1* as one of her elective courses during her freshman year. Her beginning perspective of the course was not as positive as her middle school experience:

> *I'll be honest with you; I started that class a little bit intimidated just because I was the only girl there.*

When discussing her current high school experience, Ashley explained feelings of intimidation and self-doubt. She went into her technology and engineering class aware of her gender. She may be noticed as the only girl, but when she was placed at the center of attention at times because of her gender, the comments from her teacher only heightened that awareness.

> *I know Mr. Dillion; he's a very respectable person. I honestly love him, but one thing that he would constantly say would be telling the boys, "Don't compare yourself to the girl," or something like that. That was just the thing that was kind of awkward—having to be that center of attention because of my gender. Mr. Dillion would say stuff like don't compare yourself to me, it was kind of awkward because it was like, yeah don't compare yourself to me the girl. Awkward.*

Throughout our interview, Ashley discussed having a lot of self-doubt at the beginning of the class, not just because of being the only girl but also because she was not confident in her ability to create things out of metal.

The beginning okay, I'm like obviously the whole intimidated thing, and not just by the fact that I was the only girl, but also the fact I'd never made a whole entire toolbox of just metal, and I hadn't done all the things before like we were doing.

However, Ashley grew in her abilities and confidence, which grew her excitement and enjoyment of the class:

I'd be really excited about it. I would text my mom and grandma every day "guess what we did in class today." It was something that gave me some kind of joy. It was a class that I would always have fun with, and I would tell my friends what I did.

Ashley continued to share that she built the mindset to believe in her abilities, even amid self-doubt:

I was really scared to go in front the class and try stuff because I'd think they're gonna watch me and look at how the girl is doing it. But then, every time I just kind of thought about the fact that, "Ashley you know you really enjoy this class; don't let a few people's opinions try and stop you." I just try and put everyone's opinions kind of aside and do my own thing, and at first it was really hard because there was always a voice in the back of my head saying, "They're probably sitting there just watching me right now, as the girl," but over time I kind was like whatever. It just didn't bother me anymore.

I witnessed Ashley's self-worth and confidence build as she told me about the projects she completed, the skills she learned, the nerves settled, and the additional classes she hoped to take in the future.

Curriculum interest. Ashley also spoke to the enjoyment of the inquiry-based, hands-on process curriculum in her class. She appreciated learning the skills to take something from

straightforward beginnings and build that into a useable product. This mindset matched closely with her initial influence of different things people can do and create:

> *I enjoyed the hammer because that showed we were doing many things. Like using machines, castings, I got to braise as well, and castings. So there were different things [steps] that were put into it that I took an interest to.*

Embracing the different activities and skills she was learning also showed up in Ashley's ratings of her abilities. She responded in the survey that she somewhat agrees that she understands concepts she has studied and has confidence in her work. Her discussed experience and survey responses projected that she grasps the concepts from her course and she appeared very confident.

Belonging. Even with a sense of confidence in herself, enjoyment of the content, and knowing that her teacher knew her abilities and promoted them, Ashley still felt her peers did not see her as a resource for helping them. This attitude is corroborated with two of her survey responses as well. She disagreed that her peers saw her as a technology and engineering person, and she disagreed that others would ask her for help in these classes. Ashley discussed these beliefs with some tension in her voice:

> *I'll be honest with you, when we did different projects, I wouldn't say Mr. Dillion treated me differently, but I felt some of the classmates would. When they would need help with something, I could be standing there done my project, but they go out of their way to get a guy to ask for help instead. I know that people would really hesitate to come to me because, I'm the girl. The girl probably doesn't know anything.*

Although she expressed feeling that her peers may not have confidence in her abilities, she still has a desire to persist in the field, explaining her upcoming plans and the reasons for her choices:

I took the Metal 1 class this year, and I am taking the woods one this upcoming spring because I want to see which material I like working with better. But at this point, I can see myself doing it in the future.

Ashley reflected both positive and negative perspectives and attitudes toward her experiences in a technology and engineering course. Her ability to develop skills and confidence while overcoming feeling out of place demonstrates an internal desire to persist in her Technology and Engineering course selections and aspire for a future in this field. Responding that she strongly agrees that she sees herself in a technology and engineering career additionally aligns with this point.

* * * * * *

The journey Ashley shared from her youth to her time within her high school technology and engineering course has impacted her technology and engineering identity and the attitudes and perspectives she holds for her course experience. She has formed a positive mindset, which persist, even when faced with internal doubt or external adversity. Wanting to pull from this positive mindset, questions were asked at the end of the interview to see what Ashely believed or recommended so that other girls could also persist and form a technology and engineering identity. Ashley shared a myriad of ideas that she believes could positively impact girls' choices to take technology education classes at the high school. These ideas included navigating the reality that high school is a social beast and other people's opinions matter to high schoolers.

You need to just not let other people's opinions stop you from doing things you like. Don't get me wrong; if you don't like doing things with technology and engineering, then you don't. But if you do, don't let something as small as someone else's opinion stop you because if someone has an opinion of you not being able to do it, you can prove them wrong. We

have nothing to lose going against someone else's opinion. And I just wish that girls will know that.

In her final reflection, when asked how she recommended encouraging more girls to take high school courses, she suggests showcasing the girls already in the classes and women in technology and engineering careers:

Show a lot of women doing tech and stuff because then that can almost assure them like … hey yeah … see girls do this, too. Maybe even having them come and see like a girl who's doing it in high school. Just so that like they can understand that like, hey it's cool if you do this. Not having someone sit there and judge you. So I feel like if they find someone to look up to maybe they would want to be like that.

4.1.1.2 Jennifer's slipper

The experience Jennifer shared of her technology and engineering course was focused on her time in the *Wood and Manufacturing 1* course. Her attitudes from her survey response and perceptions from her interview match well except for her identity. Jennifer somewhat disagreed that she has a technology and engineering identity and somewhat differs from seeing herself in a future technology and engineering career. Interestingly, these survey responses collected from Jennifer did not correspond to most of the experiences she shared throughout the interview, which reflected a positive perceived identity.

Influences. Jennifer did not mention any personal influences growing up that may have led her to take a technology and engineering course. However, she recalled several other experiences she felt influenced her decision. She first recalled that she loved her middle school technology education experience, which may have influenced her to enroll in the *Wood and Manufacturing 1* course.

It was definitely one of my favorites in middle school technology classes. We had a lot of options. There's obviously woods, metals and all the rest, but I liked woods class.

In her survey responses, Jennifer somewhat agreed that she enjoys learning about technology and engineering content and somewhat agreed she wants to learn more, showing a positive attitude toward the content. Tinkering and making things sparked her interest.

When I was younger, I was always around things that you got to make with like LEGOS. Also when I was in elementary school, I got to make something where you had to drop an egg in a parachute.

Another influence Jennifer mentioned was the out-of-school experience participating in Girl Scouts.

I used to be in Girl Scouts, and we went to a STEM convention. There was a lot of stuff there that was obviously STEM-like.

These experiences seemed to have left a positive impression on Jennifer related to STEM content and her interest in taking her high school course.

In addition to the influence Jennifer's experiences had on her, she also discussed her perception of the course projects' importance in relation to course selections.

At the end of the year [curriculum night], we got to walk around in the gym and see all the options for high school classes. I saw a bat in the woods [course] section, and I wanted to make a baseball bat.

Jennifer's influences to enroll in the *Wood and Manufacturing 1* course can be directed to her interest in the final products made in the course, her experiences in Girls Scouts, and her middle school technology education courses.

Freedom in project work. Jennifer discussed the importance of freedom to create projects in the *Wood and Manufacturing 1* course.

> *It's [Woods and Manufacturing] always been an enjoyable class, and I like that it's hands-on. I've probably enjoyed the cutting board the most because it was our first big project that we just got a lot of free will with.*

Not only was creative free reign important to Jennifer but so was the fact that she could make her project unique within the project guidelines.

> *Everyone's unique, and if you just build it off what one person likes or what he [the teacher] likes, not everyone in the class is going to like that. So I liked that everyone got to make their own unique cutting board.*

This freedom and open-ended approach to project creation gave Jennifer a sense of independence. As she spoke about being given this freedom, her voice changed with excitement and a matter-of-fact sharpness that was not there before.

Jennifer recommended that when designing project constraints, considering what would interest girls is something she believed would help attract more to the practical technology and engineering courses.

> *I mean, give more feminine options in the woods course. Like baseball bats, I thought baseball bats are cool, but not all girls think baseball's cool. Maybe do something like a picture frame or something that they [girls] can build that would interest them like a jewelry box or something.*

Jennifer points to the importance for educators to consider not only the skills to be taught, but also the gender and interest of all students enrolling in their courses.

Classroom environment. Jennifer discussed some of her experiences in her *Wood and Manufacturing 1* course that stood out to her involved more of the classroom climate. She discussed the only negative experience she had dealt with being punished for a dress code violation and feeling singled out because of it.

> *I got dressed coded like three times in that class. None of my other teachers cared. Just Mr. Asher. One time with safety. One time was both, and then one time was because my outfit was not appropriate. It was so annoying and apparently, it's like a rule in the dress code. But no guys got it.*

Although she noted that "no guys" received a dress code violation in her class, she discussed later in our interview that gender was not an issue in her class experience.

This gender-neutral mindset matches well as she strongly disagreed that she felt alone and strongly disagreed that she had to prove herself within her course when responding to the survey.

> *I thought there are a lot of guys here [in the Woods class] and a lot of them are cute, but other than that I didn't really think about gender at all. I had maybe five girls in the class. There were definitely more guys than girls, but it wasn't really a problem.*

Jennifer also noted that when it comes time for students to enroll in courses, she believes some girls consider gender, but friends and interests also have an impact.

> *There are a lot of guys. When you go into high school, you probably think about it when you're picking the classes, not when you're in the class, because at that point, you're there. When you're picking the classes, you're like, "There's probably going to be all guys in this class." Also, you pick a lot of classes, that your friends pick. A lot of girls pick art and usually girls with other girls. My best friend picked wood, so I picked wood. But that's not the only reason I picked it, I also enjoyed class.*

Jennifer's perception of the classroom environment for her is laced with an awareness that there are gender differences and some that may sway girls from taking the course, but none that make her feel that she does not belong.

Jennifer's experience and perceptions show her unique attitude and perspective in her technology and engineering identity. Her interests began with experiences in making, tinkering, and STEM content provided outside of school. Her middle school technology and engineering courses seemed to have further sparked her interest in the content area, especially woodworking. She believes that her overall experience in her technology and engineering course was positive. Her explanations are partly due to the nature of the hands-on course and the open-ended projects where she could create things based on her interest.

4.1.1.3 Lauren's slipper

Lauren's shared experience is another journey that highlights a different perspective and attitude about technology and engineering education. Lauren's perceptions and interest in technology and engineering courses seemed to focus on several influences. These influences stem from several areas: her family, the curriculum, participating in an after-school club, and the district's graduation requirements. Her experiences specific to the technology and engineering coursework reflect her time in the *Digital Media 1* course, which is traditionally more gender-neutral when it comes to stereotypes and enrollment.

Influences. Lauren's inspiration toward technology and engineering came from her interest in math and science and her belief in her abilities in these areas.

> *I really find science interesting and then math on top of it. I just feel that's where I really excel the most. So when it's combined, it's like, "yeah!" I'm good at it. Plus, it's what I like to learn about.*

Similar to this statement, Lauren responded ‘strongly agreed’ to the prompt that she enjoys learning about technology and engineering. She further reinforced this attitude and included her middle school experience when she explained:

> *Engineering overall just seems really cool to me because I'm interested in a lot of the subjects they have involved. When I was over in the middle school, I really enjoyed the class that they had in the wood shop.*

Another influence for Lauren’s decision to take a technology and engineering course was her participation in an after-school club, the Technology Student Association (TSA):

> *I'm in TSA, the technology student association, and that's my favorite club ever because you get to figure out what you're really interested in and then competing in that!*

Lauren’s passion for designing and solving problems is apparent in her recollection of TSA. This out-of-school influence also enabled her to combine her curricular interests in technology, science, and math with discovering new things and designing.

High school students typically have district-set requirements to graduate that fit into certain curricular contents. Lauren discussed this as a primary influence on why she chose *Digital Media 1.* This course would fulfill her graduation requirements and meet her academic needs.

> *So honestly, my schedule is really jam-packed, especially with honors classes. So, if I'm gonna take electives, I want them to be the ones that are easier or won't take as much effort to do.*

Lauren shared that the influences of her teacher and desire to help her family helped sway her decision to take *Digital Media 1* over another practical courses that could have still met the graduation requirements.

First of all, I like the teacher, but it just seemed kind of cool because a lot of people in my family are all wanting to get into photography and all that stuff. So I kind of just took the chance so that I could teach all of them how to do it, too.

Her survey responses reinforce this shared perception that her teacher and family influence her. She strongly agrees that her teacher sees her as a technology and engineering person and her family sees her as a technology and engineering person. She also shares that she has a desire to teach others what she will learn in her coursework.

Open-ended curricular freedom. Lauren shared that what she enjoyed the most in her technology and engineering class and the most positive experiences came from the freedom associated with the open-ended projects and the social aspects. This shared experience also matches her survey responses that she strongly agrees she enjoys the content and somewhat agrees she wants to learn more about the technology and engineering content.

I really liked like getting to go out[side] when you're taking pictures of things. It just becomes so much more interesting and especially when you get people from the class to get involved with it. It just makes [the class] so much more fun because it's adding a social aspect to it. The audio engineering project was cool because you'd get to do everything by yourself. You're responsible for finding all the noises, and if it didn't work out, it was you who could fix it.

Lauren enjoys the shared experience of working in a social setting in this class while taking photos and creating. Still, she also enjoys the individual responsibility and freedom associated with the projects where she is in control and responsible for the content.

Belonging. Lauren discussed that being in a class with other girls makes her feel more comfortable. She recalled that she didn't want to take a practical course offering because of the representation of fewer girls.

> *Not really in the one that I took because it was mostly half and half. I know in the other classes that I was thinking about taking it was one or two girls in it. I think it was wood had one girl in it, so I was like, "I don't want to be the only girl."*

Lauren's self-perceptions about her attitude toward belonging in technology and engineering courses match her perspective. She somewhat agrees that she belongs as a student in the *Digital Media 1* course. In this case, she belongs if the class has other girls.

Lauren did share her ideas as to why she believes girls are not taking high school technology and engineering courses at the same rate as the boys. On this point, she highlights issues with exposure, lack of female peers, and comfort.

> *I think it's just maybe because they haven't really been exposed to it. Either that or they just don't want to be alone. Where there isn't very many of them [girls], they don't want to continue. It's kind of like an ongoing loop.*

Lauren's overall experience was a positive one, and although she enjoyed her experience, she didn't immediately plan to take more technology and engineering courses. She is continuing her participation in her TSA club. Her experiences show several perceptions about technology and engineering and a path to taking them from Lauren. One shared perception was that a sense of belonging was noticed in a course not traditionally dominated by a single-gender. Lauren was aware, however, of gender differences and even shared that as a reason why she did not choose to take a practical course as an elective. Her desire to take the *Digital Media 1* class, which included the reputation that the course was more accessible and fit a graduation requirement, influenced her

selection. In addition, the influence of her out-of-school TSA club and her strong desire to help her family with photography and teach them what she learned shows a social shared experience is important to her, both in the class and in sharing her knowledge.

4.1.1.4 Sarah's slipper

The technology and engineering experiences sophomore Sarah shared included reflections primarily from her high school *Wood and Manufacturing one* course and secondarily her middle school courses, out-of-school experiences, and role models. Her interview and survey responses show a young woman who has a positive perception and attitude about her technology and engineering education experience. Her attitudes about her abilities and technology and engineering identity were 'somewhat agreed' in all responses from the survey, matching much of the perceptions she shared within the interview of her educational journey.

Influences. Sarah mentioned that one thing she believes influenced her interest in technology and engineering content was working with her dad.

> *I've grown up with my dad, helping him with little projects and stuff and it's always just interested me. It's never been something I'm like, "oh no, I don't want to do that."*

In addition to her dad, Sarah reflected on her middle school technology courses opportunities. An out-of-school club called the Technology Student Association (TSA) influenced and shaped her interest in technology and engineering further.

> *Being a part of TSA throughout middle school and having those two classes as well impacted how I enjoyed the topic itself and like pursuing it. My Dad and then joining TSA was definitely a big factor. It just like came to me like, "Okay, I think I can do this! I genuinely enjoy this, and it's something that I want to do."*

Sarah's TSA club experience was where she found that the passion of her advisors and working with other students contributed to her interests. She enjoyed working with like-minded peers towards a common goal, which motivated her to want to learn more.

> *In TSA it was nice to have our advisors who had passion as well for those sorts of things and then being around that group of students who also had the same passion. Even if it wasn't in the same kind of direct area, everyone was working towards the same goal and in the same way and having the same drive for it. I think being around all of that, being able to be creative, and getting feedback from people who I knew what they were talking about and doing was really helpful. That really just pushed me to want to do more with it.*

Based on the influences and experiences from middle school, her father, and TSA, Sarah signed up for the *Wood and Manufacturing 1* course as a freshman. The course was held during the pandemic in both a virtual hybrid and face to face environment which Sarah referenced as part of her experience.

Freedom within the curriculum. Even with the online and virtual hybrid setting, Sara found that given the freedom to follow her plans in her course was a positive experience.

> *There's a lot of things different this year because we were lacking time, and we were online for a little bit, so it was a little bit different. I had a little bit of freedom, or something did happen that I didn't intend to happen, but it did have a positive outcome. Wood is definitely my favorite, and I would say that because I do have the creative freedom, I feel. I enjoy like being able to put the different pieces of wood together having the different like colors and shapes and never really having the same outcome as you plan. But still on the same basis and still providing the freedom of what you want to make and allowing it to come to life.*

For Sarah, the biggest positive within her *Wood and Manufacturing 1* course experience was having freedom in the curriculum with what she was creating and having her own unique ownership of your project, even if things did not go as planned. Strongly agreeing' that she enjoys learning about technology and engineering and 'somewhat agrees' that she wants to learn more aligns with the positive perspective and freedom she has experienced in the Wood and Manufacturing 1 course. This expresses the value for Sarah in having an open-ended curriculum, which gave her a sense of freedom to put her knowledge and skills to use creatively.

Wanting respect. Sarah's only negative perception about her course experience was geared around respect. This included classmates not having mutual respect for working with power equipment and each other.

> *There were a couple times in the class where some people just did not know what they were doing at the time or did not understand, and that [lack of understanding] showed through projects. I mean it gets a little scary sometimes because you're around a lot of like big machines and a lot of working things. But I never let that kind of turn me away from it because I know that if I'm confident and using it, then I know that I'll be okay. The only negative thing is just some people don't know what they're doing or don't have that mature respect for being around those big things and other people as well, and just mutual respect for each other.*

Sarah recognized that sometimes the course had intimidating and scary aspects, but she had confidence and respect for the importance of how the machines worked and for class content. She showed awareness of others' needs and actions in her desire for her classmates to offer the same mutual respect that she put forth.

Growing confidence. Even when mentioning something that she believed to be negative in lack of respect, Sarah's own positive perception and confidence in her ability continued to surface throughout our interview. When discussing her project work throughout the course, Sarah's stories of her course experience showed growth in confidence in herself and her abilities. Her response is also reflected and matches her attitudes in the survey response that she 'strongly agrees' that she is confident in her work and 'somewhat agrees' that others see her as a technology and engineering person. When discussing one project with turning on a lathe, she expressed not feeling confident in her abilities or knowing what she was doing, but she overcame that and gained the skills she needed, which in turn influenced others.

> *I had no idea what I was doing, but I was like, "I think this will turn out good, I'm; I'm excited for this." I put it on the lathe, and I started doing my thing, and I was like, "Okay, this is new. I guess I'll figure it out along the way," and I did. It turned out really good and a lot of people in the classroom were happy with my outcome. It actually influenced someone else to create their own blank [wooden cylinder for processing] and stuff and that made me feel really good.*

Sarah's survey response of 'strongly agree' signified that she enjoys learning about technology and engineering content, and her interview responses match this attitude yet go further, showing even challenging content was of benefit and enjoyment

> *It was definitely a little bit of a challenge at first just thinking through it [content], but while I was in the class, I did enjoy it and I really found my way through it. Not to say that it wasn't a challenge, but it was something I enjoyed challenging myself in.*

Her reflection of her experience from the beginning to the end of her course showed true personal growth in her abilities, even when it may have been challenging.

Belonging. Sarah seemed to personally block out the notion that she was in a class that traditionally has stereotypical gender roles associated with it. Her survey responses also match this perception as she somewhat disagreed and strongly disagreed that she must prove herself, feels different and does not belong in the classroom. Although she acknowledged gender and empathized with other girls who may be intimidated, she has built a mindset that recognizes gender differences but is not impacted by it.

> *I do think about it outside of the classroom. When I'm in the classroom and I know what I'm doing and I feel confident when I'm doing it, I don't really let it bother me, especially when I'm around people I genuinely enjoy. I liked a lot of people in my class, and we were building off each other and helped each other. I wasn't really put down in any sort of way.*

She pointed out that she was in a class with three or four other girls, which seemed to help her belong. However, she pointed out that it was a bit harder for her at the beginning of the course, with hybrid classes and less girls.

> *I don't know if any of the other girls in my class felt that way because everyone genuinely enjoyed each other and had someone with them. But I feel like it would be hard for a girl who didn't have anybody in the class or didn't get along with other people in the class. I know it would have been hard for me if I didn't have those kinds of people, and it kind of was at first when we were split half and half, and I only had ten other people in the classroom with me; I think I did better with a lot more people.*

Sarah projected a strong respect for her teacher and his support. She also explained that comments from her teacher didn't bother her but made her realize that unintentionally he was bringing out a gendered notion.

Sometimes the teacher would say "this is why I love having girls in the class" or "This is why I love having_____" if there were a question answered or people responding differently. Obviously, that's a negative or a positive thing, but it was kind of bringing out the idea of like "okay, this is a female not a male kind of thing." I don't really have an opinion on it that makes me feel good or bad because I'm just there to enjoy the class, but I don't know how that makes the males feel in the class.

Although Sarah expressed that the comments from her teacher didn't make her feel bad, it made her more aware of his comments and wonder how it made the boys in her classroom think and feel.

Sarah's overall perceptions of her experiences show the power of her father's influence and activities from her middle school years on her decision to take high school technology and engineering courses. She has constructed a mindset that exudes confidence in her skills and abilities as a woodworker and creative being. She has blocked the idea that gender is even an issue for her but is still aware that it is present for others.

* * * * * *

Within the interview, Sarah discussed her recommendation to increase the number of girls choosing to take technology and engineering courses in the high school by focusing on positive mindsets about the course.

Have a more positive mindset of it. I don't know what's really being projected about the class or if the teachers are like you need to come here to work kind of thing. I think just a more positive outlook from both the school and the students because it does go both ways, but I think it needs to start first with the school because that's what the students are looking up to, especially me as a freshman not knowing anything.

4.1.1.5 Julia's slipper

Julia is a junior whose attitudes and perceptions of her technology and engineering courses bring another unique angle to this data. Julia is the only interviewee to have taken more than one technology and engineering course at the time of the interview, and both of those courses were not practical tech courses but instead focused on digital media. Her attitudes and perceptions add to the diverse experiences of how girls perceive their technology and engineering courses and why they chose to take them. Overall, her experiences and survey responses align. Julia believes she is a technology and engineering person and has formed an identity toward technology and engineering.

Influences. Julia recalled that the support, encouragement, and time influenced her interests and guided her to choose technology and engineering courses.

> *My dad is an engineer. So, every year, I think it started when I was eight, there's take your kid to work day, and they always have fun little activities. My dad's also very much of a problem solver. He also got the camera and was kind of interested in photography as well. So I think he encouraged me to do photography, but I think he also encouraged me to try those things and take harder classes and stuff.*

Julia believed her sister and STEM activity school days helped guide her to taking technology and engineering classes and explained why she chose *Digital Media 1* and *Digital Media 2* over her other courses.

> *I think my sister just talked on the side, and so I think I've kind of been pushed in that direction. But I've had the resources and stuff available to me to do that. I do know when we had little STEM days at school; I always found those so fun and little activities you have to do. So, I'm not necessarily opposed to doing another [class].*

Julia is open to learning about all areas of STEM and STEM classes. Still, her specific desire to learn about photography and digital media seems to keep her focused on a certain course path.

Julia recalled that she took both digital media courses to grow in her passion for photography. This point corroborates well with her survey responses toward her interest in technology and engineering. She strongly agreed that she enjoys learning technology and engineering content and wants to learn more.

> *My dad bought a good camera, and I had begun to play around with it. I just found that photography was something that I was really interested in and passionate about. I wanted to learn more about it and extend my knowledge; so, that's why I ended up taking Digital Media 1. I just loved the class, I love my teacher, and I felt like I learned a lot in Digital Media 1, so I took Digital Media 2 as well.*

The influence of Julia's father, STEM activities, her interest in the subject, and her positive experience in the first level course have empowered Julia to build interest in the subject matter and the desire to take more courses to deepen her understanding.

Classroom environment. Julia references many positive experiences and a supportive environment during her digital media courses and could not think of a negative aspect in her experiences. When discussing the projects and curriculum, she specifically enjoyed the hands-on process and was surprised at all she learned. Julia's processes and interests align well with her survey responses that she strongly agreed with her ability to do well on tests and projects in her courses.

> *It was always kind of scary to ask questions, but whenever I did, Mr. Bell was always helpful and supportive, and encouraging. He's such a jokester, which is always really nice.*

I think it really makes it feel not so scary and like, "Oh my god, you have to do this." [In] Digital Media 2, I love doing the live streams. I think they're so fun and tearing everything down and plugging all the stuff back in. Every morning the TV studio broadcasting, I love. I totally went into that class just because I loved photography just because I wanted to learn more about photography, and it's not just photography. It's video and audio, and I've learned so much more about video and audio than I ever thought I was going to.

Contrary to her positive mindset, is Julia's response in her survey about how her peers and teachers see her. Julia responded that she somewhat disagreed that her classmates see her as a technology and engineering person. She was the only participant in this study to respond that she disagreed that her teacher sees her as a technology and engineering person.

Belonging. Julia felt she belonged in her Digital Media course and shared that thinking about her gender or experiencing stereotypes had not crossed her mind until taking the pre-interview survey before our interview.

I never really thought about the whole gender part of it until I was taking that quiz, and I was like, "oh wow." But no, I haven't ever felt like, "oh my God, I'm the only girl in this class" or whatever. I feel with digital media and photography, a lot of people take Digital Media 1 because it's an easy class or they think it's going to be an easy class, and photography is just fun. I feel with professional photographers, I think there's a good balance between male and female.

Julia somewhat agreed that there were times she felt isolated or alone, and she also somewhat agreed that she sometimes felt she must prove herself. This doesn't fully match her interview responses to feeling that she belongs, but this may have been expressed differently due to the nature of the questions. However, she did reflect that she was hesitant to take a practical-

based class because of the gender difference yet was quick to reinforce that she enjoyed it in middle school.

> *I think personally, I would be scared to take woodshop because traditionally that's a male thing. But um, I had so much fun, we did that in middle school, and maybe I should take wood shop.*

Ultimately, Julia's classroom experiences in Digital Media 1 and Digital Media 2 were positive, and she did not feel as though she was not an important part or did not belong.

Julia did share that she believes so few girls are taking the practical technology and engineering courses due to an intimidation factor.

> *I think they can sometimes feel intimidating. I don't know. Personally, the thought of being in a room with a ton of males it's just like "eww, yikes." Personally, if I was in class and I needed help, I think I'd feel more comfortable asking one of my friends or just asking a girl in general, which is maybe just a me thing. I think it's just intimidating.*

Being the only girl is intimidating and wanting to be with friends led to Julia's recommendation to increase girls to take courses.

> *Add a graduation requirement to take a STEM class. I think that might help get more girls, but it would also just increase the amount of boys as well. Maybe you can say half of the class has to be boys and half has to be girls.*

Increasing the class male to female ratio to be more equal addresses her reason for not taking courses that are currently skewed in gender and shows that even though she said she is interested in the other tech ed subjects, she will not take one if she believes there are not many girls in the class.

Julia's experiences show a girl who has had a positive, strong male influence in her life. His supportive and encouraging ways have had a large influence on her enrollment in technology and engineering courses. She has followed her passion for photography and learned other content along the way that she is proud to talk about. Her experience in two technology and engineering courses shows that the classroom environment and the teacher have created a welcoming and impactful learning space that she has enjoyed. Although she has taken classes in the technology and engineering department, she is still intimidated to take a practical technology and engineering course primarily due to her interest and expressed the perception that they are full of boys and not for her.

4.1.1.6 Natalie's slipper

Natalie, the only senior participant in the study, shared an important perspective, including more years of course work and more opportunities to have chosen technology and engineering courses. Natalie somewhat agreed and saw herself as a technology and engineering person. However, Natalie strongly believed that her family and teachers saw her as a technology and engineering person.

Influences. Listening to her describe her experiences, she has formed this identity toward technology and engineering based on her family's influence, her intrinsic desire to create things, and the confidence she built within the practical side of hands-on woodworking. Natalie has always enjoyed creating things and seeing how things work together. Experiences with her dad and art classes were her first influences in the technology and engineering content area. Later, her preferred learning style and recommendations from her brother led to enrollment in technology and engineering courses.

My dad and I remember us building birdhouses for our backyard and we built a garden out of wood and just small things that really got me started and creating stuff. I feel like I've always done art, even as a little kid. I just loved creating things.

While many things influenced her decision to take the Wood and Manufacturing 1 technology and engineering course, Natalie attributed her decision to how she learns practically and how she can learn by doing in these courses.

I'm a hands-on learner. I just like being up and doing things. I don't really learn well when someone is just talking at me and showing me something on the board. So, when I can actually put that into practice and do it myself, I really feel like I get a deeper understanding. Everyone has to take a practical arts course at our school, but I just felt like it was important, just to have an understanding. Before this I understood tech ed a little bit, but I just feel like I wanted to be more well-rounded in the area. I thought (woods) sounded more interesting and, the projects seemed cool like my brother took it. So, he told me that it was a good course to take. I kind of just like seeing the way that like things work together. Like the process of creating something. I just like creating things and I get to do that. In shop and I've done all four years of drawing and painting, and I just think it's really cool to see that from a practical side, instead of an art. I can still be creative, but I think it's cool to see a practical side instead an art side.

Natalie's value for learning skills and ability to see connections between content areas was truly striking. Her voice continued with a raise of excitement as she explained that hands-on learning is how she learns and understands best. It was also apparent her maturity as a learner. She was able to express the power of creativity in learning and her enjoyment of seeing it in both art and the practical side of technology and engineering.

Growth in skills and confidence. Natalie mentioned being able to stretch her creativity while in Wood and Manufacturing 1 and learning from and with her peers, and then teaching her peers. Her discussion of this process showed her growth from initial fear to someone willing to share their knowledge and skill in helping others.

> *I was one of the first people to do my baseball bat project in that class on the lathe, and I was like really scared about it at first. I was like, "oh man, I don't know what's going on." I had to ask this girl every day what I was supposed to be doing. And then, once I got the hang of it, all these other people started getting on the lathe, and then they asked me for help. And then I would teach them. And then they would teach other people. So, I just thought it was cool to see not just Mr. Asher but also students teaching each other throughout that process.*

Her recognizing and being confident in what she knew about the content also matched the attitude conveyed within her survey responses. Natalie strongly agreed that she has confidence in her technology and engineering work and strongly agreed that others come to her for help with technology and engineering.

Natale's perception of confidence was also expressed as a desire for other girls to have experience and a potential solution for the low enrollment numbers.

> *I think it's more of an experience thing. Maybe if they heard more girls talking about their good experiences in the classroom, they'd be more open. People talk to me, and they're girls that I'm friends with, and they're like, "Oh, I had so much fun in this classroom," and then other people will be there, and they're like, "Oh, maybe I should try it." So I think a lot of it is also word of mouth.*

Her suggestion of the power of word of mouth and shared stories shows the value of her experience and her belief in peers' social power on course selections.

Belonging. Natalie discussed not feeling that there was a major difference regarding gender in class other than numbers and students' initial confidence to use the equipment. This perception supports her responses regarding belonging in technology and engineering class within her survey. Her responses all reflected that she disagreed in feeling different, alone, and had to prove herself.

> *There was a noticeably large amount of boys in our class, and there are only four girls. That was something that I picked up on when I first went into the class. I always noticed that the guys are just ready to go on everything, and the girls, took a little bit more time with things. We're maybe a little hesitant to get on the machine just because we weren't used to that or didn't have history with it, but I don't really think it was like a big difference.*

Natalie also recalled some interactions with her peers that stood out her in mind. Although her peers would offer help, she could not discern the offering as a compliment or insult. They made it seem that she was not competent, and they could do it for her instead.

> *I feel, like some of the time, the guys would be like, "Oh, do you need help with this? Do you need help with that?" Maybe they were just being nice, but they were always just offering to help, and I was like, "no, it's okay, I got it." I don't know; they probably just thought that we didn't know what we're doing some of the time, which I didn't know what I was doing, but I learned. And they were just always asking you if we needed help or trying to do stuff for us…I was like, "I got it."*

These interactions or offers of help, even if they came from a good place, made it seem to her that she was not competent, and they could do it for her instead. Natalie kept a confident mindset and reminded herself that she could do the work herself.

The experience and perceptions Natalie shared show her journey in forming a technology and engineering identity is one that does not always form quickly. Her initial interests began more closely in the world of art, yet she appreciates and sees the worth of how different subjects and mediums can still lend themselves to a creative spirit. She believes her interest in the subject and willingness to take the practical courses comes from experiences with her dad and recommendations from her brother, showing the power and influence family can have. Her shared overall experience in Wood and Manufacturing I are positive and demonstrate that she has grown in her abilities, skills, and confidence in herself as a creator, and she holds a willingness to share that with others.

4.1.2 Results – Phase 1 themes

From these portraits and the data presented, four main themes emerged that demonstrated the differences and commonalities in the participating girls' experiences with technology and engineering: influences, belonging, curriculum, and mindset. Throughout the portraits, the girls' responses illustrated how outside influences, their interest, the course content, peer interactions, and their self-confidence shaped their attitudes and experiences in the technology and engineering courses. In the sections below, the emergent themes and topics within the themes attempt to highlight the unique differences and similarities between the girls' experiences.

4.1.2.1 Influences that generate interest in technology and engineering

The first theme that emerged from the qualitative data was the common occurrence that some influences from their youth generated interest in technology and engineering and influenced their choice to take a technology and engineering course. Within this theme, three topics emerged.

Many of the girls mentioned a family member as an influence on their interest in technology and engineering content. Another influence mentioned by many of the girls was an out-of-school experience that sparked interest in the content of technology and engineering. Finally, the third topic falls into an academic influence, either driven by academic requirements, personal interest in the course, or prior in-school experiences.

Family influence. Most of the girls (4 out of 6) specifically mentioned a family member as someone who helped to foster an interest in technology and engineering. Interestingly, five of the six family members mentioned were men and the woman mentioned was a sister who influenced Julia by talking about classes. A fifth girl, Lauren, described that wanting to help her family was a driver for her interest in choosing to take a technology and engineering course. The girls varied in describing the family influence and recalled the influence itself.

For example, Ashley described influence from the experience of seeing her grandfather and working in his shop, "*I would go up there, I would see the stuff that he did, and I think that probably started something."* Similarly, Sarah recalled hands-on projects with her dad and "*helping him with little projects and stuff and it's always just interested in me.*" Julia spoke more to her dad's encouragement than working with him as an influence, "*My dad's also very much of like a problem solver. He also got the camera and was kind of interested in photography. I think he encouraged me to do photography, but I think he also encouraged me to try those things and take harder classes and stuff."* These student participants showed that the girls had specific experiences they believed influenced their interests and decisions to take technology and engineering courses. Their descriptions collectively show that influence by a family member or influence due to the desire to help one's family can make a difference in young girls' technology and engineering courses and experiences.

Out of school experiences. Another topic that emerged as an influencer in the girls choosing technology and engineering courses was out-of-school experiences. The majority of the girls (5 out of 6) shared an out-of-school experience they believed influenced their interest and decision to take technology and engineering courses. The girls mentioned various out-of-school experiences they had in their adolescent years or those they were still a part of as high schoolers. Julia shared the experience when she was young of "*take your kid to work day, and they always have fun little activities."*

Natalie recalled loving art and "*taking art classes."* Jennifer discussed being a part of Girl Scouts*, "I used to be in Girl Scouts, and we went to a STEM convention, and there was a lot of stuff there that was obviously STEM-like."* Variance in this subcategory occurred not in just the experiences themselves but in what the girls expressed the out-of-school experience provided for them. For example, Sarah mentioned that the passion of her advisors and working with like-minded people were her primary influence while in the TSA club. "*In TSA it was nice to have our advisors who had passion as well for those sorts of things, and then being around that group of students who also had the same passion…. That really just pushed me to want to do more with it."* Lauren mentioned the same afterschool club, but in her experience, the clubs' influence came from personal interest and competition in specific content, not from people. "*I'm in TSA, the technology student association, and that's my favorite club ever because you get to figure out what you're really interested in and then compete in that*." The girls illustrated through their told experiences that any exposure to technology, engineering, science, math, and art could invoke an interest in girls. These experiences illustrated that each girl's experience can have a different perceived influence whether it be personal interest, social enjoyment, exposure to content, or influence of passionate role models.

Academic influence. In contrast to an out-of-school experience, the final topic to emerge related to the influence was generated from an academic influence. Every girl (6 out of 6) responded that there was some academic influence on their decision to take a high school technology and engineering course. The majority (4 of 6) of the girls discussed the influence of their middle school courses as a primary academic influence. For example, Ashley said, "*I know that in middle school when we would have our tech classes, I really enjoyed them, and that was the one class that I always looked forward to going to."* Jennifer discussed*, "It [woods] was definitely one of my favorites in middle school technology classes. We had a lot of options. There's obviously woods, metals and all the rest, but I liked the wood class."* Sarah also mentioned the influence of her middle school class, *"Having those classes in middle school, it just like came to me like "Okay, I think I can do this! I genuinely enjoy this, and it's something that I want to do."* Lauren also mentioned middle school classes*, "When I was over in the middle school, I really enjoyed the class that they had in the wood shop."*

Natalie expressed a different reason for her choice of academics. She discussed meeting her graduation requirements, but also a desire for her learning, "*Everyone has to take a practical arts course at our school, but I just felt like it was important, just to have an understanding. Before this, I understood tech ed a little bit, but I just feel like I wanted to be more well-rounded in the area."* Another varied interpretation came from Lauren's academic influence. Her influence was centered on her interest, "*Engineering overall just seems really cool to me because I'm interested in a lot of the subjects that they have involved*." Lauren, too, focused on requirements to graduate, but from the stance the course would be a lighter weight on her honors course schedule. "*So honestly, my schedule is really jam-packed, especially with honors classes. So, if I'm gonna take electives, I want them to be the ones that are easier or won't take as much effort to do."*

These descriptions stress the power of academic experiences, exposure, and requirements on a girl's choice to take high school technology and engineering courses. The girls who mentioned their middle school courses all expressed that they were enjoyable and helped with their initial interest to persist. The other academic influences of the internal interest in the content and graduation requirements also illustrate how academics can play a different role in the course selection process.

4.1.2.2 Wanting classroom belonging: Senses of gender, inclusion, and exclusion

The second theme from the data was the girls referencing their belonging experience in the classroom environment. Like the varied experiences the girls shared as a matter of influence toward interest in technology and engineering, they also varied in their sense of belonging in their technology and engineering course experiences. Some of the girls due to courses being heavy in enrollment of the male gender dissuaded them from enrolling. Others expressed feeling that they were included and belonged and never had a sense of exclusion or gender differences. Other girls recalled feeling singled out and treated differently because of their gender. The topics emerging from these belonging-related experiences were gender notions, inclusion, and exclusion.

Gender notions. The first topic within this theme to emerge was centered around gender. The majority of the girls (5 of 6) mentioned that their gender was a consideration when selecting courses and something they were more aware of because of their experiences in the course. Lauren shared her reasoning for selecting one course over another had more to do with an imbalanced gender enrollment*, "I know in the other classes that I was thinking about taking it was one or two girls in it. I think it was wood had one girl in it, so I was like, "I don't want to be the only girl." So, I want to stick with one that's more common."*

Similarly, Julia shared that she didn't take a practical technology and engineering class because of feeling intimidated by the potential that she'd be the only girl. *"Personally, the thought of being in a room with a ton of males it's, just like 'eww, yikes.' Personally, if I was in class and I needed help, I think I'd feel more comfortable asking one of my friends or just asking a girl in general, which is maybe just a me thing. I think it's just intimidating."*

A different perception of gender for some girls was simply noticing the imbalance in enrollment and the impact the enrollment had on the girls' comfort. Natalie explained, *"There was a noticeably large amount of boys in our class and there were only like four girls, so that was something that like I picked up on when I first went into the class."* Ashley highlighted the intimidation the imbalance can cause*, "I'll be honest with you, I started that class, a little bit intimidated, just because I was the only girl there*." Gender was not always an evident awareness for the girls nor was it perceived as a negative. For example, Jennifer said, *I thought there are a lot of guys here [in the Woods class] and a lot of them are cute, but other than that I didn't really think about gender at all. I had maybe five girls in the class. There were definitely more guys than girls, but it wasn't really a problem."* In a similar instance, Julia admitted she never considered gender prior to our discussion. "*I haven't ever felt like, 'Oh my God, I'm the only girl in this class' or whatever."* Another varied perception of gender was more neutral. Even though she was one of only four girls, Sarah was more aware of gender when her teacher would comment on girls' work ethic and compare girls to boys. "*Sometimes the teacher would say 'This is why I love having girls in the class' or 'This is why I love having_____' if there were a question answered or people responding differently. Obviously, that's a negative or a positive thing, but it was kind of bringing out the idea of like 'okay, this is a female not a male kind of thing.'"*

Inclusion. A second topic that materialized centered on the girls' experiences of inclusion. Some of the girls (3 of 6) discussed a positive experience that showed their feelings of support, encouragement, and teamwork from educators and peers. Julia shared how her teacher helped calm her when she was nervous. *"It was always kind of scary to ask questions, but whenever I did, Mr. Bell was always helpful and supportive and encouraging."*

Similarly, Natalie felt encouraged by her teachers to continue in the tech field. *"I think they're just excited to see more girls getting into it, so sometimes they get excited about that and show that to you."* Sara shared a different perspective of inclusion stemming from the teamwork built when working with her peers, *"They would help me, and then in the end, I can help them creatively. We balanced each other."*

Exclusion. In contrast, the final topic for the theme of belonging included some girls (3 of 6) expressing a feeling of being excluded, perceived because of their gender or ability in the technology and engineering classroom. Ashley stated that being the only girl in her class made her feel awkward and excluded. *"Almost feeling excluded part just because I had some guy friends in there, but at the same time, it was pretty awkward just every time to walk in and be the only girl."* Ashley also expressed a tense feeling that her classroom experience made her feel very different as a girl, mostly because of how her classmates treated her.

> *When they would need help with something, I could be standing there done my project, but they go out of their way to get a guy to ask for help instead. I know that people would really hesitate to come to me because, I'm the girl. The girl probably doesn't know anything.*

Similarly, Natalie mentioned how the boys in her class might offer her help because they didn't believe she knew the content.

I feel, like some of the time, the guys would be like "Oh, do you need help with this? Do you need help with that?" Maybe they were just being nice, but they were always just offering to help, and I was like, "no it's okay, I got it." I don't know; they probably just thought that we didn't know what we're doing some of the time.

Sarah instead saw the exclusion dynamic as a two-sided issue from a different point of view. "You feel you either have to compete with them, or you have to be good with them in order to work together."

The girls' descriptions illustrate the influence gender differences can have on enrolling in courses, the potential for support and encouragement to increase belonging, and feeling excluded because of your perceived lack of knowledge or experience with skills in the technology and engineering classroom.

4.1.2.3 Curriculum that stimulates interest and stokes creativity

Third, the theme of curriculum surfaced as a very positive perception of the courses and a repeat discussion point from all of the girls. Parallel to the occurrences in the analysis of the first two themes, the girls' experiences had strong commonalities and important variances. The experiences they shared centered around freedom within the course to plan, practice skills, and produce projects. They also mentioned the value of learning both content and skill in a hands-on process and application. Finally, several spoke to the positive power of creativity within the curriculum and how that capacity was cultivated through projects.

Freedom. Many of the girls described a positive perception of freedom as part of their experience in technology and engineering. The girls explained that one of the keys to enjoyment in their experience was choosing projects and working at their own pace. Jennifer expressed this notion by saying, "*we just got a lot of free will. He basically gave us instructions, but we could do*

anything we wanted with it." Sarah also enjoyed the freedom in creating projects, even if there were unexpected outcomes*, "I had a little bit of freedom, or something did happen that I didn't intend to happen, but it did have a positive outcome*." From a varied perspective, Lauren enjoyed the freedom to work on projects and the sense of responsibility that came with it. She said, "*The audio engineering project was really cool because you'd get to do everything by yourself. You're responsible for finding all the noises, and if it didn't work out, it was you who could fix it."* Her sense of freedom came more from the responsibility of handling a real-world classroom-based scenario instead of only freedom of project choice.

Hands-on process. A second topic developed from some of the girls (3 of 6) pointed to the hands-on nature of the course being of most benefit or enjoyment to them while in technology and engineering. Jennifer remarked, "*It [Woods and Manufacturing] has always been an enjoyable class, and I like that it's hands-on*." Natalie clearly explained why hands-on learning works best for her when she stated,

> *I'm a hands-on learner. I just like being up and doing things. I don't really learn well when someone is just talking at me and showing me something on the board. So, when I can actually put that into practice and do it myself, I really feel like I get a deeper understanding.*

Ashley also linked her impression of hands-on learning to the process of creating in class when she said, *"I enjoyed the hammer because that showed we were doing many things. Like using machines, castings, I got to braise as well, and embrace it. So there were different things [steps] that were put into it that I took an interest to."* Julia expressed her love of learning by doing while running the TV Studio through her course experience when she shared, *"I love doing the live streams. I think they're so fun and tearing everything down and plugging all the stuff back in.*

Every morning the TV studio broadcasting, I love. We always have such a great time doing that and it's really taught me a lot." The girls clearly described a shared positive impression about the experience and value of hands-on learning processes provided by technology and engineering courses.

Creativity in action. Like expressing value and enjoyment in freedom and hands-on learning, the third topic of creativity in action emerged from the girls' discussions. Some touched on the power of uniqueness, like Jennifer when she said,

> *Everyone's unique, and if you just build it off what one person likes or what he [the teacher] likes, not everyone in the class is going to like that. So I liked that everyone got to make their own unique cutting board.*

For Jennifer, being unique in the process of building kept her interest and enjoyment high. Like Jennifer, Sarah discussed students have more space for creativity and unintended outcomes when given freedom. She shared of her woodworking course, "*I do have the creative freedom, I feel. I enjoy like being able to put the different pieces of wood together having the different like colors and shapes and never really having the same outcome as you plan."*

Other students saw connections bigger than just creativity in projects. Natalie shared her relationship between hands-on courses with different content and materials. She expressed seeing the value between creativity in art and creativity in a practical course.

> *I kind of just like seeing the way that like things work together. Like the process of creating something. I just like creating things and I get to do that. In shop and I've done all four years of drawing and painting, and I just think it's really cool to see that from a practical side, instead of an art. I can still be creative, but I think it's cool to see a practical side instead an art side.*

These girls identified individual satisfaction in the projects, unintended outcomes, and creativity of a different medium in technology and engineering courses.

4.1.2.4 Growing a mindset of confidence and ability

The last theme that emerged from the data was the girls' growth in their mindsets and confidence from experiences in the technology and engineering classroom. They discussed the value in the long term of how these courses may benefit them in the future and acknowledged this growth in confidence in themselves or their abilities.

Self-growth in ability. Several girls shared that being a part of their technology and engineering course helped them grow as individuals or provide skills for their future, like Sarah who shared, *"And like creative thinking and all those kinds of skills that maybe if it's not just the engineering field, it will still benefit me in my future."* Growing skills and knowledge were also a point that Lauren made but from a different perspective of wanting to teach her family when she said, *"I kind of just like took the chance so that I could teach all of them how to do it too."* Julia expressed a similar desire to want to grow in abilities and knowledge*, "I wanted to learn more about it [photography] and extend my knowledge."* This desire to want to grow in their abilities for the future highlights each girl's interest in the courses she pursued.

Growth in self-confidence. Several of the girls discussed instances where they began the class intimidated or scared, but over time, they grew in belief in themselves and their skillsets.

Natalie shared her growth from being scared to teaching others. "*I was really scared, terrified about it at first. …And then, once I got the hang of it, all these other people started getting on the lathe, and then they asked me for help. And then I would teach them."* Sarah shared a more direct level of confidence throughout her discussion but clearly addressed the point when she said, "*When I'm in the classroom, and I know what I'm doing, and I feel confident when I'm doing it."*

A varied perspective showed growth in a self-assured, confident mindset. Ashley shared that she wouldn't let other people intimidate her, and their opinions wouldn't get in the way of what she enjoyed.

> *"They're probably sitting there just watching me right now, as the girl," but over time, I kind was like whatever. It just didn't bother me anymore.*

The girls shared a range of information that shed light on the nuances of their individual experiences. During this phase of the study, I sought to understand both the perspectives and attitudes these girls had of their technology and engineering courses and how their perspectives and attitudes toward technology and engineering influenced their decision to take their high school courses. Their perspectives and attitudes across all the discovered themes had commonalities and differences, especially in their individual experiences. This is a key finding, that as educators and scholars we cannot rely on one set attitude or experience to define how girls build their interest or are influenced. Instead, we need to work toward a deeper understanding and illuminate these commonalities and differences. This is a critical step toward building an educational avenue to build positive and inclusive experiences in technology and engineering classrooms.

4.2 Results - Phase 2

Supportive and transformative classroom adaptations represented the overarching research question for phase two of the study and guided the inquiry question interventions within the PDSA cycles. The interventions employed within this phase addressed the need to foster technology and engineering identities for girls enrolled in the 8th grade *Exploring Technology and Engineering* course. A quasi-experimental, within-subjects repeated measures design, was used to evaluate the

interventions and address the quantitative element of this phase. The research methodology selected for use in the phase of the study was a survey research approach (see Appendix I for protocol). The study's sample of participants was accessed through a non-probability, convenient/purposive manner, all coming from within the same course rotations, school, and intervention cycle. Descriptive and inferential statistical techniques were used to address the quantitative data for this phase of the study. The following represents the results achieved in the quantitative element of the study.

4.2.1 Preliminary descriptive statistical findings

Descriptive statistical techniques were used to evaluate the study's demographic identifying information. Frequencies (n) and percentages (%) represented the specific descriptive statistical techniques used to evaluate the primary demographic identifying variable of gender within the 8th grade *Exploring Technology and Engineering* course.

Table 4 contains a summary of findings for the descriptive statistical evaluation of the demographic identifying information for participant gender:

Table 4. Descriptive Statistics: Demographic by Gender

Variable	*n*	*%*	Cumulative *%*
Gender			
Girls	34	40.48	40.48
Boys	43	51.19	91.67
Prefer not to answer	7	8.33	100.00

4.2.1.1 Descriptive statistics: Pre-test/post-test by intervention & gender

Participant response to the 14 pre-test and 14 post-test survey items on the research instrument was evaluated by each intervention cycle and gender of participants using descriptive statistical techniques. The response set data for survey items on the technology and engineering identity survey were specifically addressed using frequencies (n), measures of central tendency (mean scores), variability (minimum/maximum; standard deviations), standard errors of the mean (SE_M), and data normality (skew; kurtosis).

Table 5 contains a summary of findings for the descriptive statistical analysis of the study's response for the pre-test and post-test conditions of the study by intervention cycle of study for girl participants. The results overall by intervention cycle for the girl participants show normal distribution based on the skewness.

Table 5. Descriptive Statistics: Findings by Intervention Cycle & Girls

Cycle/Study Condition	*M*	*SD*	*n*	SE_M	Min	Max	Skewness	Kurtosis
Intervention Cycle I								
Pre-Test	2.55	0.30	19	0.07	1.93	3.21	0.31	0.32
Post Test	2.53	0.47	19	0.11	1.86	3.57	0.59	-0.39
Intervention Cycle II								
Pre-Test	2.21	0.34	15	0.09	1.57	2.71	-0.46	-0.93
Post-Test	2.38	0.27	15	0.07	2.00	2.86	0.10	-1.04

4.2.1.2 Internal reliability

The internal reliability of study participant response to survey items on the study's technology and engineering identity research instrument was addressed using the Cronbach's alpha (a) statistical technique (Field, 2018). The evaluation of internal reliability is based upon study participant response to all survey items represented on the pre-test and all survey items on the post-test (n = 28). As a result, using the conventions of interpretation for Cronbach's alpha offered by George and Mallery (2020), the level of internal reliability achieved in the study for both study's intervention cycles were considered excellent at a = .90. After analyzing the data and using Cronbach's alpha, the data produced an excellent reliability (.90), meaning the data was validly addressing the four constructs of technology and engineering identity. This validated students' ability to track and understand the constructs of the survey. Moreover, this excellent level of internal reliability (.90) achieved for study participant responses to the survey would appear to further reinforce the credibility and trustworthiness of the data collected throughout the inquiry questions of phase two of the study.

Table 6 contains a summary of findings for the evaluation of the overall internal reliability of study participant response to survey items on the study's research instrument across both intervention cycles of the study:

Table 6. Internal Reliability Overall

Scale	# of Items	α	Lower Bound	Upper Bound
Overall	28	.90	.88	.93

Note. The lower and upper bounds of Cronbach's α were calculated using a 95.00% confidence interval.

Table 7 contains a summary of findings for the evaluation of internal reliability of study participant response to survey items on the study's research instrument across Intervention Cycle I and Intervention Cycle II of the study:

Table 7. Internal Reliability: Across Intervention Cycles I & II

Scale	# of Items	α	Lower Bound	Upper Bound
Intervention Cycle I	28	.90	.87	.94
Intervention Cycle II	28	.90	.86	.93

Note. The lower and upper bounds of Cronbach's α were calculated using a 95.00% confidence interval

4.2.2 Findings by research & inquiry questions

The study's aim and phase two's research question were addressed through the statement of three inquiry questions. Descriptive and inferential statistical techniques were used to address the phase two research question and inquiry questions. The probability level of $p \leq .05$ was selected as the threshold value for findings to be considered statistically significant for study purposes. Numeric effect sizes achieved in the study's analyses were interpreted using the conventions offered by Sawilowsky (2009). IBM's Statistical Package for the Social Sciences (SPSS v. 28) represented the statistical analytics platform specifically used to analyze phase two study data.

4.2.2.1 Inquiry question #1

Do human-centered design approaches increase girls' interest in technology and engineering courses?

The *t-test* of Dependent Means statistical technique was used to assess the statistical significance of girl study participants' mean score difference in inquiry question one's pre-test to the post-test condition of the study. The normality assumption for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the conventions proposed by George and Mallery (2020), the skew value of 0.09 and kurtosis value of -0.44 for the difference score in the analysis were satisfying of the assumption of data normality.

The mean score difference of -0.20 in the pre-test and post-test conditions of the study for girl study participants in inquiry question one was non-statistically significant ($t_{(33)} = -1.16$; $p = 13$). The magnitude of effect for the pre-test/post-test difference score in inquiry question one was considered small at $d = .20$. For inquiry question one, the survey items #1 and #2 were analyzed over the two interventions cycles. This finding found there was a non-statistically significant decrease in girls' pre-to-post perceptions of interest in technology and engineering

Table 8 contains a summary of findings for the pre-test/post-test analysis for girl study participants for inquiry question one of the studies.

Table 8. Perceptions on Human-centered Design Increasing Interest

InQ1 Pre-Test		InQ1 Post-Test				
M	*SD*	*M*	*SD*	*T*	*p*	*d*
3.03	0.58	2.93	0.51	-1.16	.13	0.20

Note. N = 34. Degrees of Freedom for the *t*-statistic = 33. *d* represents Cohen's *d.*

4.2.2.2 Inquiry question #2

How does being recognized for competence or perseverance improve girls' technology and engineering identity?

The *t-test* of Dependent Means statistical technique was used to assess the statistical significance of the girl study participant mean score difference in inquiry question two's pre-test to the post-test condition of the study. The assumption of normality for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the conventions proposed by George and Mallery (2020), the skew value of 0.09 and kurtosis value of 0.40 for the difference score in the analysis were satisfying the assumption of data normality.

The mean score difference of 0.08 in the pre-test and post-test conditions of the study for girl study participants in inquiry question two was non-statistically significant ($t_{(33)} = 1.04$; $p = 15$). The magnitude of effect for the pre-test/post-test difference score in inquiry question two of the study was considered small at $d = .18$.

Table 9 contains a summary of findings for the pre-test/post-test analysis for girl study participants for inquiry question two of the study:

Table 9. Perceptions of Recognition for Competence or Perseverance

InQ2 Pre-Test		InQ2 Post-Test				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
2.47	0.42	2.55	0.50	1.04	.15	0.18

Note. N = 34. Degrees of Freedom for the *t*-statistic = 33. *d* represents Cohen's *d.*

The results from this analysis were pulled from survey items #3-#9 and centered on recognition and performance ability within this section of the intervention cycle. The mean score difference of 0.08 showed a slight increase in this perception of the girls between both intervention cycles. This finding, although it may not have been statistically significant, remains positive and important in that there was still an increase from pre-to-post survey between both intervention

cycles. These findings, although promising in effect with the intervention, could have shown more significant findings had the number of girls in the sample size been more sufficient in number. Differences between intervention cycle one and cycle two within this inquiry question are also of importance to note. In cycle one, the mean difference for girls who perceived their classmates as a technology and engineering person increased by 0.32. However, their perception that they can do well on tests and performances decreased by the same amount, -0.32 as the mean difference.

4.2.2.3 Inquiry question #3

How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?

The *t-test* of Dependent Means statistical technique was used to assess the statistical significance of girl study participant mean score difference in inquiry question three's pre-test to post-test condition of the study. The assumption of normality for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the conventions proposed by George and Mallery (2020), the skew value of -0.10 and kurtosis value of -0.81 for the difference score in the analysis satisfied the assumption of data normality.

The mean score difference of 0.05 in the pre-test and post-test conditions of the study for girl study participants in inquiry question three was non-statistically significant ($t_{(33)} = 0.51$; $p = .31$). The magnitude of effect for the pre-test/post-test difference score in inquiry question three of the study was considered small at $d = .09$, showing an increase in their perceived belonging.

Table 10 contains a summary of findings for the pre-test/post-test analysis for girl study participants for inquiry question three of the study.

Table 10. Perceptions of Belonging Increasing Technology & Engineering Identity

InQ3 Pre-Test		InQ3 Post-Test				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
2.03	0.59	2.08	0.55	0.51	.31	0.09

Note. N = 34. Degrees of Freedom for the *t*-statistic = 33. *d* represents Cohen's *d.*

4.2.2.4 Results beyond inquiry questions

Erlingsson and Brysiewicz (2017) state, "There is often data that, although not seeming to match the study aim precisely, is still important for illuminating the problem area" (p. 5). Although the following was not initially part of the research or inquiry questions, the following data emerged and should be noted from this additional question and compared as part of this phase two of the study where the intervention cycles occurred.

Was the mean score difference from the pre-test to post-test condition for Intervention Cycle I and Intervention Cycle II of the study for girl study participants statistically significant?

Findings by intervention cycle. The *t* test of Dependent Means statistical technique was used to assess the statistical significance of mean score difference from the pre-test to post-test condition for Intervention Cycle I and Intervention Cycle II of the study for girl study participants.

Intervention Cycle I

The *t* test of Dependent Means statistical technique was used to assess the statistical significance of girl study participant mean score difference from the pre-test to post-test condition for Intervention Cycle I of the study. The assumption of normality for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the

conventions proposed by George and Mallery (2020), the skew value of -0.49 and kurtosis value of -0.84 for the difference score in the analysis were satisfying of the assumption of data normality.

The mean score difference of -0.02 in the pre-test and post-test conditions of the study for girl study participants was non-statistically significant ($t_{(18)} = 0.37$; $p = .36$). The magnitude of effect for the pre-test/post-test difference score for Intervention Cycle I of the study was considered small at $d = .09$.

Table 11 contains a summary of finding for the pre-test/post-test analysis for girl study participants for Intervention Cycle I of the study:

Table 11. Summary of Technology & Engineering Identity Pre/Post for Cycle I

Pre-Test		Post-Test				
M	*SD*	*M*	*SD*	*t*	*P*	*d*
2.55	0.30	2.53	0.47	0.37	.36	0.09

Note. N = 19. Degrees of Freedom for the *t*-statistic = 18. *d* represents Cohen's *d.*

Follow-up analyses: Statistical significance of individual elements. The statistical significance of the study's intervention from the pre-test to post-test conditions of specific elements of technology and engineering identity was assessed using the *t* test of Dependent Means for Phase I of the study. As a result, in Intervention Cycle I three survey items representing elements of technology and engineering identity in the study reflected statistically significant intervention effects for girl study participants.

Table 12 contains a summary of finding for the evaluation of the statistical significance of intervention effect for survey items representing the study's identified elements of technology and engineering identity in Intervention Cycle I:

Table 12. Statistically Significant Effects in Specific Elements for Intervention Cycle I

Survey Item/Element	Mean Difference (Pre-Test/Post-Test)	*p*	*d*
Recognition/Classmates see me as a technology & engineering person	0.32	.04*	.42
Performance/I can do well on tests and performances in technology & engineering	-0.32	.03*	-.47
Identity/ I see myself in a future career in technology or engineering	0.42	.03*	.47

Note. $*p \leq .05$

Intervention cycle II. The *t-test* of Dependent Means statistical technique was used to assess the statistical significance of girl study participant mean score difference from the pre-test to post-test condition for Intervention Cycle II of the study. The assumption of normality for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the conventions proposed by George and Mallery (2020), the skew value of 0.03 and kurtosis value of -0.86 for the difference score in the analysis were satisfying of the assumption of data normality.

The mean score difference of 0.17 in the pre-test and post-test conditions of the study for girl study participants was marginally statistically significant ($t_{(14)} = 1.67$; $p = .059$). The magnitude of effect for the pre-test/post-test difference score for Intervention Cycle II of the study was considered approaching a medium effect at $d = .34$.

Table 13 contains a summary of finding for the pre-test/post-test analysis for girl study participants for Intervention Cycle II of the study:

Table 13. Summary of Overall Pre/Post Test Findings for Intervention Cycle II

Pre-Test		Post-Test				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
2.21	0.34	2.38	0.27	1.67	.05(9)	0.43

Note. N = 15. Degrees of Freedom for the *t*-statistic = 14. *D* represents Cohen's *d.*

Table 14 contains a summary of finding for the evaluation of the statistical significance of intervention effect for survey items representing the study's identified elements of technology and engineering identity in Intervention Cycle II:

Table 14. Statistically Significant Effects in Specific Elements for Invervention Cycle II

Survey Item/Element	Mean Difference (Pre-Test/Post-Test)	*p*	*d*
Recognition/ My teachers see me as a technology & engineering person	0.60	.001***	.95[a]
Recognition/ My friends/classmates see me as a technology & engineering person	0.33	.03*	.54[b]
Recognition/ My family sees me as a technology & engineering person	0.47	.02*	.63[b]
Belonging/ Sometimes I feel I have to prove that I belong in my technology & engineering class	0.67	.002**	.92[a]

Note. *$p < .05$**$p < .01$***$p \leq .001$ [a] Large Effect ($d \geq .80$) [b] Medium Effect ($d \geq .50$)

Intervention cycle I & intervention cycle II difference score comparison. A *t* test of Independent Means was used to assess the statistical significance of girl study participant pre-test/post-test mean score difference between the study's two intervention cycles. The assumption of homogeneity of variances was addressed through the interpretation of the Levene *F* value. As a result, the Levene *F* value was non-statistically significant (F (1, 32) = 2.38, p = .13), thereby satisfying the assumption of homogeneity of variances.

The pre-test/post-test mean score difference of 0.19 favoring the intervention's effect in Intervention Cycle II of the study was statistically significant ($t_{(32)} = 1.69$; $p = .05$). The magnitude of effect in the pre-test/post-test mean score difference favoring the intervention's effect in Intervention Cycle II of the study was considered medium at $d = .57$.

A summary of findings for the comparison of pre-test/post-test mean score difference for girl study participants between Intervention Cycle I and Intervention Cycle II of the study is presented in Table 15:

Table 15. Comparison between Pre/Post Test for Intervention Cycle I & Cycle II

	Group 1		Group 2				
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
Difference	-0.02	0.27	0.17	0.39	1.69	.05*	0.57

Note. N = 34. Degrees of Freedom for the *t*-statistic = 32. *D* represents Cohen's *d*. $p \leq .05$

4.2.2.5 Overarching research question for phase 2

Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities?

The *t* test of Dependent Means statistical technique was used to assess the statistical significance of girl study participant mean score difference from the overall (Intervention Cycles I & II) pre-test to post-test condition of the study. The assumption of normality for the difference score achieved in the analysis was assessed using the array's skew and kurtosis values. As a result, and using the conventions proposed by George and Mallery (2020), the skew value of 0.52 and kurtosis value of -0.77 for the difference score in the analysis were satisfying of the assumption of data normality.

The mean score difference of 0.18 in the pre-test and post-test conditions of the study for girl study participants in the overarching research question was marginally statistically significant ($t_{(33)} = 1.64$; $p = .055$). The magnitude of effect for the pre-test/post-test difference score for Intervention Cycle II of the study was considered approaching between medium and large $d = .63$.

Table 16 contains a summary of finding for the pre-test/post-test analysis for girl study participants for the overarching research question of the study:

Table 16. Perceptions on Classroom Environment for Overacrhing Research Question

Overarching Pre-Test		Overarching Post-Test				
M	*SD*	*M*	*SD*	*T*	*p*	*D*
2.06	0.61	2.24	0.82	1.64	.05(5)	0.63

Note. N = 34. Degrees of Freedom for the *t*-statistic = 33. *D* represents Cohen's *d.*

4.3 Summary of Results

To summarize both phases of the study, there are several similarities and differences between both findings (see Figure 6). Linking this qualitative and quantitative data helps to further explain the variety of ways a girl's technology and engineering identity can be formed. The qualitative portion of the study provided emerging themes that showcased the perspectives and attitudes of girls already choosing to take technology and engineering courses at the high school level and having formed an initial identity in technology and engineering.

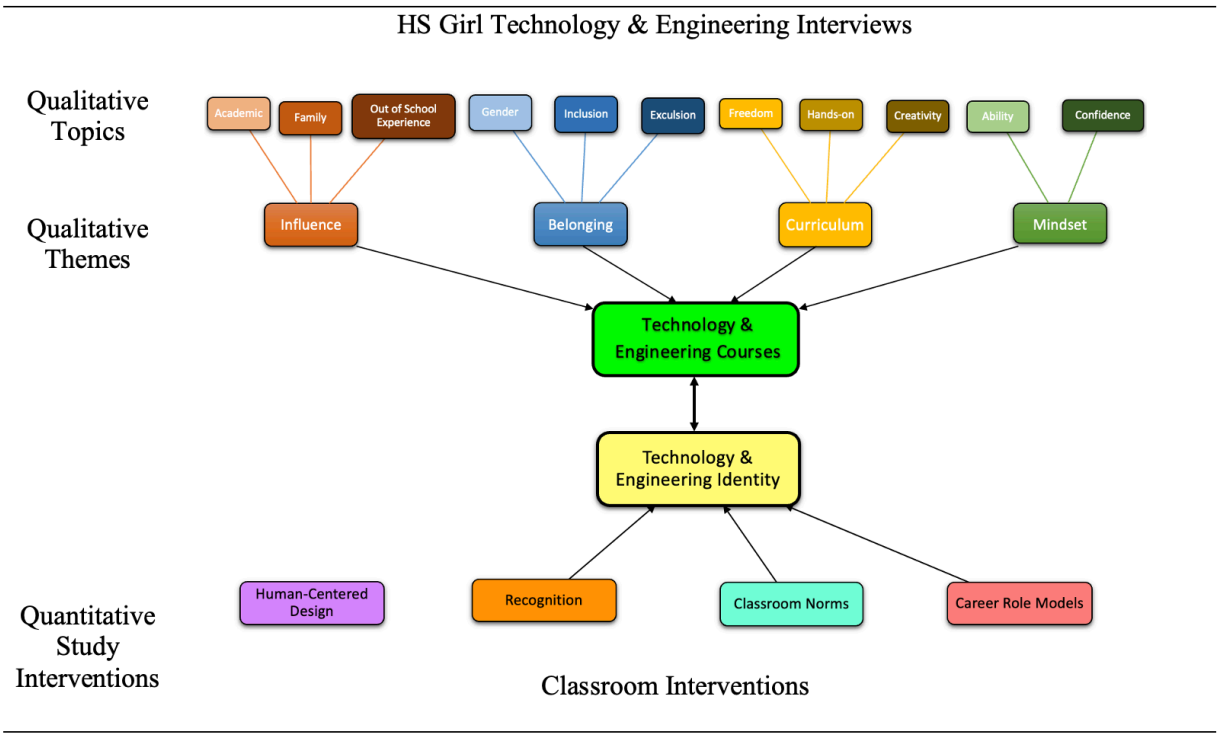


Figure 6. Forming a Technology & Engineering Identity Study Comparisons

Figure 6 can be broken down into three main sections: (a) Qualitative Topics, (b) Qualitative Themes, and (c) Quantitative Study Interventions. Beginning at the first level of Figure

6, the findings of the qualitative study demonstrated eleven topics (academic, family, out of school experience, gender, inclusion, exclusion, freedom, hands-on, creativity, ability, and confidence) that the participants similarly referenced as part of their perspective, attitude, or experience with technology and engineering education. These qualitative topics and the participant portraits helped inform further the qualitative themes found on the second level of Figure 4. These themes can lead to a formed technology and engineering identity including influences, belonging, curriculum, and mindset.

Several of the themes and subtopics found within this study directly corroborate the work of many other pieces within the literature base. The notion that influences from family build a strong technology and engineering identity in this study supports Dasgupta and Stout (2014) that parents' influence is an early indicator of academic interest, especially in STEM. In addition, Dasgupta and Stout (2014) recommended informal STEM learning experiences to promote retention and build interest in young girls for STEM content, and the findings of this study support the importance of out-of-school experiences based on many of the girls' responses. The subtopics within the curriculum theme support the findings of connected learning framework (Ito et al., 2013) and the work of Quigley et al. (2020) notion that student interests can be fueled when teachers create opportunities for "discipline integration, problem-based approaches, student choice, technology integration, and multiple solutions" (p. 1456).

These themes and subtopics were all the direct result of the attitudes, perceptions, and experiences high school girls within the study explained to be part of the reasoning for their enrollment in technology and engineering courses and what they feel about their experiences in those courses. Within the high school girl's survey responses showing a technology and engineering identity, of the high school girls that participated five of the six agreed they were a

technology and engineering person and could see themselves in a future career, indicating a strong discipline identity toward technology and engineering. The emerged subtopics as well as the themes strongly show that experiences early in a girl's life at home, in school, and out of the classroom can help build her identity toward the technology and engineering discipline. This corroborates the work of Dou et al. (2020) and their findings of the importance of informal STEM experiences and how that builds STEM identity and STEM career interests.

Paying close attention to these themes, the second phase of the study included two PDSA cycle interventions with pre-and post-course surveys. The third level of Figure 6 shows the four intervention tactics that were implemented in Cycle I and Cycle II of phase two of this research study. This quasi-experimental, within-subjects repeated measure showed results that not every hypothesized intervention increases girls' technology and engineering identity, but overall, there was a statistically significant increase between both interventions that increased girls' technology and engineering identity. Specifically, the human-centered design approach did not show any statistically significant increases toward increasing the girl's interest. What did show the most promise in building girls' technology and engineering identity came from setting classroom norms, recognizing girls individually and full group for their abilities, and showing professional women engineers as role models frequently in the classroom.

5.0 Discussion

Overall, my dissertation and accompanying research study illuminates a multitude of ways girls can potentially form technology and engineering identities. I discovered through the literature many disparities girls face in persisting to careers in technology and engineering. The literature also highlighted promising approaches to best support girls' identity formation in the classroom. Following the guidance of several conceptual frameworks already developed in other STEM disciplines (Carlone & Johnson, 2007, Hazari et al., 2010, Dou & Cian, 2020, Godwin et al. 2016), I was able to focus on the constructs of interest, recognition, performance, and belonging as the tenants in which my study would be grounded. The problem of practice I looked to change was: girls in the Southern Hills School District are choosing high school technology and engineering courses at a disproportionately lower rate to that of their boy peers. Utilizing the technology and engineering identity constructs, I first interviewed girls already taking high school technology and engineering courses to determine their perspectives, attitudes, and potential influences toward technology and engineering courses. Then applying the reviewed literature, technology and engineering identity constructs, and themes developed from the interviews, I developed interventions to use within my classroom. These two intervention cycles, grounded in improvement science, implemented change ideas focused on increasing girls' interest and persistence in technology and engineering classrooms.

After reviewing the findings and discovered themes across the entire study, it was apparent to me that there was a conceptualization of how we can form girls' technology and engineering identities emerging from my study. I developed Figure 7 to visualize the findings and implications this study provides.

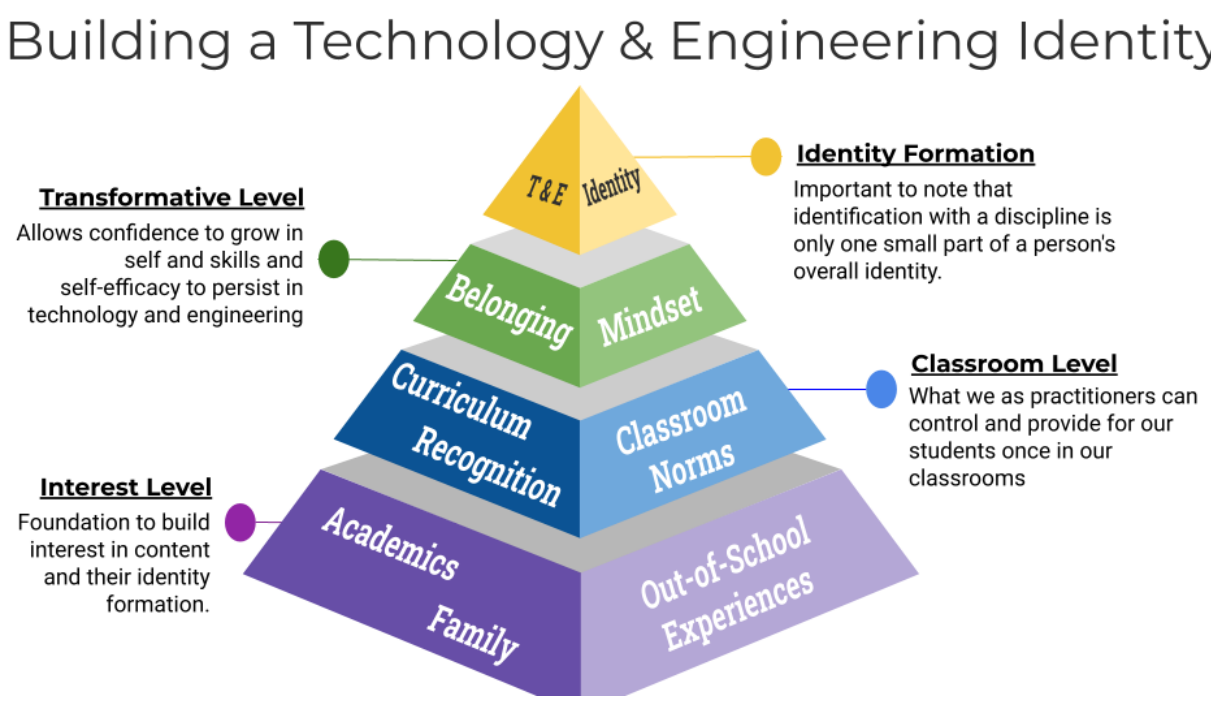


Figure 7. Building a Technology & Engineering Identity

I believe Figure 7 shows the potential implications educators and educational systems can look to in helping to form pathways toward technology and engineering identities.

For the girls in my study, most have their technology and engineering identities forming well before they enter the high school classroom. What is at the base are the influences of adolescent academic experiences, out of school learning experiences, and familial support and encouragement. This is the interest level where the beginnings toward a technology and engineering identity are formed. They are necessary for constructing the identity and show the foundational connection of building that interest throughout each level. The base foundation is what helps girls get in the door of our high school classrooms and into careers and is truly the foundation for the interest in their identity formation. It should be one that educational systems and communities look to as the gate for bridging the gap in underrepresented groups. Not all

students have equal access to foundational academic interest, support, and experiences. Therefore, it is a key conversation and beginning piece for systems to look to in order to build strength within the STEM pipeline.

The next level, the classroom level, is what we as practitioners can control and provide for our students once in our classrooms. An open-ended curriculum with project based, inquiry driven, and hands on learning experience that as value and meaningful all impacted girls within this study. A curriculum that also highlights underrepresented groups in engineering and technology careers and opens a discussion about wondering and noticing of those individuals allows students time to reflect themselves, as well as time to learn together. In addition, we can recognize and build confidence in the girls and address societal based stereotypes when we clearly highlight the strength girls have in both working through struggles and mastering skill, especially when we address this in front of their boy peers. In purposefully recognizing we must be mindful of the language we use, as some girls in this study noted, clearly defining gender in recognition can make them feel awkward. Therefore, when we recognize it should be done without pointing to or identifying gender. Finally for this level, setting classroom norms, as Darling-Hammond (Darling-Hammond et al., 2019) has discussed, are a way to make sure everyone is on the same page about how to treat one another in academic spaces and give students the productive abilities to work with the teacher on classroom management, not have it given to them.

If the first two levels can be developed, then transformation can occur within the girls at the third level. It is not strictly up to them for this transformation to occur. The educational systems and practitioners in the classrooms still play a vital role in strengthening this transformation. If we build a sense of belonging through the first two layers, girls begin to recognize and feel their belonging as a contributing and valued asset to the course themselves. If a growth and positive

mindset can be curate through the classroom experience, then girls should then have the tools to develop a sense in which they are confident and able to persist in following their passions and desires even in the midst of negative bias and stereotypes.

All of these base levels, if crafted in a way that meets the girls where they are as they enter our classrooms and empowers them to find their worth and passion in our content, should build to the point of a formed technology and engineering identity.

The following sections are dedicated to the further thorough discussion of my findings and implications for future practice.

5.1 Discussion by Study Phase and Research Question

5.1.1 Phase one

The following represents a discussion of the research questions from phase one formally stated within the study.

5.1.1.1 Research question 1

What are girls' perspectives and attitudes of technology and engineering courses?

Phase one of this study investigated the perspectives and attitudes girls held for their technology and engineering courses. The girls interviewed were already enrolled in high school technology and engineering courses. Their experiences were assessed to learn how they were persisting in technology and engineering so findings could be used to inform the later interventions of the study. The findings and themes discussed in the last section revealed rich descriptions of the

girls' perspectives and attitudes of their technology and engineering courses. These perspectives and attitudes included sensing gender notions when they felt at times included but at other times excluded. They also discussed the ability to grow in confidence and skill because of their course experience.

Most of the girls in the study had a heightened sense of awareness of gender while in their technology and engineering course. For example, Natalie discussed noticing the imbalance in gender enrollment right away at the start of the course, and Ashley said she was intimidated being the only girl enrolled in her course. This finding corresponds to the literature and work of Legewie and Diprete (2014) that high school environments play a role in students' orientation toward STEM fields. If we want to have our girls develop positive perspectives of our technology and engineering courses, we need to work on ways to reduce the stark disparities in enrollment between genders. The girls in this phase of the study signed up for courses even knowing there would be gender differences, but others purposefully swayed away from more traditionally boy-dominated courses because they didn't want to be a minority in gender. It was alarming to me how matter of a fact the girls were about not wanting to be in those courses because of their gender and saddens me that we haven't done more to stop the cycle of biased gender enrollment from occurring.

A varied perspective that was positive in the gender norms included some of the girls sharing that although they noticed their gender differences, their teachers or their classmates made them feel included. This could be found in Julia explaining her course educator as, "*always helpful and supportive and encouraging.*" Sara shared she felt inclusion and a sense of balanced teamwork when working with her classmates. This finding contradicts the work of Silverman and Pritchard (1997) that the classroom environment, influenced by the behavior of boy classmates, created a biased environment. Therefore, it should be noted that a stereotypical perception of technology

and engineering classes shouldn't be that it is always biased and unwelcoming for the girls enrolled in the course. From the perspectives of these participants, their experiences were quite the opposite.

Exclusion was negatively perceived by some of the girls enrolled in a technology and engineering course. These perceptions came from only the girls in the practical technology courses (*Wood and Manufacturing 1 and Metals 1*) which is of no surprise, as the Digital Media 1 and 2 courses were reported as gender-neutral for the participants in this study. For example, Ashley expressed feeling "*awkward*" and "*excluded*" because she was the only girl in the class. In addition, she felt as though her classmates hesitated in asking her for help even if she was finished with a well-made project, which she interpreted as them believing, *"the girl doesn't know anything."*

Perceptions and attitudes of the course content itself can be deemed as a positive perception for all the girls. Each of the six girls discussed a positive experience within their technology and engineering course that directly related to the curriculum or instruction of the course. Many noted the freedom that comes with the course material, the hands-on learning process, and the creativity that was fostered in the course. For example, Jennifer noted that choice was a part of each project and the fact she could be creative in the uniqueness of her cutting board was something that she really enjoyed. This finding was not part of the initial literature reviewed nor part of the identity formation constructs. I suggest that it may play a more significant role in the girls' persistence through courses than literature has proven and thus should be considered for future research within the field.

Finally, many of the girls shared a positive perception of the growth they experienced personally in their technology and engineering course. Most of the girls shared some type of notion that they grew in their ability, self-confidence, or skill level. Sarah shared that what she learned would help her if she had a career in technology and in any field. Sarah shared her growth in her

abilities and skills and how that allowed her to feel confident enough to teach her classmates, which she noted she enjoyed. Finally, Ashley felt her experience helped her grow in a mindset that gave her self-assuredness that she should not let others' bias or opinions stop her from doing what she enjoys. Another finding emerged that had not been reviewed within the literature and should be noted for future research within technology and engineering education literature.

5.1.1.2 Research question 2

How do girls' perspectives or attitudes toward technology and engineering influence their decisions about taking technology and engineering courses in high school?

The second research question was also addressed within phase one of the study. The question examined how girls' perspectives or attitudes influence their decisions to enroll in technology and engineering courses. The qualitative portions of phase one also revealed several perceived influences that can impact a girls' decision to take technology and engineering courses in high school. The findings from this phase found that the shared influences included family, out-of-school experiences, and academic influences.

The Murcia et al. (2020) study found that students described their parents and siblings as most influential in career thinking. The findings from my study associated well with the Murcia et al. (2020) results but in the notion of technology and engineering courses. Many of the girls expressed experiences with family as an influence toward taking an interest in and signing up for technology and engineering courses. This family influence was associated with spending time working with family to create and build. For example, Sarah mentioned building interest from working with her dad and "*helping him with little projects.*" Ashley also noted that watching her grandfather build projects and working with him as a kid gave her an interest in building and creating. Natalie mentioned the influence of her brother's recommendation for which courses she

may enjoy in the tech ed department. As well, sibling influence came from Julia's sister about course selections. The power that family influence has over encouraging and guiding girls in their choices could be seen within this finding. Additional attention should be paid to properly inform families and parents in our district so that they are aware and can communicate the opportunities girls may have or come to find in the technology and engineering department.

Several of the girls discussed influences that may have formed an interest in technology and engineering, including activities they participated in outside of the school setting. This included taking your daughter to work day, girl scouts, and art classes. Legewie and Diprete (2014) found that reducing gender segregation in extracurricular experiences plays a massive role in lessening the gender gap in STEM orientation, especially for girls. This corroborates the findings within this study as many of the girls discussed also participating in extracurricular STEM activities such as the co-ed Technology Student Association (TSA) which they spoke to as being their "favorite club ever" and "pushed them to do more." Out-of-school experiences for the girls in this study formed a positive attitude toward technology and engineering which helped build the identity formation toward the discipline and potentially influence their high school course selection.

Academic influence was also noted as a perceived influence to enroll in technology and engineering courses, but for two very different reasons. Most of the girls discussed the influence their middle school technology and engineering class had on the interest, enjoyment, and decision to take high school technology and engineering. This both argues and compliments the finding of Silverman and Pritchard (1997). Even though most girls enjoyed technology education classes and had a positive experience in middle school, that perceived positive experience wasn't enough for most of them to enroll into those courses in the high school. The girls interviewed were influenced

by their positive middle school experience to take high school courses, but the finding also reinforces the idea that these girls are a select few and not "most" as Silverman and Prichard (1997) state. The other reason academics may influence girls to take courses is the graduation requirement. This wasn't a concept that I contemplated as a potential perspective prior to the interviews and was surprised when two of the girls mentioned it. For example, Lauren mentioned the influence to take her course was to meet the practical arts requirement and also chose a course she believed "*won't take as much effort to do*" with her honors schedule. This indicates that revising graduation requirements and courses that are labeled as "practical" could be worth investigating further in the hopes they are taken for better reasons and truer to the work completed within the courses.

Overall, the girls interviewed in phase one projected a positive perception and attitude of their technology and engineering courses. They expressed that some experiences were negative, but none seemed to push the girls away from continuing and taking more classes. Interestingly, the one participant who was the only girl in her course and discussed having the most biased situations has continued to take two more courses in the department since our interview. She also had reported a strong technology and engineering identity and notions of growing in her confidence and mindset. This substantiates the work of Hill et al. (2010) and Tellhed et al. (2017), that found it is important for girls to have self-efficacy and feel social belonging for their interest in STEM to grow and allow them to continue in studies and careers. The perceptions and attitudes of these girls also revealed the power of influence begins at a young age, and those experiences can have a lasting impact of sparking the interest. However, the influence to enroll in courses may come more from out of school experiences, especially those in middle school and academic interest developed prior to high school.

5.1.2 Phase two

The following represents a discussion of phase two with discussion specific to the three inquiry questions and overarching third research question that guided this phase as previously stated within the study. Data findings were analyzed from the alignment of survey items to inquiry and research question (see Appendix I for alignment protocol).

Within phase two of my study, initial discussion is centered on my quantitative findings, especially among the descriptive statistics that were conducted of primary importance, survey completion rate, and the internal reliability of the survey instrument. First, the complete intactness of my survey completion rate demonstrates the credibility of the findings that were reported within this phase two of my study. In addition, the content items created within the technology and engineering identity survey were initially built through the judgment and work of other discipline-based identity surveys (Hazari et al.,2020, Dou & Cian, 2020, Godwin et al. 2016). After analyzing the data and using Cronbach's alpha, the data produced an excellent reliability (.90), meaning the data were validly addressing the four constructs of technology and engineering identity. This validated students' ability to track and understand the constructs of the survey. Moreover, this excellent level of internal reliability (.90) achieved for study participant responses to the survey would appear to further reinforce the credibility and trustworthiness of the data collected throughout the inquiry questions of phase two of the study.

5.1.2.1 Inquiry question 1

Do human-centered design approaches increase girls' interest in technology and engineering courses?

For inquiry question one, the survey items #1 and #2 were analyzed over the two interventions cycles. The non-statistically significant decrease in girls' pre-to-post perceptions of interest in technology and engineering was a surprising discovery, as I had hypothesized based on other literature that human-centered design challenges would increase interest. This finding that human centered design decreased the interest of my participants contradicts the work of Burks and Amos (2019) and Capobianco and Yu (2014) who found that curriculum enhanced with socio-ethics, empathy, and holistic engineering practices, all found in human-centered design, can have a positive impact on the engineering identity. The limitations within this study, as discussed later in this section, may have influenced this inquiry question results more than most other sections. The decreased finding in inquiry question one after the first intervention cycle, established the importance of re-evaluating the way in which the human-centered design challenge was structured and presented to students in intervention cycle two. This led to the updating and reconfiguring of the human-centered design prompt and adding examples of similar creative solutions. Even with the addition of changes, human-centered design still proved to not be a major contributor for improving girls' interest in technology and engineering within this study's findings. As noted in Figure 7, this finding, when compared to the findings from phase one, what seems to be more important is curricular freedom and open-ended project-based projects.

5.1.2.2 Inquiry question 2

How does being recognized for competence or perseverance improve girls' technology and engineering identity?

In determining if girls felt they were recognized throughout the course and if that recognition increased was analyzed based on findings from survey items #3-#9. The mean score difference in girls' perception of being recognized increased between both intervention cycles.

This overall positive finding of an increase from pre-to-post survey between both intervention cycles shows that recognition can increase girls' It is also important to note the differences between intervention cycle one increases and cycle two. In cycle one, the mean difference for girls who perceived their classmates saw them as a technology and engineering person increased but the recognition of family and the teacher did not see a high increase in cycle one. After the evaluation of intervention cycle one data, additional revisions to intervention cycle two occurred to include smaller pairings for the students in teams of two, adjustments to the presentation style of the product, and additional instances of recognition occurred. These smaller tests of change within the intervention cycle two proved to reflect statistically significant effects for girls within this inquiry question of the study. The three survey items that focused directly on recognition of girls were found to have a mean difference increase from pre-to-post survey as follows: recognition by teachers (0.60), classmates (0.33), and family (.047). The largest increase and effect size coming from the recognition of the teacher. This substantiates the reflections found in the teacher reflection journal that indicate intervention cycle two included more full group recognition and noticing of other students going to girls for help. This finding also corroborates the research by Hughes, Schellinger, and Roberts (2021) that recognition in various forms can improve girls' identity in a discipline (coding identity for their study). The findings from this inquiry question show a novel finding from the professional technology and engineering literature base. When girls are recognized by their educators for their work as experts in a topic or persevering when struggling, both publicly in front of the class or individually, their technology and engineering identity improves.

5.1.2.3 Inquiry question 3

How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?

The final inquiry question findings were analyzed with data from survey items #10-#12. These three survey items addressed the identity construct of belonging. The data showed an increase from pre-to-post survey showing girls sense of belonging improved over the course and because of the interventions. Specifically for the construct of belonging, revisions to the intervention for cycles included purposeful welcoming and departure greetings at the classroom door every day, presenting classroom norms at the beginning of the class, and incorporating more women in the engineering career connections curriculum. The largest statistically significant finding can be seen in the construct of belonging in intervention cycle two. The survey item (Sometimes I feel that I have to prove I belong in my technology and engineering course.) asked girls their perspectives if they sometimes felt they have to prove they belonged in the technology and engineering class had a mean difference of 0.67 from the pre-to-post survey, making it statistically significant and having a large effect. This significant finding carries a similar nuance to what occurred in inquiry question two. The statistical finding substantiates my educator's reflective journal entries that highlight noticing of girls making connections and going out of their way to talk with and recognize me in locations outside the classroom. These findings are confirmed in the literature as promising approaches to improve a sense of belonging as stated by Silverman and Pritchard (1997) and Ladson-Billings (2014). These relationships and perceptions developed by the girls over the intervention cycles show that, when girls experience opportunities to develop a deeper sense of belonging to the technology and engineering classroom, an increase in their identity can occur.

5.1.2.4 Overarching research question 3

Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities?

The findings of the overarching research question could be traced through the entire data set and the final two survey items, which asked girls their potential interest in a future career and if they believed they were a technology and engineering person. First, there was a statistically significant increase from intervention cycle one to intervention cycle two mean score difference of 0.19 in girls' overall technology and engineering identity. Additionally, the two survey items (#13, #14) specific to girls' identity formation resulted in a marginally statistically significant finding of 0.18 increase overall for girls' identity formation. Central to the entire phase of this study was the notion that the PDSA intervention process would provide me, as the practitioner, with the tools to potentially enact change within the classroom from one intervention cycle to the next. Overall, the findings within phase two were incredibly important, as they validated the hypothesis that conducting this intervention over multiple cycles could add a layer of strength to the intervention process. If interventions had not been conducted and data analyze between to inform the next cycle, the impact on students' experience would not have been as positive. Comparing the value of how PDSA cycles and iterations are meant to be impactful, it was statistically clear and supported that the second cycle and interventions improved my practice and students experience. The second intervention cycle alone was statistically significant and had a significant increase over intervention cycle one for developing girls' technology and engineering identities. This can be seen as influence on the girls learning as a positive implication for moving them toward a technology and engineering identity. The findings also indicated that conducting the study in two intervention cycles, through which I could learn and adjust between each,

produced more robust findings. This finding confirms the work of Bryk et al. (2015), Perry et al. (2020), and Hinnant-Crawford (2020) that improvement science in education is robust, especially for the educational practitioner, as they cannot only improve their instructional practice but also build their knowledge. This was evident for me as the practioner and the gains for my students expereince as shown in the increases between findings in the students data.

To summarize, findings from across this dissertation suggest promising approaches to promote girls' technology and engineering identity. There is potential when more effective and prevalent experiences within technology and engineering classrooms surround girls with recognition, open-ended curriculum, transformative norms, and career role models. Educator-crafted and guided experiences should allow girls to see themselves as valued members of the course who contribute to the technology and engineering classroom for who they are as young girls and the experiences they bring. Each perception, experience, and opportunities are varied based on several factors including influence, belonging, curriculum, and mindset. Employing a consistent and appropriate instructional and practitioner approach to the technology and engineering classroom could lessen some of these differences to allow for a supportive and transformative classroom environment that would benefit our students.

5.2 Limitations

The first limitation to this study was the COVID-era obstacles and restrictions that were part of the educational setting. Unfortunately, my study was limited to zoom interviews for the six participants in phase one of the study, which I believe inhibited me from getting a complete experience as a researcher to connect with my interviewees. This also prohibited me from

conducting focus group interviews, which I had initially planned to do, but none of the girls could participate at times offered, thus leading to individual interviews. The same limitations occurred due to COVID within phase two of the study with 19 students between both intervention cycles out of the classroom due to quarantines or choosing temporary virtual learning. Another limitation was that the timing of the survey administration was over the school holidays of Thanksgiving and Winter Holiday. I believe some of the instructional practices that were part of the intervention were not as successful during these segmented portions of time. Also, absences were higher due to extended holiday breaks families chose. Finally, within phase 2, the study sample of 34 girls, although adequate for a medium effect in the intervention cycles to detect a significant finding, was however not adequate in some of the analysis, particularly in inquiry questions two and three. Had the sample size been more robust, I feel the results would have shown more statistical impact.

5.3 Implications for Technology & Engineering Educator Practice

Based on the results from this study, the discussion of constructing a technology and engineering identity in Figure 7, and particularly the PDSA intervention cycles of phase two, I believe the perceptions and attitudes of girls can be improved to increase their technology and engineering identities. Implications for practice based on phase one findings for the girls interviewed showed how out-of-school experiences, the classroom environment, the structure of the course curriculum, and the experiences in middle school technology and engineering education courses should all be considered by educators. As shown in Figure 4 and discussed previously, there are many avenues to increasing technology and engineering identity. Specifically, because of this study, our schools should find more extracurricular opportunities related to technology and

engineering for girls to find interest and exposure to STEM content similar to the experiences the girls in phase one shared. There is value in considering the connected learning framework (Ito et al., 2013) or the conceptual model for STEAM education (Quigley et al., 2017) as resources to guide the teaching practices within our technology and engineering departments. The investigation from this study supports both premises of the CL framework and STEAM conceptual model and should be considered further in the technology and engineering profession. Our high school technology and engineering classroom environments need to address the unique identities of the girls who enroll in these courses. This means not only encouraging and supporting them, but also recognizing their unique strengths and highlighting those for the entire class. We also need to be mindful of addressing them or comparing them to their classmates who are boys. Several of the girls in the study had the perception that although their educators meant well, saying things like, "This is why I love having girls" or "Don't compare yourself to the girl" makes them feel worse and pulls out the notion that they are different from their classmates. The ways in which we present course curriculum is necessary to promote positive perceptions of our courses for young girls. The girls interviewed who shared their course experiences, repeatedly mentioned the positive impact of having freedom in their learning. This openness and choice allowed them to not only build confidence in themselves but appreciation for the process and connections to creativity. The more that classrooms use open-ended creative processes, the more positive experiences our students will have. Finally, experiences in the middle school courses were discussed as inspiring many girls to take high school courses. From this perspective, it is also important to know that middle school girls are still open and impressionable in their thinking, and one should not take that adolescent learning phase lightly. The findings of phase two of the study validated the use of the two-cycle PDSA intervention process that was implemented to build girls' technology and engineering

identities. The interventions conducted most notably impacted the girls' perceptions of their recognition, belonging, future career in technology or engineering, and overall identity within the technology and engineering discipline. The nature of the intervention in the second cycle after it was modified could represent a template for future interventions or even professional development within the technology and engineering profession.

5.4 Recommendations for Future Research

Future research may include focusing on how influences within middle school technology and engineering classrooms can positively or negatively impact high school enrollment. Also, specific to phase one of this study, a larger sample and a more comprehensive array of technology and engineering courses could provide more attitudes and perceptions not noted in this study. Another recommendation specific to phase two of the study is to replicate the study in non-COVID times when demands and interruptions to the regular teaching cycle would not add a layer of stress to the study. It is also recommended that phase two of the study be replicated, but it is necessary to adjust survey administration times. I recommend conducting the study ad when it is more conducive to the participants' schedules. The study should be replicated starting with the design of intervention cycle 2 with a more sufficiently powered sample of participants. These recommendations for future research should be conducted within the technology and engineering classroom where applicable. The literature reviewed and study revealed a lack of scholarly work for the educational impacts that occur in the classroom, yet many studies within mathematics and science education. When we study STEM education and practices that can impact our youth, we should not exclude the "T&E" of this acronym. I strongly feel that the research base is missing

important information by not focusing more on the technology and engineering component in STEM and STEAM classrooms.

5.5 Conclusion

In revisiting my stated problem of practice, that girls in the Southern Hills School District are choosing not to take high school technology and engineering courses at a disproportionate rate to that of their boy peers, I was struck by the word "girls." I decided to do a frequency count within this document and found that the word "girls" had been used 464 times in this document. As Hinnant-Crawford (2020) states,

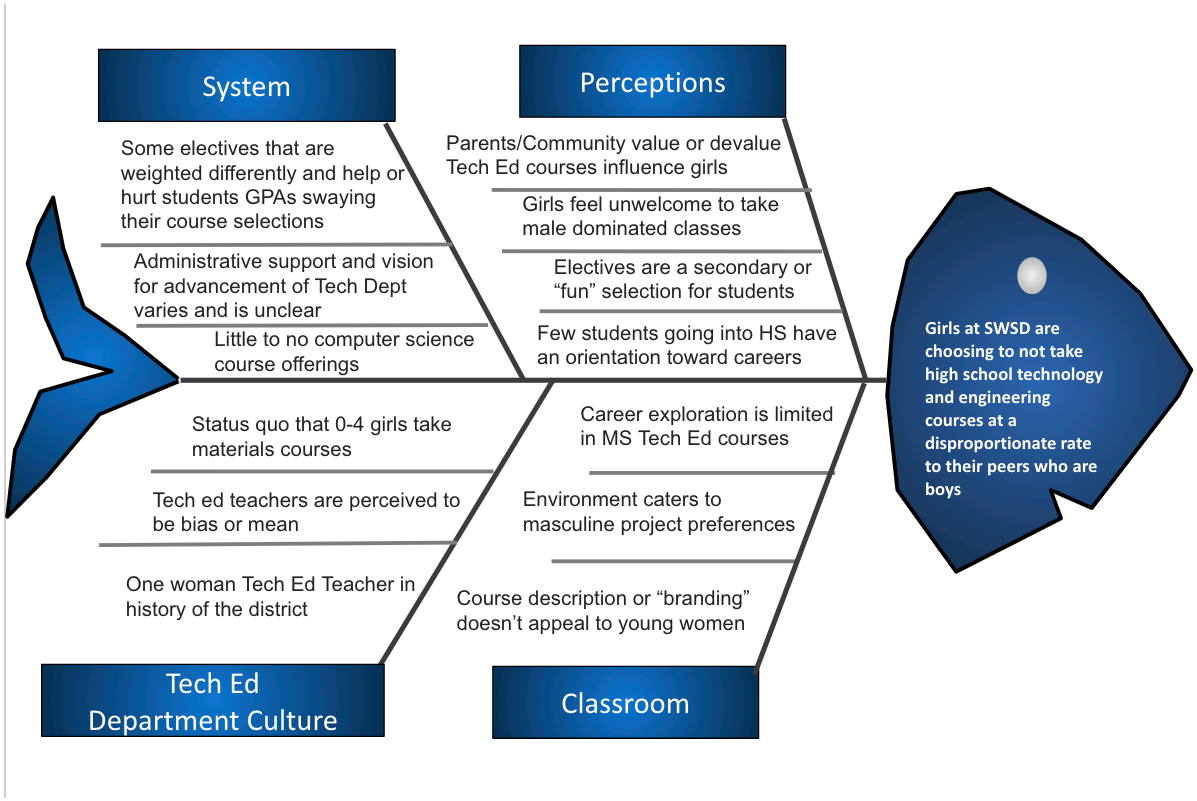
> In order to improve with equity in mind, you have to think about ***who is involved*** in the improvement (whose voices have been considered in the definition of the problem and the design of the solution) and ***who is impacted*** by the improvement. (p. 205)

The *who* for my entire study has been focused on the girls in my school district and determining how I could use what I learned to give them slipper-building opportunities, foster mindsets of persistence in technology and engineering, and be a change agent for all girls. However, what I have found is that not only have my girls been impacted, but I have been impacted. As a practitioner, I have been humbled and energized to see how small tests of change can have positive implications when thoroughly planned and enacted. I am motivated to continue tests of change and share these findings with my department and district so they can see the power these findings may have for our students. I am inspired to conduct more research to add to the professional knowledge base for other technology and engineering educators. This experience has given me the insight to recognize and purposefully craft each interaction, experience, and

opportunity I present to the girls in my classroom. So, in turn, they can build their glass slipper, stiletto, moccasin, or boot, as unique to them as to the technology and engineering world they will persist in.

Appendix A – Fishbone Diagram

The fishbone diagram was created and used to operationalize the theories the researcher investigated as to how and what were the drivers or influences of the problem of practice and how they could be addressed throughout the improvement science journey.



Appendix B Semi-Structured Interview

Individual Interview Protocol Script

Building Their Glass Slipper: Existing Challenges and Promising Approaches for Girls in Technology and Engineering

Interview Preamble:

I would like to thank you for taking the time to meet with me today. I have your written assent and your parents' consent on file at this time, therefore we can proceed with today's interview. My name is Jana Bonds and I would like to talk to you about your experiences as a student at Southern Hills School District. Specifically, your experience in Technology, Engineering and Physics courses. The total time for this interview should take less than 45 minutes. I will be taking notes during this interview, but to help ensure I do not miss any important information, I will also be recording our conversation. To help keep your identity further protected please remember to keep your video screen off today. Your responses will be kept confidential and will only be used in the research and analysis of my study. Your identity will not be shared for any reason. Remember, you don't have to talk about anything you don't want to and you may end the interview at any time.

Are there any questions about what I have just explained?

Are you still willing to participate in this interview?

Interview Questions

1.	Because technology and engineering courses are electives, I am curious about the reasons you did or did not participate in these courses. What are some of the reasons you decided to take (not take) technology and engineering (tech ed) courses at the high school? If you took these courses, which ones did you take?
2.	Are you interested in technology and engineering subjects? If yes, what are your favorite things to learn about? In addition, what do you believe sparked your interest? If no…why not?
3.	Have you ever participated in activities outside of school that you believe have influenced your course selections of Tech Ed or Physics? If not activities, do you think there are certain people who have influenced your choice of certain courses? If yes, who?
4.	Describe a positive school experience you've had in a Tech Ed or Physics course.
5.	Describe a negative school experience you've had in a Tech Ed or CS course.
6.	Tell me about a topic or project you've completed in your Tech Ed or Physics course you've enjoyed the most and why you think you've enjoyed it.
7.	Do you ever think about your gender in Tech Ed or Physics class? If so, could you explain or given an example? If not, why do you think that is? Can you give me a specific example of what you mean when you say….?
8.	Do you ever feel that your teachers or fellow students react to you in a specific way or treat you differently because of your gender?

9.	Why do you think there are so few girls taking Tech Ed courses at Southern Hills HS?
10.	What recommendations do you have for increasing the number of girls in Tech Ed courses at the HS?

Interview Closing: Is there anything else you think I should know in regard to our conversation or other experiences you would like to share? I'll be analyzing you interview and others over the next few months to help generate next steps toward my problem of practice.
If you have any concerns or decide you no longer wish to be part of this study, please email me or if you would like to speak with my advisor or the University of Pittsburgh Human Research department all contact information can be found on the student assent and parental consent paperwork you completed. If you are interested, I can share my findings with you once complete. Thank you for your time and perspective

Appendix C Survey Instruments

The following is the protocol and survey questions used for phase one and phase two of the research study. The most notable areas of difference are in the demographic questions and preamble read verbally.

Appendix C.1 Phase 1 Survey Instrument

High School Girls Pre-Interview Survey

Building Their Glass Slipper: Existing Challenges and Promising Approaches for Girls in Technology and Engineering

Information:

All assenting students whom parental consent has been obtained will be given a survey to complete prior to beginning the participant interview. Demographics will be collected to give insights into course selection comparisons, age range, and course experience.

Protocol Read Verbally

Good morning/Afternoon. I'm interested in learning about what you think of technology and engineering. As many of you know I am in the EdD program at the University of Pittsburgh and for my dissertation in practice and I am interested in learning about your experience, attitudes, and beliefs toward technology and engineering classes. The survey will take roughly 15 minutes to complete and be used in conjunction with the interviews I am conducting with you. Taking or not taking this survey will not affect your course grades in any way. If you do not want to take the survey you do not have to or if there is a question in the survey you do not want to answer you may skip it. If you have any questions please ask.

Are you still willing to participate in this survey?
If so, please say yes.
If not, please say no.

Survey Guide

Directions	Your input as students is valuable in shaping the future of technology and engineering education. THANK YOU for reflecting on your experience. Please read each statement carefully and answer as honestly as possible.

Questions	Questions are short answer or drop down for the demographics portion. The rest are a Likert-scale with (1) Strongly Disagree and (4) Strongly Agree.
Demographics	
1	Your First Name and Last Name. Short answer
2	Your grade level (9-12). Select from drop down
3	Please select the current tech ed course you are enrolled in from the drop down.
4	Please select how many tech ed courses you have taken to date during high school from the drop down.
Likert-Scale	
Interest 1	I enjoy learning about technology and engineering.
Interest 2	I am interested in learning more about technology and engineering.
Recognition 1	My teachers see me as a technology and engineering person
Recognition 2	My friends/classmates see me as a technology and engineering person
Recognition 3	My family sees me as a technology and engineering person
Perform/Comp 1	I understand concepts I have studies in technology and engineering
Perform/Comp 2	Others ask me for help in technology and engineering
Perform/Comp 3	I am confident about my work in my technology and engineering course
Perform/Comp 4	I can do well on tests and performances tasks in technology and engineering
Belonging 1	I feel different than other students in my technology and engineering course. (reverse coded)
Belonging 2	There are times in my technology and engineering course I feel alone or isolated. (reverse coded)
Belonging 3	Sometimes I feel that I have to prove I belong in my technology and engineering course. (reverse coded)
Identity 1	I see myself in a future career in technology or engineering
Identity 2	I am a technology and engineering person

Appendix C.2 Phase 2 Survey Instrument

Middle School Pre/Post Course Survey
Building Their Glass Slipper: Existing Challenges and Promising Approaches for Girls in Technology and Engineering

Information:
All assenting students will be given a pre and post course surveys.

Protocol Read Verbally and Displayed in Qualtrics
Good morning/Afternoon. I'm interested in learning about what you think of your technology and engineering experience. As many of you know I am in the EdD program at the University of Pittsburgh and for my dissertation in practice I am interested in learning about your experience, attitudes, and beliefs toward technology and engineering class. The survey will take roughly 10 minutes to complete. Taking or not taking this survey will not affect your course grades in any way. If you do not want to take the survey you do not have to or if there is a question in the survey you do not want to answer you may skip it. If you have any questions, please ask.

Are you still willing to participate in this survey? If so, please say yes. If not, please say no

Directions	Your input as students is valuable in shaping the future of technology and engineering education. THANK YOU for reflecting on your experience. Please read each statement carefully and answer as honestly as possible.
Questions	Questions are short answer or drop down for the demographics portion. The rest are a Likert-scale with (1) Strongly Disagree and (4) Strongly Agree.
Demographics	
1	Your First Initial
2	Your Last Initial
3	Your Homeroom Number
4	Your Gender (boy, girl, prefer not to answer)
Likert-Scale	
Interest 1	I enjoy learning about technology and engineering.
Interest 2	I am interested in learning more about technology and engineering.
Recognition 1	My teachers see me as a technology and engineering person
Recognition 2	My friends/classmates see me as a technology and engineering person
Recognition 3	My family sees me as a technology and engineering person
Perform/Comp 1	I understand concepts I have studies in technology and engineering
Perform/Comp 2	Others ask me for help in technology and engineering
Perform/Comp 3	I am confident about my work in my technology and engineering course
Perform/Comp 4	I can do well on tests and performances tasks in technology and engineering
Belonging 1	I feel different than other students in my technology and engineering course. (reverse coded)

Belonging 2	There are times in my technology and engineering course I feel alone or isolated. (reverse coded)
Belonging 3	Sometimes I feel that I have to prove I belong in my technology and engineering course. (reverse coded)
Identity 1	I see myself in a future career in technology or engineering
Identity 2	I am a technology and engineering person

Appendix D Data and Codes Summary Table

Frequency Counts	Categories / Themes	Quotes	Primary Codes
	Influence		
7 Mentions 5 Girls	People Influence	• "my grandfather on my mom's side actually I'm pretty sure he does like wood working for a job, and he has like a woodworking shop above their garage and I know that I would definitely go up there, sometimes I go up there more frequently now. But I would go up there, and I would like see the stuff that he do, and I think that that probably kind of started something." (A pg.2) • "I've grown up like with my dad like helping him with like little projects and stuff and it's always just interested in me it's never been something I'm like a oh no like I don't want to do that." (S. pg1) • "and like I said, like little projects on the side with like my dad and my family" (S. pg 2) • "it just like seemed kind of cool because a lot of people in my family like are all wanting to get into like photography" (L. pg 1) • "my brother took it so he told me that it was like a good course to take" (N pg 1) • "my dad and I would like, I remember us building like birdhouses for our backyard and we built like a garden out of wood and like just like small things like that really just got me started and like creating stuff." (N. pg 2) • "My dad is an engineer. So I every year, I think it started when I was eight , there's take your kid to work day and they always have fun little like activities there and now because they're engineers, like a ton of nerdy people and around these fun little activities. So I feel like he was. My dad's also very much of like a problem solver" (Ju pg 2)	Grandfather See stuff that started something Helping Dad Little projects Projects on side with Dad Family Brother told me Building things with Dad Dad took me to work
6 Mentions 5 Girls	Academic Influence	• "if I'm gonna take like electives I want them to be like the ones that are like easier or won't take as much like effort to do." (L. pg 1) • having those classes in middle school, just like came to me like Okay, I think I can do this I genuinely enjoy this and it's something that I want to do so yeah I would say that's what sparked my interest" (S. pg2) • I find like science really interesting and then math on top of it, I just feel like that's where I like really excel the most so when it's like combined it's like when i'm good at plus (L.1) • "throughout like middle school and having those two classes as well (tech ed classes), was kind of an impact on like how I enjoyed the topic itself and, like pursuing" (S. pg1) • "I'm like really interested in a lot of subjects that they have like involved. But when I was over, in the middle school, I really enjoyed like the class that they had the wood shop, I really like that one but I didn't get a chance to take this year" (L pg1) • "I know that in middle school when we would have our tech classes, I really enjoyed them like that was the one class that I was always like look forward to going to." (A pg1)	Easier electives Middle School interest Science and Math combined Middle School Class Middle School woods class Looked forward to Middle school tech ed Passionate about photography

		• "Um it was definitely one of my favorite in middle school. Like technology classes and we had a lot of options there's obviously like woods, metals and all the rest" (Jn pg 1) • I just found that photography was something that I was really interested in and passionate about and I wanted to learn more about it and like extend my knowledge so that's why I ended up taking digital media (Ju, pg1)	
6 Mentions 5 Girls	Out of School Influence	• "in TSA it was nice to have like our advisors who had the passion as well, for those sort of things and then being around that group of students who also had the same passion, even if it wasn't in like the same kind of direct area everyone was kind of working towards the same goal and in the same way and having the same drive for it, so I think being around all of that, and being able to be creative and get feedback from people who I knew what they were talking about and doing was really helpful and that really just pushed me to want to do more with it" (S. pg2) • "Having all these different opportunities and then again with my Dad and then joining TSA was definitely a big factor(S. pg2) • "I'm in TSA, the technology student association and that's like my favorite club ever because you get to like figure out what you're really interested in and then competing in that." (L. pg 2) • "I'm just like always done art, even as a little kid like I just loved creating things and then I did like art classes. I just take pictures everywhere, I go like with my camera, like I just bring it everywhere, with me and take pictures. " (N. pg 2) • "I do know like when we had like little STEM days at school and things like I always found those so fun and like little activities, you have to do" (Ju pg 1) • "Um I used to girl scouts and we went to a STEM like convention, and there was a lot of stuff there that was like obviously it's like STEM" (Jn pg 2)	TSA advisors passion Other students like me Same Drive, push me Classes in middle school TSA figured out interest Loves art lets her create STEM days Girl Scouts
	Curriculum		
8 Mentions 6 Girls	Freedom	• "Oh, you have a lot more freedom, you have a lot more of this and it's like okay, I think I'm going to take this opportunity and kind of see what I got" (S pg1) • "And um but the wood is definitely my favorite and I would say that because um I do have the creative freedom, I feel, and that comes a little easier to me not that the others do not but I enjoy like being able to put the different pieces of wood together having the different like colors and shapes and like never really like having the same outcome as you plan, but still on the same basis and still providing the freedom of what you want to make and allowing it to come to life. (S. pg 2) • "it came with positive experiences, because I didn't have a set of plans and do exactly what they said. I had a little bit of freedom or something did happen that I didn't intend to happen, but it did have a positive outcome." (S. pg2) • [this project] "was really cool because you'd like to do everything by yourself, like you're responsible for finding all the noises and if it didn't work out, it was like you could fix it" (L pg2) • "I'm a hands-on learner. I just like being up and doing thing I don't really learn well when like someone is just talking at me and like showing me something on the board, so when I can actually like put that into practice and do it myself, I really feel like I get a deeper understanding" (N. pg 2)	Freedom Freedom of what you want to make No set plans Freedom Independent work and ownership Hands on learner Do it myself Likes on your own Options

		• "is very like do it on your own, which sounds kind of bad, but it like… he gives us a lot of leeway which is also really nice and you can do whatever" (Ju pg 2) • "We had options to make a lamp I think there was like three options" (Jn pg 1) • "we actually just got a lot of like free like free will, with like I don't know that he basically gave us instructions, but we can do anything we wanted, with it, like he was like build a cutting board, but then gave us like, let us do whatever we wanted with it so that was definitely my favorite" (Jn pg 3)	Free will Do whatever we wanted
5 Mentions 3 Girls	Hands on Process	• "It's always been an enjoyable class and I like that it's hands on." (Jn pg 2) • I just think it's cool that like if I did see this as something in my future that like I could be someone to help make one of those someday so." (A pg1) • "I like learning about how to put things together" (A pg1) • "I got to watch and embrace it so like there were different things [steps] that were put into it, that I kind of took an interest" (A pg 3) • creative freedom, I feel, and that comes a little easier to me not that the others do not but I enjoy like being able to put the different pieces of wood together having the different like colors and shapes and like never really like having the same outcome as you plan, but still on the same basis and still providing the freedom of what you want to make and allowing it to come to life. (S. pg 2) • once I got the hang of it, like all these other people started getting on the lathe and then they asked me for help. And then, like I would teach them. And then like they would teach other people. So, I just thought it was cool to see like not just Mr. Asher, but also like students teaching each other throughout like that process." (N pg 2)	Hands on Want to help built things Put things together Like the process/steps Different outcomes are okay Hands on learning and teaching process
3 Mentions 3 Girls	Creative Side	• "like everyone's unique and if you just build it off of like what like what one person likes or like what he likes, not everyone in the class is gonna like that, so I liked that everyone got to make their own like unique cutting board that they specifically like" (Jn pg 3) • In shop and I've done, like all I've done all four years of drawing and painting, and I just think it's really cool to see that from like a practical side, instead of like an art and, like, I can still be creative, but I think it's cool to see like a practical side instead like an art side." (N pg 1) • I really liked like getting to go out and like I don't know like when you're like taking pictures of things it just like it becomes so much more interesting and especially when you get like. People from the class to like get involved with it, it just makes it so much more fun because, like it's like adding a social aspect to it." (L. pg2) •	Unique to make own Connection between art and practical application Interesting and fun when social Different outcomes are okay
	Mindset		
6 Mentions		• "I put it on the lathe and I started doing my thing, and I was like okay like this is new, I guess I'll figure it out along the way, and I did, and it actually turned out really good and a lot of people in the classroom happy with my outcome it actually influenced someone else to create their own blank and stuff and that made me feel really good" (S pg3) • "I mean it gets a little scary sometimes because you're around a lot of like big machines and a lot of working things and when things don't go right it's like oh gosh. But I never let that kind of turn me away from	I did my thing I figured it out It influenced others and made me feel good

2 Girls	Confidence in Ability	because I know that if I'm confident and using it then I know that I'll be okay." (S pg3) • "I know that I like what i'm doing and I feel confident when i'm doing I don't really let it bother me {gender} especially when i'm around people I genuinely enjoy like" (S pg.3) • "they were just always like asking you, if we needed help or like trying to do stuff for us…I was like I got it." (N pg 3)	If I'm confident I'll be okay I'm confident I've got it
8 Mentions 5 Girls	Self Growth	• "I kind of just like took the chance, so that I could teach all of them how to do it too." (L pg1) • "I'm like obviously the whole intimidated thing, and not just by the fact that I was the only girl, but also with the fact of I didn't really ever make like a whole entire toolbox of just metal and I didn't really do all the things before like we were doing. So before like I actually got into it, I was like oh shoot like find myself or like what if I don't like it. Like what if it just doesn't turn out. So that was definitely there, and obviously over the time that obviously went away" (A pg 2) • "But then, every time I just kind of thought about the fact that, like "Ashley you know you really enjoy this class don't let a few people's opinions like try and stop you." I just try and put like everyone's opinions kind of aside and do my own thing and at first it was really hard, because I was like, like there was always a voice in the back of my head saying like "they're probably sitting there just watching me right now, as the girl" um but every time I kind of just was like whatever, it kind of just didn't bother me anymore." (A pg 2) • "Like that's the biggest thing like you need to just not let other people's opinions stop you from doing things you like, and like don't get me wrong if you don't like doing things with like technology and engineering then you don't. But like if you do, don't let something as small as someone else's opinion stop you because that's something I think so cool if someone has an opinion of you not being able to do at them like you can prove them so wrong like. We have nothing to lose going against someone else's opinion. And I just wish that girls will know that" (A pg 4) • "I wanted to learn more about it and like extend my knowledge" (Ju pg1) • "I've learned so much more about video and audio than I ever thought I was going to. " (Ju pg 2) • "I made it and I don't use it like for anything just sits in my room but it's nice to look at and I'm proud of myself for doing it" (Jn. Pg1) • "although I don't know if I would like a career in that kind of way I feel like it's helping build like leadership. And like creative thinking and all those kinds of skills that maybe if it's not just the engineering field, it will still benefit me in my future" (S.pg1) •	I took a chance Started intimidated, but over time went away Remembered she enjoyed it Don't let other people's opinions bother you Self-assured Don't let other's opinions stop you Have mothering to lose. Want others to know that too Extend knowledge Learned more than expected Doesn't use but proud of self Sees benefit for future
Belonging			
9 Mentions		• "Like there was a noticeably large amount of boys in our class and they're only like four girls, so that was something that like I picked up on when I first went into the class." (N. pg3) • "I think it was wood had like one girl in it, so I was like I don't want to be the only girl, so I want to stick with one that's like more common to" (L. pg3)	Lots of boys, 4 girls, easily picked up on Don't want to be only girl

5 Girls	Gender Notions	• "I feel like it would be hard for a girl. Who didn't have anybody in the class or didn't get along with other people in the class and because I know it would have been hard for me if I didn't have those kinds of people and it kind of was it first when we were like split half and half, and I only have like 10 other people in the classroom with me, I think I do better with a lot more people." (S. p3) • "so I was like I don't want to be the only girl, so I want to stick with one that's like more common to." (L. pg3) • "I'll be honest with you, I started that classes, a little bit intimidated, just because I was the only girl there." (A pg 2) • "one thing that he would constantly say is like the thing I said, where he would be telling the boys like "don't compare yourself to the girl" or something like that. That was just the thing that was kind of awkward. Having to be that like center of attention away because of my gender in that. And like because of the fact that I did think that they probably would compare. They just because, obviously, like a guy like that, generally that's more like masculinity and stuff so like when it comes to stuff like that they picture, like a guy. But I know and Mr Dillion would definitely say stuff like don't compare yourself to me. Like it was kind of awkward because it was like yeah don't compare yourself to me the girl. Awkward" (A pg 3) • "the one thing that scared me like I was like what, what if I don't have any friends in this class" (A pg 3) • "I think they can sometimes feel intimidating and like I don't know personally the thought of like being in a room with a ton of males it's, just like eww yikes. And I think like that just like I don't know personally if I was in class and I needed help, I think I'd feel more comfortable like asking one of my friends or just like asking a girl in general, which is like maybe just a me thing. But um so I think it's just intimidating." (Ju pg 3) • "Sometimes the teacher would say "this is why I love having girls in the class" or "This is why I love having_____" if there were a question answered or people responding differently. Obviously, that's a negative or a positive thing, but it was kind of bringing out the idea of like "okay, this is a female not a male kind of thing." I don't really have an opinion on it that makes me feel good or bad because I'm just there to enjoy the class, but I don't know how that makes the males feel in the class". (S. pg2)	Hard for girl to be alone Don't want to be only girl Intimidated as only girl Compared for gender Awkward to be singled out Wants friends in class Intimidated Too many males Comfort with girls/friends Intimidating Singling out girls even for positive things shows the gender difference
6 Mentions 3 Girls	Inclusions	• "I was on good terms with them and, like they would help me and then in the end I can help them like in a creative kind of way like we balanced each other" (S. pg 4) • "I had to ask this girl, like every day like what I was supposed to be doing" (N pg 2) • "I feel, like some of the time, the guys would be like "Oh, do you need help with this? Do you need help with that?", like maybe they were just being nice, but they were always just like offering to help, and I was like "no it's okay I got it". Like I don't know, maybe they probably just thought that, like we didn't know what we're doing some of the time" (N. pg3) • "I don't know if any of the other girls in my class felt that way because everyone genuinely enjoyed each other and had someone with them" (S p.2) • "It was always kind of scary to ask questions, but whenever I did, Mr. Bell was always helpful and supportive and encouraging" (Ju. pg.3)	Work together and help each other Worked well with other girl Guys offered to help Being nice Everyone enjoyed each other Helpful and supportive

		• "I just I think it's just like I think they're just excited to see more girls like getting into it so sometimes they like get excited about that, and like show that to you" (N pg 4)	Teachers were excited to see girls
5 Mentions 3 Girls	Exclusion	• "almost feeling excluded part just because, like I had some guy friends in there, but like at the same time, it was pretty awkward just like every time to walk in and be like the only girl" (A. pg 2) • "I wouldn't say Mr. Dillion treated me differently, but I felt like some of the classmates would. I could be standing there done my project, but they go out of their way to get to like a guy to ask them for help instead." (A. pg 3) • "I think it's just a lot of like intimidation and like you know that some people going into that are like Oh, I know exactly what i'm doing, and you feel like you either have to compete with them, or you have to be good with them in order to like work together. (S. pg 4) • "the one thing that scared me like I was like what, what if I don't have any friends in this class" (A pg 3) • Like I don't know, maybe they probably just thought that, like we didn't know what we're doing some of the time" (N. pg3)	Feeling excluded to be only girl Classmates treated her differently. Wouldn't ask her for help. Intimidation and have to compete with them or be on good terms to work together What if I don't have friends They didn't we knew what we were doing

Appendix E Inquiry Question & Survey Alignment

Inquiry Question	Collection Protocol	Protocol Questions
1. Do human-centered design approaches increase girls' interest in technology and engineering courses?	Pre/Post Survey	**Questions:** 1. I enjoy learning about technology and engineering. 2. I am interested in learning more about technology and engineering.
2. How does being recognized for competence or perseverance improve girls' technology and engineering identity?	Pre/Post Survey	**Questions:** 3. My teachers see me as a technology and engineering person 4. My friends/classmates see me as a technology and engineering person 5. My family sees me as a technology and engineering person 6. I understand concepts I have studies in technology and engineering. 7. Others ask me for help in technology and engineering. 8. I am confident about my work in my technology and engineering course. 9. I can do well on tests and performances tasks in technology and engineering.
3. How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?	Pre/Post Survey	**Questions:** 10. I feel different than other students in my technology and engineering course. (reverse coded) 11. There are times in my technology and engineering course I feel alone or isolated. (reverse coded) 12. Sometimes I feel that I have to prove I belong in my technology and engineering course. (reverse coded)
Overarching Research Question: Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities?	Pre/Post Survey	**Questions:** 13. I see myself in a future career in technology or engineering 14. I am a technology and engineering person.

Appendix F PDSA Cycles

PDSA Cycle 1

PDSA CYCLE		
Practitioner: Jana Bonds	**Date:** 11/8/21-12/20/22	**Cycle #: 1**
Intervention/ Change Idea: What specifically are you testing? If human centered design and focus on belonging and recognition increase a girls' technology and engineering identity.		
Goal of the Test* To improve girls technology and engineering identity		
Overall goal: *To increase the number of girls enrolling in technology and engineering courses at Southern Hills HS.*		

1)PLAN Describe the who/what/where/when for the test				**2) DO** Describe what occurred
Questions: What questions do you have about what will happen?	**Predictions**: What predictions do you have?	**Data:** What data will be collected?		**What were the results?** Comment on your predictions in the rows below.
Does human-centered design challenges increase girls' interest in technology and engineering courses?	I predict 5% of the girls who complete a human centered design challenge will show an increase in their overall interest in technology and engineering.	Quantitative Pre/Post Survey	→	Pre to Post Survey there was actually a decrease in the girls perceived interest in the content of technology and engineering. Of the 19 responses, there was a decrease of 13% at the end of the course.
How does being recognized for competence or perseverance improve girls' technology and engineering identity?	I predict 5% of girls will show an improved technology and engineering identity specific to begin recognized as a "technology and engineering person" by their instructor.	Quantitative Pre/Post Survey Qualitative Teacher Journal	→	There was an increase from pre-post survey results for the girls. The went from only 8 girls somewhat agreeing they thought their teacher saw them as a tech ed person to 11 girls agreeing, (2 of which strongly agreed).
How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?	I predict 5% of the girls will show an increase in their technology and engineering identity by the end of the course based on the design approach, recognition and infusion of like representation in career connections.	Quantitative Pre/Post Survey	→	There was an increase in the girls perceived technology and engineering identity from pre-post survey. 7 girls agreed prior to the course and 10 agreed they were a technology education person at the end of the course. Interesting though 2 of the disagreeing students moved to the strongly disagreed pre to post. There was also an increase in the girls believe they could see themselves in a future career. This was the largest increase in all areas.

	↓	↓

4)ACT. What will happen next cycle?		3) Study. What do you learn?
In an effort to increase interest, next cycle I am going to cut teams down to pairs to see if that's of more benefit. I also believe allowing more creativity in their design and showing examples may benefit their human centered design approach, many of the findings from the phase one study referenced freedom and creativity. Finally, this rotation I shared 4 Career Connections Videos, next rotation I plan to increase that to 7 to show more diverse engineering fields and a wider range of professionals to see if numbers could increase further	←	I learned that human centered design may not be enough to increase girls interest in the content. I learned that recognizing girls in my class not only formed a better sense of belonging for them in my classroom but in our day to day interactions also. I noted in my journal seeing girls in the hall and lunch and them wanting to interact with me as well. I couldn't believe the increase in future career interest. I am not sure if that was due to having a woman as their teacher and showing them someone in a STEM career on a daily basis or the career connections videos show, or maybe it was a combination of both.

PDSA Cycle 2

PDSA CYCLE		
Practitioner: Jana Bonds	**Date:** 12/21/21-2/4/22	**Cycle #: 2**
Intervention/ Change Idea: What specifically are you testing? If open-ended human centered design, focus on belonging and recognition, and career connections increase a girls' technology and engineering identity		
Goal of the Test* To improve girls technology and engineering identity		
Overall goal: *To increase the number of girls enrolling in technology and engineering courses at Southern Hills HS.*		

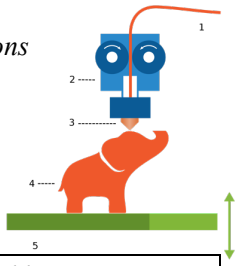
1)PLAN Describe the who/what/where/when for the test				2) DO Describe what occurred
Questions: What questions do you have about what will happen?	**Predictions**: What predictions do you have?	**Data:** What data will be collected?		**What were the results?** Comment on your predictions in the rows below.
Do open-ended human-centered design challenges increase girls' interest in technology and engineering courses?	I predict 5% of the girls who complete a human centered design challenge will show an increase in their overall interest in technology and engineering.	Quantitative Pre/Post Survey	→	Pre to Post Survey there was a small increase in the 15 participating girls perceived interest in the content of technology and engineering but of very small significance.

How does being recognized for competence or perseverance improve girls' technology and engineering identity?	I predict 5% of girls will show an improved technology and engineering identity specific to begin recognized as a "technology and engineering person" by their instructor.	Quantitative Pre/Post Survey Qualitative Teacher Journal	→	There was a larger increase this cycle that the first for recognition and performance/competence. I mentioned several times through my journal reflection the ease that recognition came this cycle versus the first. I also noted more recognition in full class
How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?	I predict 5% of the girls will show an increase in their technology and engineering identity by the end of the course based on the design approach, recognition and infusion of more like representation in career connections.	Quantitative Pre/Post Survey	→	There was an increase in this category again which shows the power of adding more career connections videos could have for educators.
				↓ ↓

4)ACT. What will happen next cycle?		**3) Study.** What do you learn?
Trying a different human centered design project may be of value to see if that can spark additional interest for girls. In addition trying other types of career connections or even bring in live speakers to meet with the class could be of benefit to see continued growth toward a technology and engineering identity.	←	I learned open ended human centered design may increase interest but not to the full extent I was hoping for. Smaller groups seem to show more promise, especially when girls are working together. I learned that recognizing girls in class not only has the potential to build their confidence but also the boys' confidence in going to them for help. I noted in my journal witnessing boys go to girls for more help this rotation after I increase the full class recognition. Career connections videos, especially those with like representation can be powerful for girls in tech ed.

Appendix G Intervention II Design Brief

Design Brief: ***"Makeable Challenge" -*** *used in conjunction with the software and lessons provided by Autodesk and PrintLab's 2021 Makeable Challenge Toolkit*



EHMMS Technology & Engineering – Grade 8
Instructor: Mrs. Bonds

Objectives - Upon completion of this engineering design challenge, all students should be able to:

- Apply the Engineering Design Process to solve a problem
- Consider the available resources in solving the problem
- Empathize with others and their day to day challenges
- Design solutions digitally using software
- Identify and apply basic principles of 3D modeling and printing techniques
- Demonstrate responsible and safe work habits and attitudes at all times.

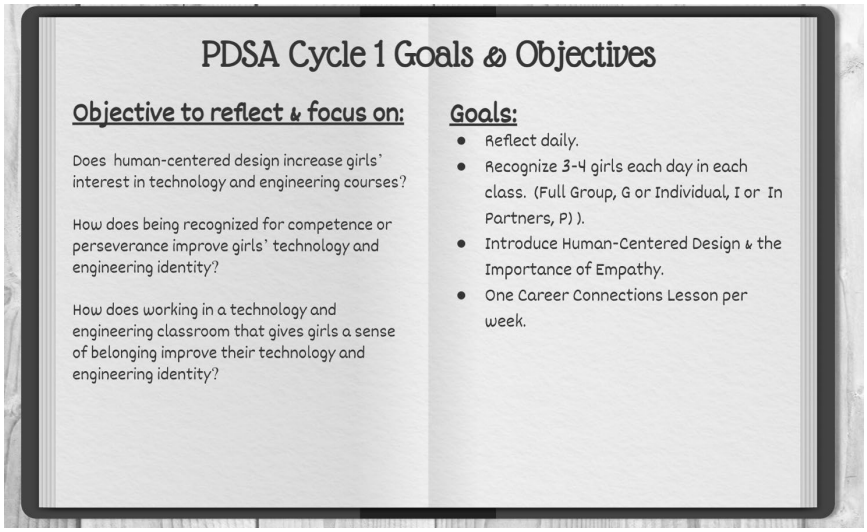
Challenge: ***Design and make a product or prototype that improves the day-to-day life of someone who is faced with an issue.*** **Each challenge and designed prototype will be different for every individual student or team based on the researched intended user*

Criteria and Constraints:

1. You will work with a partner of your choice for this project (Max- 3 per team).
2. Follow the Engineering Design Process to design, make, & test your prototype.
3. Conduct an empathy interview when possible to learn about the disability, mobility, or problem in more detail.
4. Reflect deep consideration of the intended user of your prototyped solution.
5. Your designed prototype solution must be designed for a real end user (e.g. someone in your local community), or design a product for a target user provided by Mrs. Bonds.
6. Your prototype should follow your plan, be well crafted, and consider safety always
7. The design process must include the use of either TinkerCAD or Sketchup software and the digital 3D model produced should be 3D printable.
8. A physical prototype must be created. Additionally, 3D printing can be combined with other materials and processes, such as electronics, to create the product if the student(s) have time and feel it will benefit their final prototype.
9. You must submit a 4-6 page electronic portfolio which shows:
    - Completed steps of the engineering design process
    - Information about the end user
    - How you developed a sense of understanding and empathy for your end user
    - How you framed and defined the challenge based on the needs of your end user
    - Your source and inspiration for ideas (let me see that beautiful brainstorming!)
    - All sketches (icon and diagramming worksheets)
    - Your possible 3 concept solution ideas
    - Your selected design
    - The production process, iterations, and final product

**All documentation can all be visuals/photos/or vlogs but should include descriptions (written or audio) of what occurred throughout the process

Appendix H Educator Reflective Digital Journal Excerpt



PDSA Cycle 1 Goals & Objectives

Objective to reflect & focus on:

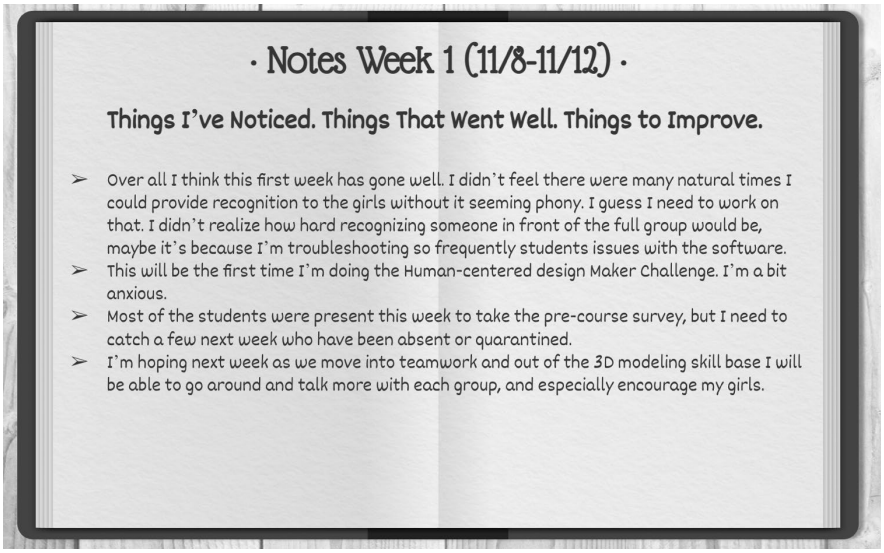
Does human-centered design increase girls' interest in technology and engineering courses?

How does being recognized for competence or perseverance improve girls' technology and engineering identity?

How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?

Goals:

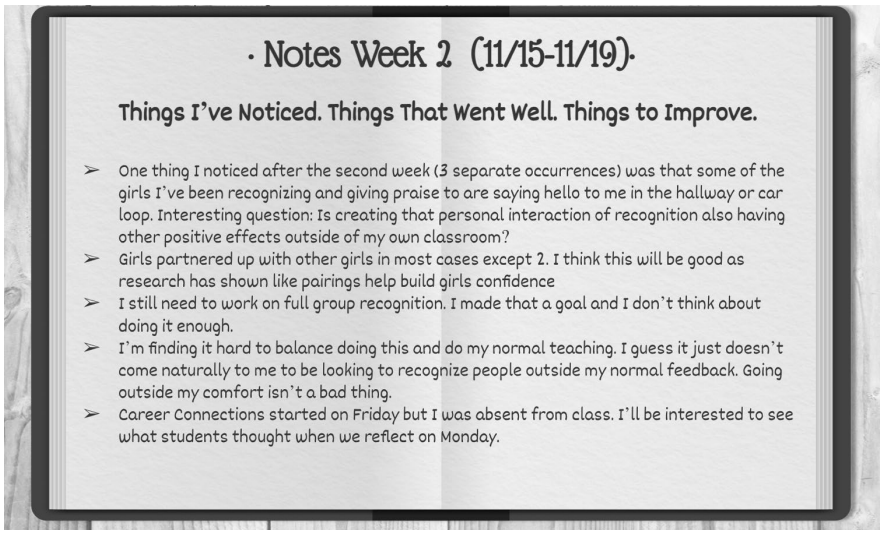
- Reflect daily.
- Recognize 3-4 girls each day in each class. (Full Group, G or Individual, I or In Partners, P)).
- Introduce Human-Centered Design & the Importance of Empathy.
- One Career Connections Lesson per week.



· Notes Week 1 (11/8-11/12) ·

Things I've Noticed. Things That Went Well. Things to Improve.

- Over all I think this first week has gone well. I didn't feel there were many natural times I could provide recognition to the girls without it seeming phony. I guess I need to work on that. I didn't realize how hard recognizing someone in front of the full group would be, maybe it's because I'm troubleshooting so frequently students issues with the software.
- This will be the first time I'm doing the Human-centered design Maker Challenge. I'm a bit anxious.
- Most of the students were present this week to take the pre-course survey, but I need to catch a few next week who have been absent or quarantined.
- I'm hoping next week as we move into teamwork and out of the 3D modeling skill base I will be able to go around and talk more with each group, and especially encourage my girls.



· Notes Week 2 (11/15-11/19)·

Things I've Noticed. Things That Went Well. Things to Improve.

- One thing I noticed after the second week (3 separate occurrences) was that some of the girls I've been recognizing and giving praise to are saying hello to me in the hallway or car loop. Interesting question: Is creating that personal interaction of recognition also having other positive effects outside of my own classroom?
- Girls partnered up with other girls in most cases except 2. I think this will be good as research has shown like pairings help build girls confidence
- I still need to work on full group recognition. I made that a goal and I don't think about doing it enough.
- I'm finding it hard to balance doing this and do my normal teaching. I guess it just doesn't come naturally to me to be looking to recognize people outside my normal feedback. Going outside my comfort isn't a bad thing.
- Career Connections started on Friday but I was absent from class. I'll be interested to see what students thought when we reflect on Monday.

Appendix I Inquiry Question and Survey Alignment

Inquiry Question	Collection Protocol	Survey Protocol Questions
1. Do human-centered design approaches increase girls' interest in technology and engineering courses?	Pre/Post Survey	**Questions:** 1. I enjoy learning about technology and engineering. 2. I am interested in learning more about technology and engineering.
2. How does being recognized for competence or perseverance improve girls' technology and engineering identity?	Pre/Post Survey	**Questions:** 3. My teachers see me as a technology and engineering person 4. My friends/classmates see me as a technology and engineering person 5. My family sees me as a technology and engineering person 6. I understand concepts I have studies in technology and engineering. 7. Others ask me for help in technology and engineering. 8. I am confident about my work in my technology and engineering course. 9. I can do well on tests and performances tasks in technology and engineering.
3. How does working in a technology and engineering classroom that gives girls a sense of belonging improve their technology and engineering identity?	Pre/Post Survey	**Questions:** 10. I feel different than other students in my technology and engineering course. (reverse coded) 11. There are times in my technology and engineering course I feel alone or isolated. (reverse coded) 12. Sometimes I feel that I have to prove I belong in my technology and engineering course. (reverse coded)
Overarching Research Question #3:		
Does a classroom environment that includes supportive and transformative norms in technology and engineering develop girls' technology and engineering identities?	Pre/Post Survey	**Questions:** 13. I see myself in a future career in technology or engineering 14. I am a technology and engineering person.

Bibliography

Abrams, E., Yore, L., Bang, M., Brayboy, B., Castagno, A., Kidman, J., Lee, H., & Villanueva, M. (2014). Culturally relevant schooling in science for indigenous learners worldwide. In N. G. Lederman & S. Abell (Eds.), *Handbook on science education: Vol. II. Interdisciplinary science teaching* (pp. 671–696). Routledge.

Alderson, N. (2017). Defining agency after implicit bias. *Philosophical Psychology, 30*(5), 645–656. https://doi.org/10.1080/09515089.2017.1296565

Blackburn, H. (2017). The status of women in STEM in higher education: A review of the literature 2007–2017. *Science and Technology Libraries, 36*(3), 235–273. https://doi.org/10.1080/0194262X.2017.1371658

Brayboy, B. M. K. J., & Maughan, E. (2009). Indigenous knowledges and the story of the bean. *Harvard Educational Review, 79*(1), 1–21. https://doi.org/10.17763/haer.79.1.l0u6435086352229

Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How America's schools can get better at getting better*. Harvard Education Press. http://web.b.ebscohost.com.pitt.idm.oclc.org/ehost/ebookviewer/ebook?sid=ffd93d18-ca6f-4766-9da4-c5674b2da246%40pdc-v-sessmgr04&vid=0&format=EK

Bryson, J. M., Patton, M. Q., & Bowman, R. A. (2011). Working with evaluation stakeholders: A rationale, step-wise approach and toolkit. *Evaluation and Program Planning, 34*(1), 1–12. https://doi.org/10.1016/j.evalprogplan.2010.07.001

Buckley, J. (2017). *Jenni Buckley: Designing for diversity*. TEDx Talks. https://www.youtube.com/watch?v=zO-k9TMnT-w

Burks, G., & Amos, J. R. (2019). Impact of ethics and social awareness curriculum on the engineering identity formation of high school girls. *Education Sciences, 9*(4), 250. https://doi.org/10.3390/educsci9040250

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal, 50*(1), 37–75. https://doi.org/10.3102/0002831212458142

Capobianco, B. M., & Yu, J. H. (2014). Using the construct of care to frame engineering as a caring profession toward promoting young girls' participation. *Journal of Women and Minorities in Science and Engineering, 20*(1), 21–33. https://doi.org/10.1615/JWomenMinorScienEng.2014006834

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teachin, 44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Cimpain, J. (2018). *How our education system undermines gender equity*. The Brookings Institution, Brown Center Chalkboard. https://www.brookings.edu/blog/brown-center-chalkboard/2018/04/23/how-our-education-system-undermines-gender-equity/

Creswell, J. W. (2009). *Research design:Qualitative, quantitative, and mixed methods approaches* (3rd ed.). SAGE Publications.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2019). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences, 1*(1), 21–29. https://doi.org/10.1177/2372732214549471

Dou, R., & Cian, H. (2020). The relevance of childhood science talk as a proxy for college students' STEM identity at a hispanic serving institution. *Research in Science Education, 51*, 1093–1105. https://doi.org/10.1007/s11165-020-09928-8

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2020). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education, 103*(3), 623–637. https://doi.org/10.1002/sce.21499

Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. *African Journal of Emergency Medicine, 7*(3), 93–99. https://doi.org/10.1016/j.afjem.2017.08.001

Field, A. (2018). Discovering statistics using IBM SPSS statistics. *Angewandte Chemie International Edition, 6*(11), 951–952.

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology, 43*(3), 338–346. https://doi.org/10.1037/0022-0167.43.3.338

Fouad, N. A., Smith, P. L., & Zao, K. E. (2002). Across academic domains: Extensions of the social-cognitive career model. *Journal of Counseling Psychology, 49*(2), 164–171. https://doi.org/10.1037/0022-0167.49.2.164

Fry, R., Kennedy, B., & Funk, C. (2021). *STEM jobs see uneven progress in increasing gender, racial and ethnic diversity*. Pew Research Center. https://www.pewresearch.org/science/wp-content/uploads/sites/16/2021/03/PS_2021.04.01_diversity-in-STEM_REPORT.pdf

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25*, 99. https://doi.org/10.2307/1167322

George, D., & Mallery, P. (2020). *IBM SPSS statistics 26 step by step*. Routledge.

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice. *Journal of Engineering Education, 105*(2), 312–340. https://doi.org/10.1002/jee.20118

Gutiérrez, K. D. (2008). Developing a sociocritical literacy in the third space. *Reading Research Quarterly, 43*(2), 148–164. https://doi.org/10.1598/rrq.43.2.3

Gutstein, E. (2007). Multiple language use and mathematics: Politicizing the discussion. *Educational Studies in Mathematics, 64* (2), 243–246. https://doi.org/10.1007/s10649-006-9063-z

Haines, E. L., Deaux, K., & Lofaro, N. (2016). The times they are a-changing … or are they not? A comparison of gender stereotypes: 1983–2014. *Psychology of Women Quarterly, 40*(3), 353–363. https://doi.org/10.1177/0361684316634081

Hand, S., Rice, L., & Greenlee, E. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education, 20*(4), 929–945. https://doi.org/10.1007/s11218-017-9408-8

Harding, S. (2016). *Whose science? Whose knowledge?* Cornell University Press. https://doi.org/10.7591/9781501712951

Hazari, Z., Chari, D., Potvin, G., & Brewe, E. (2020). The context dependence of physics identity: Examining the role of performance/competence, recognition, interest, and sense of belonging for lower and upper female physics undergraduates. *Journal of Research in Science Teaching, 57*(10)*,* 1583–1607. https://doi.org/10.1002/tea.21644

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003. https://doi.org/10.1002/tea.20363

Hill, C., Corbett, C., St. Rose, A., & American Association of University Women. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. AAUW.

Hinnant-Crawford, B. N. (2020). *Improvement science in education: A primer*. Myers Education Press. https://books.google.com/books?id=lWvwDwAAQBAJ

Honey, M., Pearson, G., Schweingruber, H. A. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press.

Hughes, R., Schellinger, J., & Roberts, K. (2021). The role of recognition in disciplinary identity for girls. *Journal of Research in Science Teaching, 58*(3), 420–455. https://doi.org/10.1002/tea.21665

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., Schor, J., Sefton-Green, J., Watkins, S. (2013). *Connected Learning: An agenda for research and design.* Digital Media and Learning Research Hub. www.dmlhub.net/publications

Johnson-Bailey, J. (2012). Positionality and transformative learning. In E. W. Taylor & P. Cranton (Eds.), *The handbook of transformative learning: Theory, research, and practice* (pp. 260–273). Wiley.

Kane, J. M. (2012). Young African American children constructing academic and disciplinary identities in an urban science classroom. *Science Education, 96*(3), 457–487. https://doi.org/10.1002/sce.20483

Kanny, M. A., Sax, L. J., & Riggers-Pieh, T. A. (2014). Investigating forty years of stem research: How explanations for the gender gap have evolved over time. *Journal of Women and Minorities in Science and Engineering, 20*(2), 127–148. https://doi.org/10.1615/JWomenMinorScienEng.2014007246

Kokka, K. (2020). Social justice pedagogy for whom? Developing privileged students' critical mathematics consciousness. *Urban Review, 52*(4), 778–803. https://doi.org/10.1007/s11256-020-00578-8

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465. https://doi.org/10.2307/1163320

Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: a.k.a. the remix. *Harvard Educational Review, 84*(1), 74–84.

Lagesse, R., & Marshall, D. (2019). Girls in engineering: How to in increse the number of young girls in technology and engineering courses. *Technology and Engineering Teacher, 78*(5), 28–31.

Lawrence-Lightfoot, S., & Davis, J. H. (1997). *The art and science of portraiture*. Jossey-Bass.

Le, H., & Robbins, S. B. (2016). Building the STEM pipeline: Findings of a 9-year longitudinal research project. *Journal of Vocational Behavior, 95–96*, 21–30. https://doi.org/10.1016/j.jvb.2016.07.002

Legewie, J., & Diprete, T. A. (2014). The high school environment and the gender gap in science and engineering. *Sociology of Education, 87*(4), 259–280. https://doi.org/10.1177/0038040714547770

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of

career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Martinez, A., & Christnacht, C. (2021). *Women making gains in STEM occupations but still underrepresented*. US Census Burea. https://www.census.gov/library/stories/2021/01/women-making-gains-in-stem-occupations-but-still-underrepresented.html

Menter, I., Elliot, D., Hulme, M., Lewin, J., & Lowden, K. (2011). *A guide to practitioner research in education*. SAGE.

Meyer, X., & Crawford, B. A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education, 6*, 525–547. https://doi.org/10.1007/s11422-011-9318-6

Moss-Racusin, C. A., Sanzari, C., Caluori, N., & Rabasco, H. (2018). Gender bias produces gender gaps in STEM engagement. *Sex Roles, 79*, 651–670. https://doi.org/10.1007/s11199-018-0902-z

Murcia, K., Pepper, C., & Williams, J. (2020). Youth STEM career choices: What's influencing secondary students' decision making. *Issues in Educational Research, 30*(2), 593–611.

Noonan, R. (2017). *Women in STEM: 2017 Update (ESA issue Brief #06-17).* Office of the Chief Economist, Economics and Statistics Administration, U.S. Department of Commerce. https://www.census.gov/programs-surveys/acs/.

Osterman, K. F. (2010). Teacher practice and students' sense of belonging. In T. Lovat, R. Toomey, & N. Clement (Eds), *International research handbook on values education and student wellbeing* (pp. 239–260). Springer, Dordrecht. https://doi.org/10.1007/978-90-481-8675-4_15

Perry, J. A., Zambo, D., & Crow, R. (2020). *The improvement science dissertation in practice*. Myers Education Press.

Pinar, W. F. (1992). "Dreamt into existence by others": Curriculum theory and school reform. *Theory Into Practice, 31*(3), 228–235. https://doi.org/10.1080/00405849209543547

Quigley, C. (2011). Pushing the boundaries of cultural congruence pedagogy in science education towards a third space. *Cultural Studies of Science Education, 6*(3), 549–557. https://doi.org/10.1007/s11422-011-9335-5

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics, 117*(1–2), 1–12. https://doi.org/10.1111/SSM.12201

Quigley, C. F., Herro, D., Shekell, C., Cian, H., & Jacques, L. (2020). Connected learning in

STEAM classrooms: Opportunities for engaging youth in science and math classrooms. *International Journal of Science and Mathematics Education, 18*, 1441–1463. https://doi.org/10.1007/s10763-019-10034-z

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96*(3), 411–427. https://doi.org/10.1002/sce.21007

Saldaña, J. (2015). *The coding manual for qualitative researchers* (3rd ed.). SAGE Publications.

Sawilowsky, S. (2009). New effect size rules of thumb. *Journal of Modern Applied Statistical Methods, 8*(2), 597–599. https://digitalcommons.wayne.edu/coe_tbf/4

Sensoy, O., & DiAngelo, R. (2017). *Is everyone really equal? An introduction to key concepts in social justice education*. Teachers College Press.

Silverman, S., & Pritchard, A. (1996). Building their future: Girls and technology education in Connecticut. *Journal of Technology Education, 7*(2). https://doi.org/10.21061/jte.v7i2.a.4

Smithsonian Science Education Center. (2018). *The STEM imperative.* https://ssec.si.edu/stem-imperative

Stringer, E. T. (2014). *Action research* (4th ed.). Sage.

Tellhed, U., Bäckström, M., & Björklund, F. (2017). Will I fit in and do well? The importance of social belongingness and self-efficacy for explaining gender differences in interest in STEM and HEED majors. *Sex Roles, 77*, 86–96. https://doi.org/10.1007/s11199-016-0694-y

United States, C. on N. S. C. (2001). *Road map for national security: Imperative for change: The phase III report of the U.S. Commission on National Security/21st Century*. United States Commission on National Security/21st Century. https://www.hsdl.org/?abstract&did=

Vélez-Ibáñez, C. G., & Greenberg, J. B. (1992). Formation and transformation of funds of knowledge among U.S.-Mexican households. *Quarterly, 23*(4).

Virtanen, S., Räikkönen, E., & Ikonen, P. (2015). Gender-based motivational differences in technology education. *International Journal of Technology and Design Education, 25*(2), 197–211. https://doi.org/10.1007/s10798-014-9278-8

Weber, K. (2012). Gender differences in interest, perceived personal capacity, and participation in STEM-related activities. *Journal of Technology Education, 24*(1), 18–33.

Weisgram, E. S., & Bigler, R. S. (2007). Effects of learning about gender discrimination on adolescent girls' attitudes toward and interest in science. *Psychology of Women Quarterly, 31*(3), 262–269. https://doi.org/10.1111/j.1471-6402.2007.00369.x

Zachry, M., & Spyridakis, J. H. (2016). Human-centered design and the field of technical communication. *Journal of Technical Writing and Communication, 46*(4), 392–401. https://doi.org/10.1177/0047281616653497

Zilberman, A., & Ice, L. (2021). Why computer occupations are behind strong STEM employment growth in the 2019–29 decade. *Beyond the Numbers: Employment & Unemployment, 10*(1).