MULTIPLE CASE STUDY ANALYSIS OF YOUNG WOMEN'S EXPERIENCES IN HIGH SCHOOL ENGINEERING

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To my loving parents,

Phillip and DeAnne Pollock

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Words cannot adequately express how grateful I am to my parents for their love and encouragement throughout my lifetime. As a child, they fostered my love of learning and achieving, and as an adult, their friendship has carried me through tough times. This work is dedicated to them for their tireless support of my dreams and ambitions.

As strong, smart, and independent women, my best friends Katy Sparks, Gina Hann, and Heather McClendon proved to be incredible sources of strength. These are my chosen sisters, and role models each in their own way.

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Without amazing educators since early childhood, I would not be where I am today. A tremendous thank you goes to my PhD advisor Dr. Monica Cardella for her patience and guidance and to my committee, Dr. Alice Pawley, Dr. Susan Walden, Dr. Şenay Purzer, and Dr. Richard Gale, for their contributions to this work.

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ABSTRACT

Pollock, Meagan C. Doctor of Philosophy, Purdue University, Summer 2014. Multiple Case Study Analysis of Young Women's Experiences in High School Engineering. Major Professor: Monica Cardella.

At a time when engineers are in critical demand, women continue to be significantly underrepresented in engineering fields (11.7%) and degree programs (21.3%) in the United States. As a result, there is a national demand for improved K-12 STEM education and targeted efforts to improve equity and access to engineering and science careers for every underrepresented group.

High school engineering has become a nascent and growing market for developers and an emergent opportunity for students across the United States to learn introductory engineering skills through strategic career pathways; however there is a disparity in participation at this level as well. Much useful research has been used to examine the problematization of underrepresentation (K Beddoes, 2011), but there is a dearth of literature that helps us to understand the experiences of young women in high school engineering. By examining the experiences of young women in high school engineering, we can learn ways to improve the curriculum, pedagogy, and environment for underrepresented groups such as females to ensure they have equitable access to these programs and are subsequently motivated to persist in engineering.

Understanding the needs of marginalized groups is complex, and intersectional feminism seeks to understand gender in relation to other identities such as race, class, ethnicity, sexuality, and nationality. This theory asserts that gender alone is neither a total identity nor a universal experience, and it is thus advantageous to consider each of the intersecting layers of identity so as to not privilege a dominate group as representative of all women. Thus, to understand how female students engage with and experience engineering in grade school, it is useful to examine through the lens of gender, class, race, and sexuality, because this intersection frames much of the human experience.

The purpose of this study is to examine high school females' experiences in engineering, with a goal to richly describe the diversity of experiences. A multiple case study analysis, this study answers the question: *How do gender, class, race, and other components of intersectionality, influence high school females' experiences in engineering?* Nine young women taking a high school engineering course in a suburban high school in Central Texas during the school year 2011-2012 volunteered to participate. The students were observed in their engineering classes for half of the spring 2012 semester, with bi-weekly interviews with the students, monthly interviews with the teacher, and a single interview with a parent of each volunteer.

The nine rich case studies provide us with new stories that help prevent us from narrowing the experiences of women to a single incomplete stereotype, because these young women vary across race, socioeconomic backgrounds, and sexual orientation. Although each story is unique, there are commonalities among their experiences, including family, influence, classroom environment, biases, and beliefs. By drawing from their collective experiences in high school engineering, the findings direct us toward recommendations for educators, parents, engineering curriculum developers, designers of teacher professional development, and future research to improve equity and access for every student in engineering.

CHAPTER 1. INTRODUCTION

There are stories that we tell about women we know in engineering. The stories come to have a similar tune of smart girls who are good at math and science and have persevered despite odds. This tune becomes a stereotype, an assignment that helps us make sense of the world and find community with others. My own personal story of how I came to be an engineer was very similar. I found solace and camaraderie with other women who achieved the same. However, the challenging journey of this work made me realize my story is more than the one I had always believed. I heard the tune, a single story of the female engineer, and it became my own. It was not exactly untrue, after all, just astoundingly incomplete.

Writer Chimamanda Adichie warns that if we hear only a single story about another person or country, we risk a critical misunderstanding. Given the vast disparity of participation of women in engineering that has remained largely unchanged over the past two decades, I fear that somewhere along the way, we have indeed reached a critical misunderstanding.

The motivation of this study is to tell more stories, but from a budding population not yet often examined. The stories told reflect power relations and the influence of gender, class, race, and sexuality on the experiences of young women who have elected to study engineering in high school. Although all are smart, good at math and science, and have persevered despite odds, their stories aim at beginning to change the tune.

1.1 Background of the Study

Engineers are in demand, and despite achievements in math and science, women are significantly underrepresented in engineering fields and degree programs in the United States. To meet the demand, improve innovation, and advance equality among the sexes, it is prudent to increase the potential as well as the yield of women entering in and persisting in engineering careers. One way to accomplish this is to begin introducing engineering to students in grade school, as is a resulting product of a National STEM Education initiative. Although there are national guidelines for what K-12 engineering education should look like and entail, there is no accountability among K-12 engineering education programs. Thus we should study these instances/environments to better understand the experiences and needs of young women to ensure we are able to increase female participation and persistence in engineering.

1.1.1 Engineers Are in Demand

Many of the jobs of tomorrow do not even exist today, because they are dependent on future problems that will arise and the required technologies needed to solve those problems. However, the demand for engineers is imminent today, so let us examine some of the patterns of growth and concerns for the workforce.

The science and engineering (S&E) workforce has shown sustained growth for more than half a century. The number of workers in S&E occupations grew from about 182,000 in 1950 to 5.4 million in 2009. This represents an average annual growth rate of

5.9%, nearly 5 times the 1.2% growth rate for the total workforce older than age 18 during this period (National Science Board, 2012). Even in times of economic collapse, S&E continues to see growth. For example, while workforce growth in S&E occupations from 2000 to 2009 was slower than in the preceding two decades, at 1.4% growth annually, it still far exceeded the 0.2% growth rate for the general workforce. Given how embedded technology has become in our society, and the Grand Challenges we face, we can expect persistent growth among S&E jobs in the coming decades.

An additional concern is that, although the number of S&E trained persons in the workforce will continue to grow, many S&E workers are reaching traditional retirement age (26% were older than age 50 in 2006 (American Association of University Women, 2010; National Science Board, 2010)). Therefore, in addition to openings from job growth, many openings will be created by the need to replace the many highly skilled engineers who will retire over the next decade. Looking specifically at engineering, the U.S. Department of Labor Bureau of Labor Statistics predicts that overall employment for engineers is expected to grow by 14 percent during the 2010-20 decade, while 7 of the 10 fastest-growing occupations requiring at least a bachelor's degree will necessitate significant scientific or mathematical training (National Science Board, 2012).

1.1.2 Women (and Minorities) Are Underrepresented in Engineering

There is a tremendous disparity of women (10%), Blacks (5%), and Hispanics (7%) in engineering, and equitable participation for all is imperative to meet the needs of the 21st century (NSF, 2009). Looking specifically at women, since 2000, women have earned approximately one-half of all S&E bachelor's degrees (NSF, 2009). However, further examination reveals that there is a significant gender gap in the number of women earning engineering degrees. Women today represent only 19.2% of bachelor's degrees awarded in engineering, a percentage that has remained nearly stagnant over the past 20 years. In 1990, 15.4% of bachelor's degrees in engineering were awarded to females. The trend peaked in 2002 at 20.9%, gradually dipped to 18.1% by 2009, and slowly climbed to 19.2% in 2012. In the workforce, women represent a diminutive 11.7% of engineers, a meager increase from 5.8% in 1983 (National Science Foundation, 2012).

1.1.3 Women Aren't Participating Despite Achievement

The disparity of women in engineering is not because they are not good at math and science, or that they are not prepared by their high school course selection. On average, females receive higher grades in school in every subject including mathematics and science; females earn more credits in math and science courses than males; and female high school graduates have a higher combined GPA in math and science courses than males (Dwyer & Johnson, 1997; Kimball, 1989; Shettle et al., 2007; U.S. Department of Education - National Center for Education Statistics, 2007). Despite these achievements, young women are not readily choosing engineering as a college major and career path, but instead are more likely to secure degrees in the humanities and life and social sciences (Lubinski & Benbow, 2006). Young women tend to believe that science and technology are not relevant to their future career goals or they do not find the learning contexts inviting (Brophy, 2008; Hsi, Linn, & Bell, 1997; R. W. Lent et al., 2005; Linn, 2003; E. Seymour & N. M. Hewitt, 1997).

Areas in which consistent gender differences have emerged are children's and adolescents' interest in math and science, their beliefs about their abilities in math and science, and their perceptions of the importance of math and science for their futures (Halpern et al., 2007). Acknowledging and addressing these areas can increase young women's awareness, interest, and confidence to pursue a career in engineering. Social and environmental factors contribute to the underrepresentation, thus aggressive and focused intervention efforts targeting women are recommended to address the gender gap in engineering (Congressional Commission on the Advancement of Women and Minorities in Science Engineering and Technology Development, 2000).

1.1.4 Case for Diversity

Three types of justifications for diversity have commonly appeared over the last 50 years: legal, economic, and social arguments (Slaton, 2010). Where social arguments are more for moral rather than strictly practical reasons, the most common argument is that of economics. We need an enlarged technical labor pool, and increasing the participation of all is key. We know that women are prepared to enter engineering, but because social influences discourage them, they lose access to high-demand, high-wage jobs in engineering and science that would benefit them individually, or their families as providers. In addition, diversification of the workforce improves the quality of teamwork and innovation. Striving to improve equity and access to engineering is good for people and it's good for business.

1.1.5 National STEM Education Initiative

Improving America's STEM education is one of the top priorities for the U.S government. President Obama has said repeatedly that efforts to improve STEM education are "going to make more of a difference in determining how well we do as a country than just about anything else that we do here." A world-class STEM workforce is essential to virtually every goal we have as a nation—whether it is broadly shared economic prosperity, international competitiveness, a strong national defense, a clean energy future, and longer, healthier, lives for all Americans. White House correspondent Phil Larson (Larson, 2012) writes, "If we want the future to be made in America, we need to redouble our efforts to strengthen and expand our STEM workforce."

With the economic demand, and the government emphasis, billions of dollars in grants are available to schools to implement or improve STEM programs. These grants come from corporate foundations such as those at Texas Instruments, nonprofit foundations such as the Bill and Amanda Gates Foundation, government funding agencies such as the National Science Foundation, or specific government funds such as Race to the Top. Race to the Top asks states to advance education reforms, and phase three of funding required that state applicants identify how they would also improve STEM education.[1]

Schools across the country are implementing engineering as a way to improve math, science, problem solving, and critical thinking skills. A National Academy of

[1] Race to the Top asks states to advance reforms around four specific areas: (1) adopting standards and assessments that prepare students to succeed in college and the workplace and to compete in the global economy; (2) building data systems that measure student growth and success, and inform teachers and principals about how they can improve instruction; (3) recruiting, developing, rewarding and retaining effective teachers and principals; (4) turning around lowest-achieving schools. In phases 1-3, 19 states have received Race to the Top funding.

Engineering (NAE) report (Katehi, Pearson, & Feder, 2009) summarizes that “a variety of claims have been made for the benefits of teaching engineering to K-12 students, ranging from improved performance in related subjects, such as science and mathematics, and increased technological literacy to improvements in school attendance and retention, a better understanding of what engineers do, and an increase in the number of students who pursue careers in engineering.” The data, however, are not substantial to support each of these claims. Even so, many schools are moving forward with the implementation and integration of engineering because of the national priority and “cutting edge” nature of the discipline in K-12 systems.

1.1.6 K-12 Engineering Education

K–12 engineering education is an area of growing national interest, winning attention not only in the engineering community but also within the general education community.

Created by the National Academies, the Committee on Prospering in the Global Economy of the 21st Century, chaired by Norman Augustine, retired Chairman and CEO of Lockheed Martin Corporation, published a report (2007) titled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* This congressionally requested report makes four recommendations that federal policymakers should take to create high-quality jobs and focus new science and technology efforts on meeting the nation’s needs. The first recommendation is to increase America’s talent pool by vastly improving K-12 mathematics and science education. A committee was subsequently established with a goal to provide carefully reasoned guidance to key stakeholders regarding the creation and implementation of K-12 engineering curricula and instructional practices, focusing especially on the connections among science, technology, engineering, and mathematics education. Released in 2009, *Engineering in K–12 Education: Understanding the Status and Improving the Prospects* reviews the scope and impact of engineering education today and makes several recommendations to address curriculum, policy, and funding issues. The book also analyzes a number of K-12 engineering curricula in depth and discusses what is known from the cognitive sciences about how children learn engineering-related concepts and skills. In 2010, another NAE commissioned committee published *Standards for K-12 Engineering Education*, asserting that although theoretically possible developing stand-alone standards for K-12 engineering education would be extremely difficult to ensure their usefulness and effective implementation. Two alternatives are recommended: infusion and/or mapping (Katehi et al., 2009).

The first approach, infusion, is a proactive strategy to embed relevant learning goals from one discipline (e.g., engineering) into standards for another (e.g., mathematics). The second approach, mapping, would involve integrating “big ideas” in engineering onto current standards in other disciplines. Mapping is a strategy for retrospectively drawing attention to connections that may or may not have been recognized by the developers of current standards.

In an effort to capitalize on an opportunity to appeal to states who are in the process of educational standards reform, that is, adopting common core standards in mathematics and English/language arts, *A Framework for K-12 Science Education* is grounded in the most current research on science and science learning and identifies the science that all K-12 students should know. This report released in 2012, was commissioned by the NAE as well. In a process managed by Achieve, states are now leading the "development of K-12 science standards, rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally-benchmarked science education."[2] The Next Generation Science Standards (NGSS) are based on the Framework and will prepare students for college and careers.

The committee that wrote the 2009 NAE report*, Engineering in K-12 Education*, provided a historical perspective and attempted to moderately quantify engineering education. The first formal K-12 engineering programs in the United States emerged in the early 1990s, but the community has seen significant growth over the past two decades, from no curricula to several dozen today. The committee, estimated (note 2009 release date) that some 18,000 teachers[3] have received pre- or in-service training to teach engineering-related coursework, and that no more than 6 million[4] K-12 students have had any kind of formal engineering education since 1990. Informal engineering learning opportunities were not explored or quantified. The committee believed it impossible to predict whether this upward trend will continue, flatten out, or reverse itself, but that the future of K-12 engineering education will depend at least in part on whether engineering becomes a catalyst for integrated STEM education.

In order to meet the workforce demands for a technologically literate, and scientific and mathematically minded people, we must begin to prepare students to meet these

[2] http://www.nap.edu/catalog.php?record_id=13165.
[3] By comparison, U.S. public and private middle and high schools employ roughly 276,000 mathematics teachers, 247,000 science teachers, and 25,000 to 35,000 technology education teachers.
[4] In comparison, estimated enrollment in 2008 for grades pre-K-12 for U.S. public and private schools was nearly 56 million.

demands in K-12. We cannot wait until students specialize in a discipline in university. The National Academy of Engineering has directed much of the conversation on K-12 Engineering Education through their research and reports. These reports act as a framework for what K-12 engineering education should look like and achieve in the K-12 education system.

1.1.6.1 Where is Engineering Education in K-12?

Engineering exists in many forms in K-12, and is driven by multiple factors. Looking specifically at secondary education (refer to Figure 1.1 for examples), engineering can be a stand-alone course in a career tech education program, or as a 4^{th} year science supplement. Engineering can be integrated in the core classes, such as biology or calculus, through integrated STEM modules, or via excerpts from the large publishers. Finally, engineering in secondary education can be co-curricular and exist as student organizations (like the Junior Engineering and Technical Society) or competition teams, such as FIRST Robotics. While many schools adopt STEM, or specifically engineering programs to be "cutting edge" (re: stem academy, stem certification), many states have standards that already include engineering skills, and new national standards are introducing engineering in a whole new way.

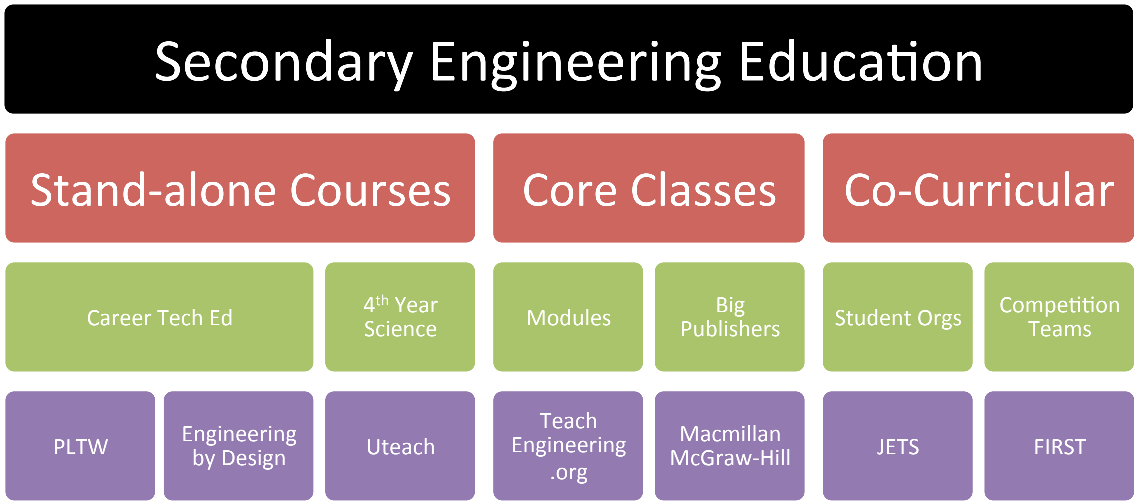

Figure 1.1 Engineering in Secondary Education, examples

1.1.6.1.1 Standards

Engineering exists in state standards across the nation. Students are learning about engineering and technology design formally and informally in both academic and vocational classrooms. Carr, Bennett and Strobel (2012) performed an examination and analysis of mathematics, science, technology and vocational/career standards in all 50 states. Findings show that 41 states have engineering content in their educational standards, though five of these states were found to have only minor or weak references to engineering and technology design components. Their analysis identified that of the 36 states with a strong presence of engineering, eleven states have their own explicit engineering standards, fifteen states have explicit engineering standards borrowed from the Standards for Technological Literacy from the ITEEA, four states aligned explicit engineering standards with Project Lead the Way curriculum, and six states have engineering in the context of technology design (Figure 1.2). Engineering or technological design standards from these 36 states appear in different standards sets.

Twelve states have engineering content that can be found in science standards, 8 in technology standards, 5 in engineering and technology standards, 2 in STEM standards, 8 in career and vocational standards and 1 state had references to engineering or technological design in their math standards (Figure 1.3). Carr, et al (2012) assert that this large presence of pre-college engineering, just like educational standards, is not going away soon.

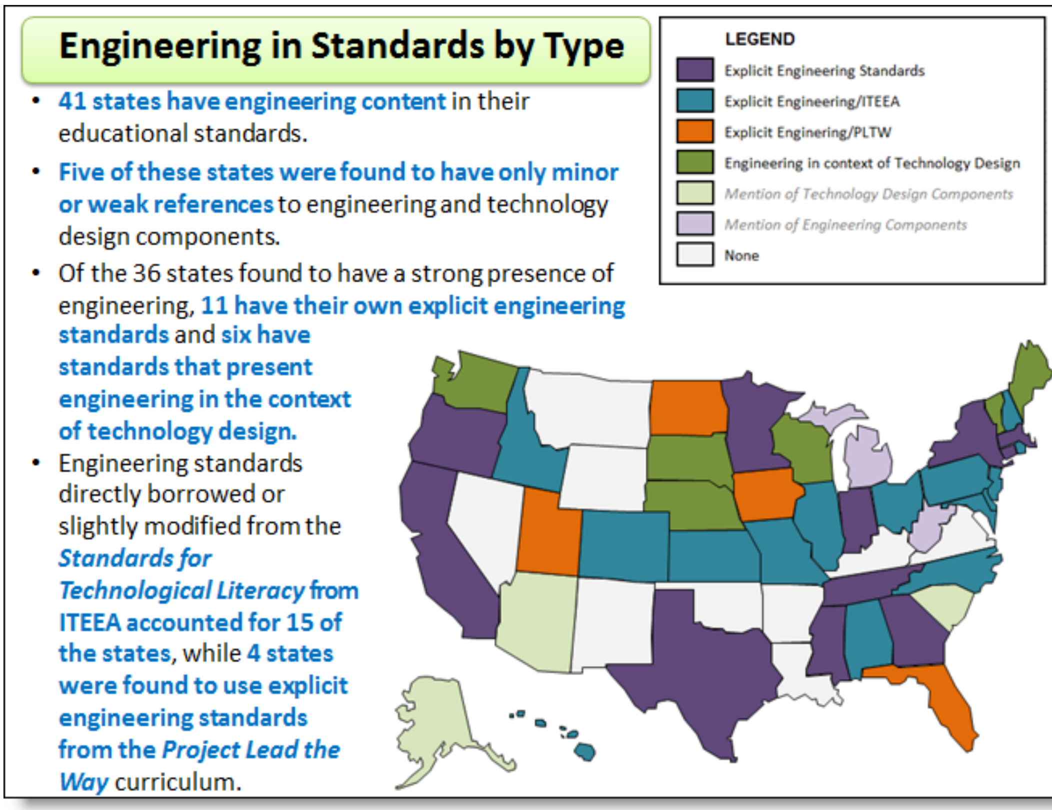

Figure 1.2 Engineering Standards by Type

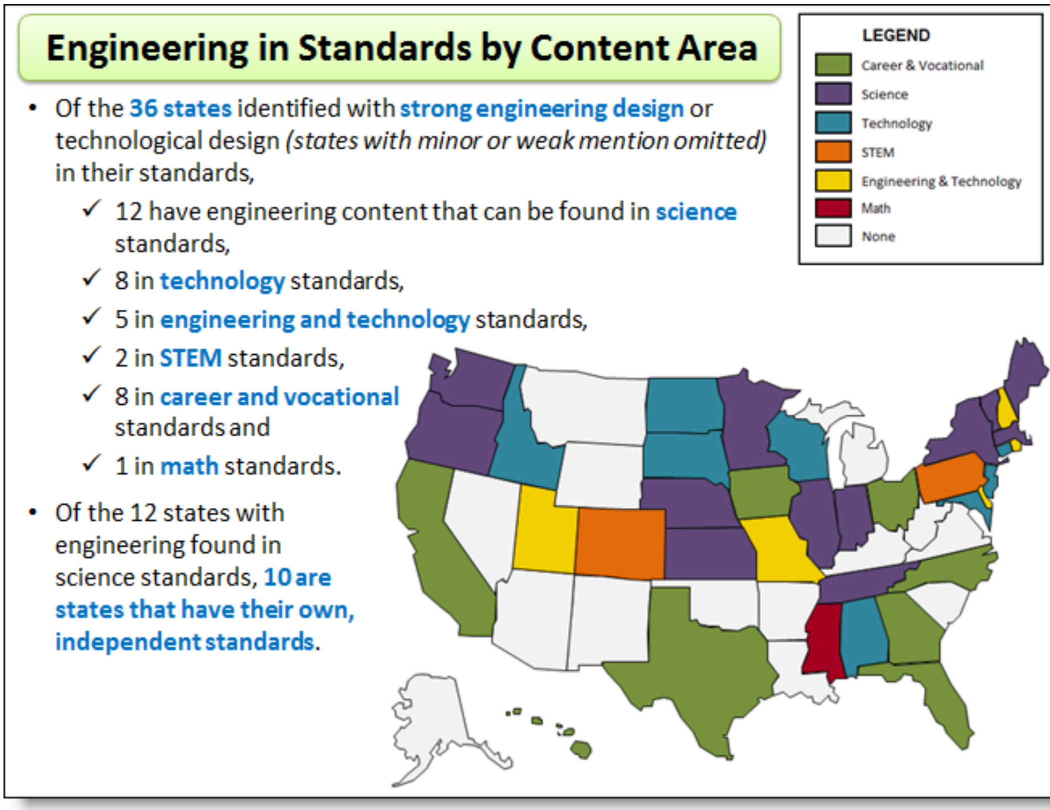

Figure 1.3 Engineering Standards by Content Area

Again looking at the 36 states with strong engineering design or technological design content, twenty states include engineering in their standards throughout K-12, nine are just in high school, six are in middle and high school grades, and South Dakota has engineering design or technological design content only in K-5 and middle school grades.

In an effort to quantify the market of students who have engineering standards, the National Center for Education Statistics enrollment data (2009-10 latest available at time of report) was cross-sectioned with the data from Carr et al.'s (2012) state standards analysis. The objective was to get a snapshot of the potential reach of engineering based on what the states report in their standards. What these numbers do not take into consideration is the variation in what exact grade level engineering appears in the standards, so these numbers are not precise. Regardless, the objective is to simulate the reach of formal secondary engineering education in the public U.S. high schools as it stands today.

In the 2009-10 school year, there were 12.2 million public high school students across the 36 states with engineering in their state standards, see Figure 1.4. Figure 1.5 shows that 3.5 million public high school students should, based on the standards, be learning engineering in their science class. The average number of science credits required for graduation among these states is three[5], so it is reasonable to assume that approximately three million students should be learning engineering annually in their science course, not to mention technology or career and vocational courses.

[5] Data extrapolated from individual states' websites by the researcher.

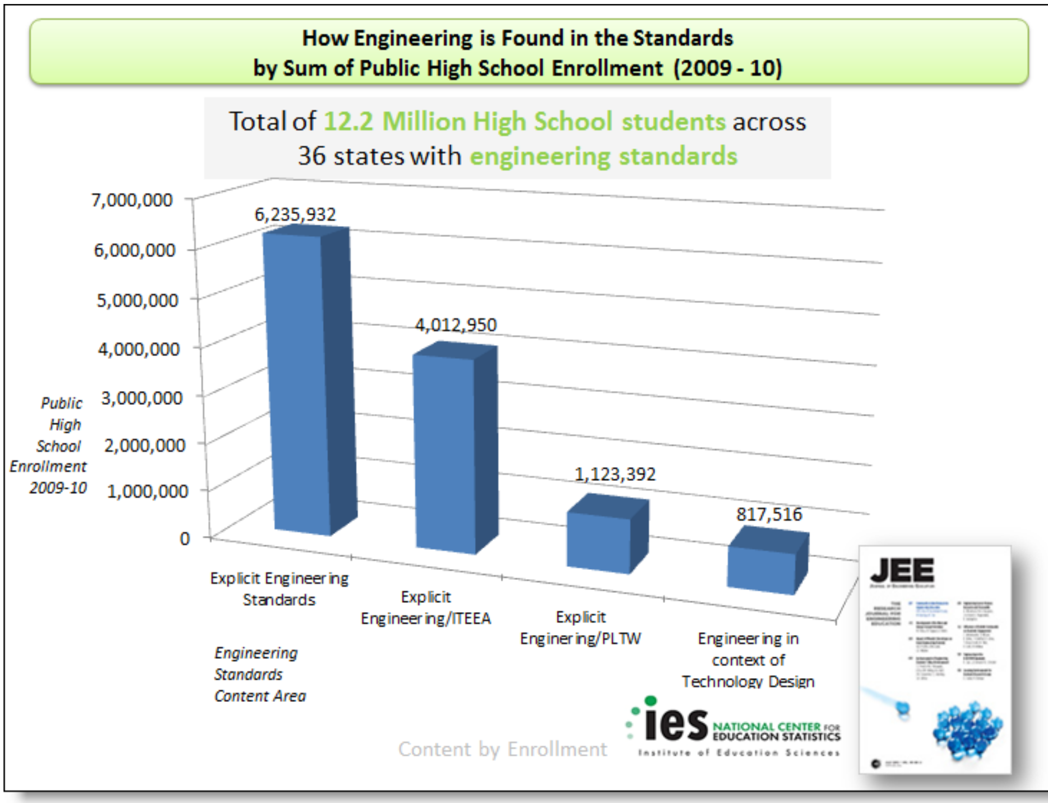

Figure 1.4 How Engineering is found in the Standards by Public HS Enrollment

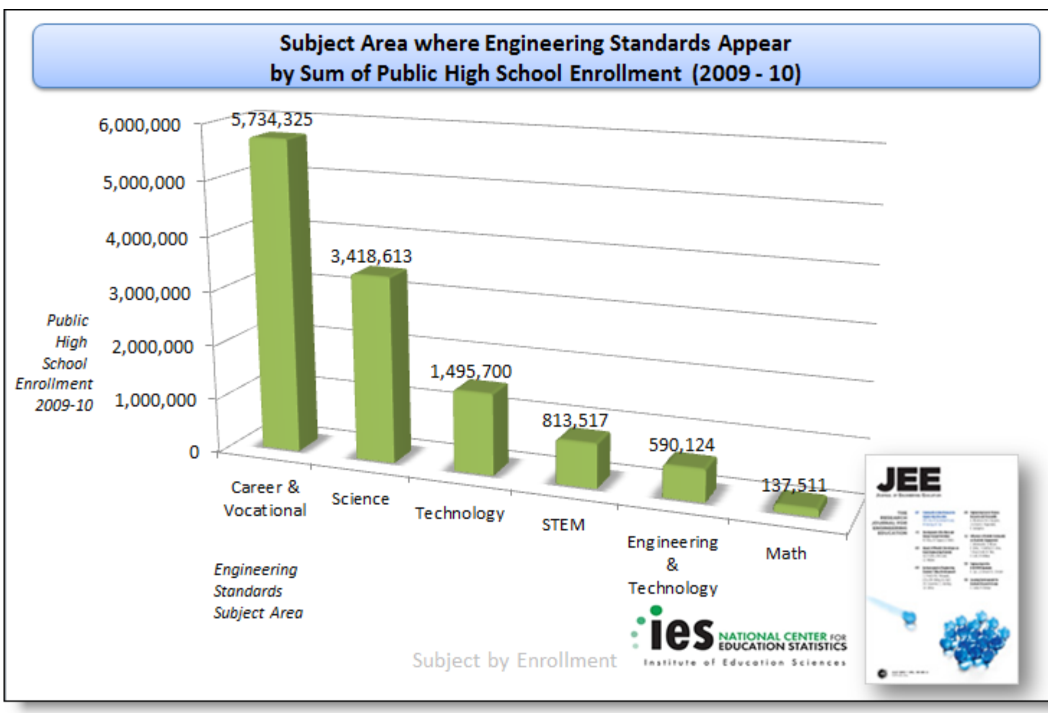

Figure 1.5 Subject Area where Engineering Standards Appear by Public HS Enrollment

1.1.6.1.2 New Standards

The development and adoption of new standards that require engineering ways of thinking and doing, or directly relate to engineering practices provide substantial opportunity for engineering in the classroom. The Common Core State Standards Initiative (CCSSI) is a state-led effort to establish a shared set of clear educational standards for English language arts and mathematics that states can voluntarily adopt. The high school standards call on students to practice applying mathematical ways of thinking to real world issues and challenges, and emphasize mathematical modeling – both cornerstones to engineering thinking and design[6]. At the time of data collection[7], 45 states and three U.S. territories have adopted the Common Core. Grounded in the most current research on science and science learning, the Next Generation Science Standards, final release of April 2013, with 11 stated committed to adopting, identify content and science and engineering practices that all students should learn from kindergarten to high school graduation[8].

[6] http://Www.corestandards.org/about-the-standards/key-points-in-mathematics
[7] Summer of 2012
[8] http://Www.nextgenscience.org/implementation

1.1.6.1.3 Participation

The National Center for Education Statistics9 analyzed public high school graduates transcripts for participation in career/technical education courses.

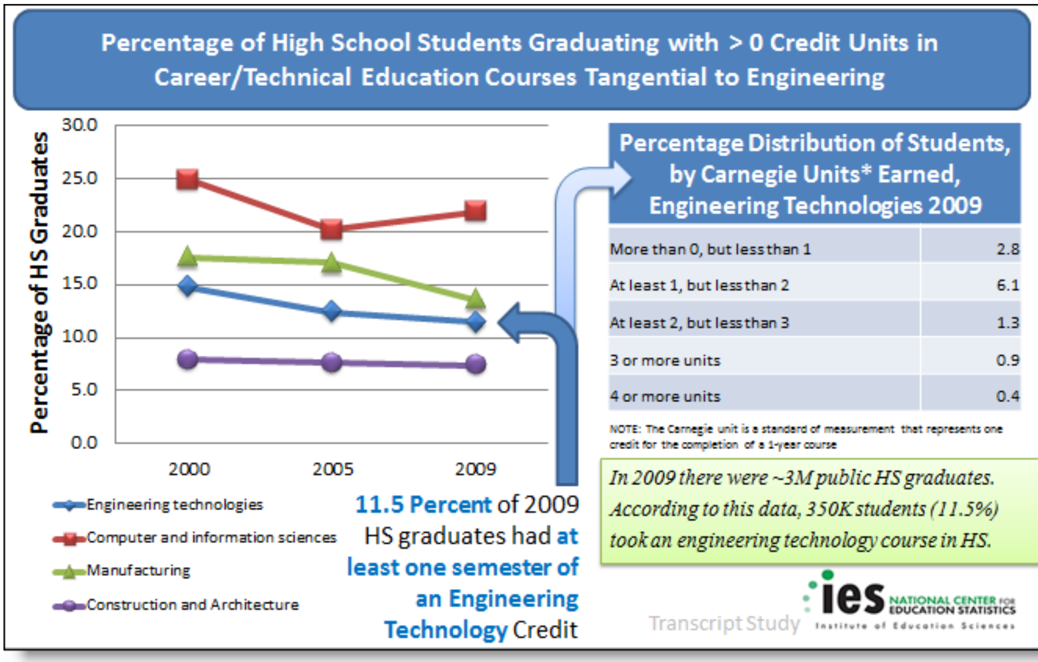

Figure 1.6shows the percentage of high school graduates who had at least one semester of a CTE course tangential to engineering. In 2009, 11.5 percent of public high school graduates had at least one semester of an engineering technology credit. When you consider there were approximately three million public high school graduates that year, according to this study, 350K students of the 2009 graduating class took an engineering technology course in high school. In that same year, 145K students enrolled as first year or freshman students, in engineering or engineering technology undergraduate degrees[10].

[9] http://nces.ed.gov/programs/digest/d11/tables/dt11_160.asp

[10] Science and Engineering Indicators 2012 by the National Science Foundation. http://Www.nsf.gov/statistics/seind12/c2/c2s2.htm#s1

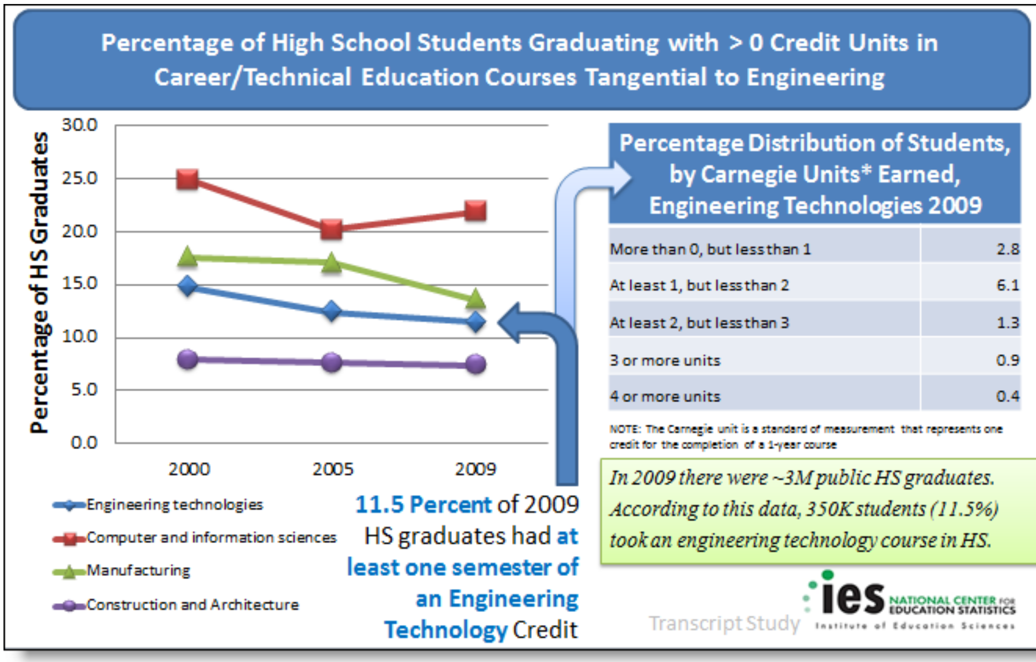

Figure 1.6 Percentage of Public High School Students Graduating with >0 Credit Units in Career/Technical Education Courses Tangential to Engineering

1.1.6.1.4 State 4x4 Requirement

Over the last few years, many states have increased the math and science credit requirements for high school graduation. With some states moving to a 4x4 curriculum, requiring four years of math and four years of science, there is the opportunity for engineering curriculum to meet the fourth year science/math requirement for students. Through an analysis of graduation requirements posted on individual states' websites, eight states currently require four years of math and four years of science for public high school graduation. These states include: Alabama, Connecticut, District of Columbia, Georgia, Indiana, Louisiana, Mississippi, and Texas. The public high school enrollment for these 8 states in 2009-10 was ~2.9 million students. Figure 1.7 is a snapshot of current state math and science credit requirements for high school graduation. More states may move to a similar requirement in the next decade.

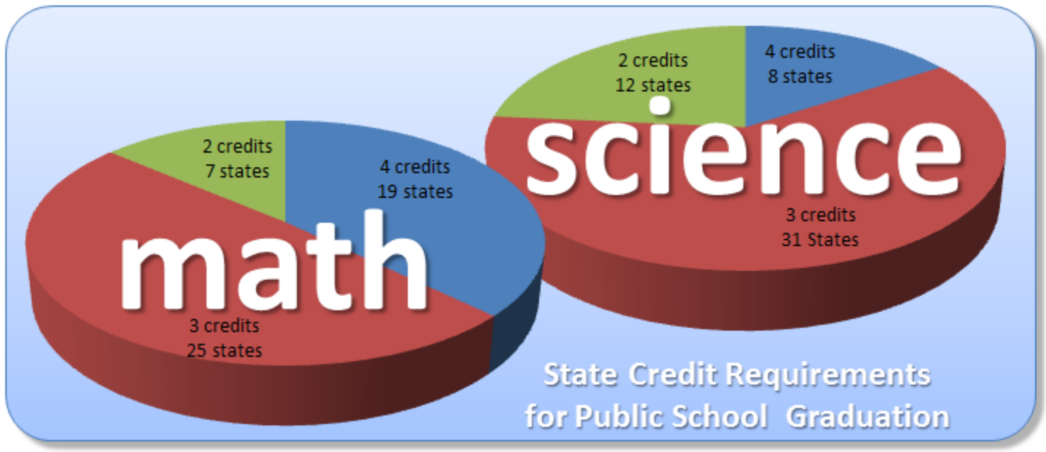

Figure 1.7 State Credit Requirements for Public High School Graduation, Math & Science

Engineering exists in K-12 as standalone courses, integrated among core classes, and/or as co-curricular activities. As STEM education continues to be a growing national priority, and as more states adopt new standards, we will begin to see more schools with engineering programs.

1.1.6.2 <u>What Should K-12 Engineering Curriculum Look Like?</u>

Although there are many engineering curriculum solutions, not all are meeting the guidelines set forth by the NAE or grounded in research. Curriculum content should be accurate and reflective of engineering, promote technological literacy, use positive and effective messaging, be inclusive, integrate well with STEM, and provide opportunities for career exploration.

1.1.6.2.1 Content

The report by the NAE and National Research Council (NRC), *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*, outlines three general principles for K-12 education (Katehi et al., 2009):

Principle 1: K-12 engineering education should emphasize engineering design.

Principle 2: K-12 engineering education should incorporate important and developmentally appropriate mathematics, science, and technology knowledge and skills.

Principle 3: K-12 engineering education should promote engineering habits of mind. Habits of mind are systems thinking, creativity, optimism, collaboration, communication, attention to ethical considerations.

1.1.6.2.2 Increase technological literacy

An earlier report by the NAE and NRC suggests that because our economy is increasingly being driven by technical innovation, and because an increasing percentage of jobs require technological skills, a rise in technological literacy would have positive impacts for our community (Pearson & Young, 2002). Technological literacy is defined as encompassing at least three distinct dimensions: knowledge, ways of thinking and acting, and capabilities (Pearson & Young, 2002).

1.1.6.2.3 The message of engineering must be correct and clear

When compared to other professions, such as medicine or civil service, engineering is largely misunderstood by the general public. Educational research shows that K-12 teachers and students generally have a poor understanding of what engineers do

(Cunningham, Lachapelle, & Lindgren-Streicher, 2005; Knight & Cunningham, 2004), and it is most often believed that engineers "fix" or "construct" things like a car mechanic or construction worker. In addition, public perception of the prestige of professions ranks engineers in the middle of the pack, far below firefighters, scientists, doctors, and nurses (Harris Interactive, 2004). After all, a typical stereotype engineer seems to fit the image of *Dilbert*, a cartoon character of a corporate cubicle bound engineer who is smart, honest, inflexible, and dull, a stark contrast to the image of a "renaissance" engineer, Leonardo da Vinci, who was creative, literate, and well-rounded (Yurtseven, 2002) (needless to say both images are male). Dilbert is hardly an accurate portrait of engineers today, and certainly not a figure young people would desire to emulate.

In a famous clarifying quote from Theodore von Kármán, "Scientists investigate that which already is; Engineers create that which has never been."

In general, the public, and especially students, have a poor understanding of what engineers actually do on a day-to-day basis, and there is a strong sense that engineering is not "for everyone," and perhaps especially not for women. Current messages of engineering frame it as requiring extraordinary skills in mathematics and science, and that without an aptitude and strong interest in these subjects, one is unlikely to succeed in engineering. In order to sustain U.S. capacity for technological innovation, and to attract young people to careers in engineering, the NAE commissioned a study (released in 2008) to identify and test positive messages of engineering to improve the public's understanding (Committee on Public Understanding of Engineering Messages, 2008). The study found that the "branding" of engineers must be modified to appeal to different audiences, especially young women. By changing the conversation from an emphasis on math and science, to the value that engineering has on our society, we can attract more students to engineering. The results of the study found the following three statements to be the most accurate and positive descriptors of engineering:

1. Engineers make a world of difference and help shape the future.

   From new farming equipment and safer drinking water to electric cars and faster microchips, engineers use their knowledge to improve people's lives in meaningful ways.

2. Engineering is essential to our health, happiness, and safety.

   From the grandest skyscrapers to microscopic medical devices, it is impossible to imagine life without engineering.

3. Engineers are creative problem-solvers.

   They have a vision for how something should work and are dedicated to making it better, faster, or more efficient.

Thus, according to the 2008 report by the NAE, *Changing the Conversation*, it is imperative for engineering education to have an aligned message of engineering. K-12 engineering education efforts should not stray from the new positioning statement for engineering:

> "No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their

imaginations to help us meet the needs of the 21st century."—NAE New Positioning Statement

1.1.6.2.4 The material should be inclusive

There are consequences to having material and activities that ignore gender and race (Rosser, 1998). Because females are more likely to be interested in topics and choose careers with a strong social value (Ashby & Schoon, 2010; R. Duffy & Sedlacek, 2009; M. Jones, Howe, & Rua, 2000; Ros, Schwartz, & Surkiss, 1999; Simpkins & Davis-Kean, 2005), it is important to broaden pre-engineering from the typical robots, racecars, and rockets. Naturally, implicit biases are are mitigated as much as possible not perpetuated in new curricula (Hill, Corbett, & St Rose, 2010).

1.1.6.2.5 The material should integrate well with STEM

The NAE and NRC call for an integrated STEM education (Katehi et al., 2009). Science, technology, engineering, and mathematics are so closely intertwined that it should be impossible for an education in one to be in isolation of another (AAAS (American Association for the Advancement of Science), 1993).

The integration of engineering in a way that includes collaborative learning, hands-on experiences, engaging authentic activities, emphasis on practical applications, and the teaching of science and math in a more holistic, inclusive and social context (Barton, 1998; Campbell, Jolly, Hoey, & Perlman, 2002; Carlson & Sullivan, 1999; Fancsali, 2002; Wenglinsky, 2000) can positively affect high school students' STEM performance and increase student awareness and interest in engineering.

1.1.6.2.6 The program provides for career exploration

In a nation that was seeded by freedom and opportunity, the roots of the United States are grounded by hard work, innovation, and determination. Most often through identification with a worker, ages 5 to 10 is the stage of life when the concept of working becomes ingrained in the child's conception of his or her adult life (Havighurst, 1964). Immersed in a society that is dominated and driven by work, and vulnerable to social influences of prestige and gender bias, children as young as 5 years begin to postulate what career they will one day have (Gottfredson, 1981). Young people tend to choose professions that are familiar (Parker & Jarolimek, 1997), whether traditions in their family or professions they have been exposed to through education and experience. Young children can begin to gather information about careers and acquire the skills and competencies that will one day support success in the workplace (P. Duffy, 1989). Harkins states that because work readiness is developed over time, it makes sense to begin with young children (Harkins, 2001). It is important that the program curricula include plenty of opportunities to explore careers, in this case various disciplines of engineering.

1.1.6.3 Summary: K-12 Engineering Education

Why do we have engineering in K-12? To meet the workforce demands for a technologically literate, and scientific and mathematically minded people, we must begin to prepare students in K-12. We cannot wait until students specialize in a discipline in university. The NAE has directed much of the conversation on K-12 engineering education through its research and reports. These reports act as a framework for what K-12 engineering education should look like and achieve within the K-12 education system.

Engineers are in demand, yet women are significantly underrepresented in engineering fields and degree programs in the United States. Introducing engineering to students in grade school is one way to address the pipeline issue of participation, and it is growing more and more popular. Thus we should study these instances/environments to better understand the experiences and needs of young women to ensure we are able to increase female participation and persistence in engineering.

1.2 Focus of the Study

Within K-12, students can learn engineering ways of thinking and problem solving, as well as become more aware of specific engineering careers and opportunities for their future. Thus, the purpose of K-12 engineering is career readiness, awareness, and problem solving—but ultimately, it is designed to increase the pipeline of students entering into engineering degrees and careers. However, if K-12 engineering perpetuates the gender divide, then will not solve the problem and we will are create inequitable learning environments and additional access issues for one-half the population (more, including minorities). Although grade school engineering curricula exist, they are not widespread in the United States, and any instances should be studied to improve the curriculum, pedagogy, and environment for underrepresented groups such as females.

To understand how students engage with and experience engineering in grade school, it is useful to examine through the lens of race, gender, and class, because this intersection frames much of the human experience. The literature identifies that gender, race, and class influence experiences and that their intersection is important to understand. However, it has not been explored among females in high school engineering.

Feminist theories are underutilized within engineering education scholarship, and engagement with feminist theories are described to be a beneficial way to move the field forward. Identity and oppression of marginalized groups are complex, and intersectional feminism seeks to understand gender in relation to other identities such as race, class, ethnicity, sexuality, and nationality. This theory asserts that gender alone is neither a total identity nor a universal experience, and it is thus advantageous to consider each of the intersecting layers of identity so as to not privilege a dominate group as representative of all women.

Surveys could help us to understand interest and motivation and broad equity and access issues; however, they do not allow for a nuanced understanding of the experiences of young women in engineering, and how those experiences might potentially influence their persistence, and participation of other females in engineering. We have stories of young women in university engineering, but there is a dearth of information on the experiences of young women in the nascent K-12 engineering. Therefore, it is important to paint a picture of high school females' experiences in engineering.

1.3 Objective of the Study

To tell a rich nuanced story of young women in high school engineering, we cannot just look at their experiences as one dimensional, that is, as gender alone. Our experiences are influenced by not only gender, but also race, class, sexuality, and age—

multiple dimensions that intersect to frame our unique experiences. These intersections matter.

The purpose of this study is to richly describe the diversity of female experiences in high school engineering as influenced by dimensions of intersectionality. The research is a multiple case study analysis of the experiences of young women in high school engineering, answering the question: *How do gender, class, race, and other components of intersectionality, influence high school females' experiences in engineering?* Nine young women volunteered to participate. This study will share their stories and will allow us a better understanding of how these experiences influence female participation and persistence, leading us to improve equity and access for all in engineering.

CHAPTER 2. THEORETICAL FRAMEWORK

The previous chapter makes an economic, social, and political case for this study by describing the demand and disparity of women in engineering, and the status of engineering education in K-12. This chapter briefly examines the current research around the diversity of experience for women in high school engineering, explicitly identifies a gap in the research, makes the case for the theoretical perspective, and establishes a conceptual framework for the evaluation of the experiences of young women in high school engineering.

2.1 High School Engineering

Increasing the engineering pipeline is a national imperative, and that includes bringing engineering into K-12. The case has been made that K-12 engineering education can "support acquisition of a wide range of knowledge and skills associated with comprehending and using STEM knowledge to accomplish real world problem solving through design, troubleshooting, and analysis activities (Brophy, 2008)," to help us reach the economic goals, but little has been done to help us understand the influence of high school engineering on the social goals of increasing the participation of women in engineering.

Chapter 1outlined the status of K-12 engineering education: where it appears and what it should look like; however, currently there little data to help us understand what the student experience is in the high school engineering setting. While some research exists from the K-12 teacher perspective regarding perceptions and professional development (Daugherty, 2009; Yaşar, Baker, Robinson−Kurpius, Krause, & Roberts, 2006; Zarske, Sullivan, Carlson, & Yowell, 2004), there is even less regarding students. There is research about primary school student perceptions on engineering (Capobianco, Diefes-dux, Mena, & Weller, 2011; Cunningham et al., 2005; Fralick, Kearn, Thompson, & Lyons, 2009; Knight & Cunningham, 2004; Oware, 2008), the effects of pre-engineering on math and science achievement (Tran & Nathan, 2010), high school student attitudes about STEM (Aschbacher, Li, & Roth, 2010; Mahoney, 2010), and studies on engineering design or problem solving in K-12 (Apedoe, Reynolds, Ellefson, & Schunn, 2008; Klahr, Triona, & Williams, 2007; Watkins, Spencer, & Hammer, 2014). However, no research focuses deeply on the female student experience inside the high school engineering classroom.

2.2 Gender in Engineering Education

Understanding the current state of women in the engineering pipeline, and the environment in which we are training future female engineers and releasing them into, enables increased clarity to the sociological and physiological implications for young women in the classroom. The book *Why So Few?* (Hill et al., 2010) is an excellent synopsis of the research that aims to understand gender disparity in STEM, and I refer to this free publication for a more comprehensive discussion. For the purpose of laying the theoretical groundwork, listed below are brief highlights drawn from the book:

- Gender differences in self-confidence in STEM subjects begin in middle school and increase in high school and college, with young women reporting less confidence than young men do in their math and science ability (Pajares, 2005).
- Though young women take more science and math classes, and make better grades in these subjects than males (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; U.S. Department of Education - National Center for Education Statistics, 2007), they are not choosing STEM careers – opting for more commonly perceived socially beneficial careers (Eccles, 1994).
- Interest in an occupation is influenced by many factors, including a belief that one can succeed in that occupation, and culturally prescribed gender roles (Correll, 2001; Eccles (Parsons), Adler, & Meece, 1984; Wigfield, Eccles, Schiefele, Roeser, & Davis Kean, 2006).
- Two stereotypes are prevalent: girls are not as good as boys in math, and scientific work is better suited to boys and men. As early as elementary school, children are aware of these stereotypes and can express stereotypical beliefs about which science courses are suitable for females and males (Good, Aronson, & Inzlicht, 2003; Good, Rattan, & Dweck, 2012). Stereotype threat may also help explain why fewer girls than boys express interest in and aspirations for careers in mathematically-demanding fields. Girls may attempt to reduce the likelihood that they will be judged through the lens of negative stereotypes by saying they are not interested and by avoiding these fields. Teaching a growth mindset promotes persistence in STEM (Good et al., 2012).

- Most people associate science and math fields with “male” and humanities and arts fields with “female” (Nosek et al., 2009). Implicit bias is common, even among individuals who actively reject these stereotypes. This bias not only affects individuals’ attitudes toward others but may also influence girls’ and women’s likelihood of cultivating their own interest in math and science.
- Many young women graduate from high school with the skills needed to succeed in majors in science, technology, engineering, and mathematics, yet college-bound women are less likely than men to pursue majors in these fields (National Science Board, 2010). The culture of academic departments in colleges and universities has been identified as a critical issue for women’s success in earning college degrees in STEM fields (National Academy of Sciences, 2006).
- People tend to view women in “masculine” fields, such as most STEM fields, as either competent or likable but not both, and the combination of these traits are important for advancement in the workplace (Heilman, Wallen, Fuchs, & Tamkins, 2004). This balance may be more difficult for women than men to achieve in science and engineering fields, and thus may impede advancement.

As this list demonstrates, stereotypes and gender roles create cultures that negatively affect the confidence of women to enter into and succeed in STEM disciplines. As a result, gender influences females’ career choice (Ceci, Williams, & Barnett, 2009; Halpern et al., 2007; Hill et al., 2010). Researchers have studied this phenomena for decades. Much of the research claims that self-efficacy, relating to Social Cognitive Career Theory(R. W. Lent et al., 2005), is the leading factor in why girls do not choose engineering (Marra, Rodgers, Shen, & Bogue, 2009; Zeldin, Britner, & Pajares, 2008;

Zeldin & Pajares, 2000). In addition, research on stereotype threat (Corra, 2007; P Huguet & Régner, 2007; Pascal Huguet & Régner, 2009; Steele, 1997), and gender bias (Nosek et al., 2009; Sadker & Sadker, 1994) have implications for girls in STEM classrooms. These theories indicate that gender does influence choice to pursue engineering, but the theories have not been explored inside the high school engineering classroom.

2.3 Race in Engineering Education

People of color are significantly underrepresented in engineering, and it is important to understand the influence of race on students' participation and persistence in engineering. Disaggregation by gender and race/ethnicity in the study of persistence in engineering has been called for (George & Science, 2001) but has not been undertaken on such a scale as is accomplished by a team of researchers working with a large cross-institutional longitudinal data set of matriculating engineering students[11]. From their work, Lord et al (2009) offer a thorough description of the status of representation and persistence of people of color in engineering. Later publications by the same research team (Ohland et al., 2011) found that gender differences in persistence of Asian, Black, Hispanic, Native American, and White students are far outweighed by institutional differences, where racial differences are more pronounced. To provide context to some of these differences, Amy Slaton provides a historical account of race and engineering in *Race, Rigor, and Selectivity in U.S. Engineering* (2010). The book describes the history

[11] Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). MIDFIELD includes student data from 12 engineering colleges, including seven of the 50 largest US undergraduate engineering programs. https://engineering.purdue.edu/MIDFIELD

of the staunch racial divide and overt efforts to keep African Americans out of engineering, all the way into the 21st century. While some research has examined race in a university engineering education context (Besterfield−Sacre, Moreno, Shuman, & Atman, 2001; Hackett, Betz, Casas, & Rocha-Singh, 1992; McGee, 2009), few studies examine student experiences with race as a contributing factor, with one notable exception (Foor, Walden, & Trytten, 2007), where no studies at a high school level are identified in the literature. If we examine only the behavior of the majority in engineering, the White, male population, we will not be able to understand the depth of experiences of those underrepresented, and learn how to improve equity and access for those students.

2.4 Class in Engineering Education

Calls for diversity in engineering to include the underrepresented, expands further from gender and race, but also income status or social class (Stanley, Sterkenburg, & Dillman, 2003). Strutz et al. (2012) calls students of low socioeconomic status an "Invisible Minority," as their needs are different, yet largely unaddressed by larger systemic programs within institutions. Social class impacts parents' attitudes toward their children's education (Gorman, 1998), and as a result, a student's choice in a higher education institution is powerfully shaped by their social class (and race) (Reay, David, & Ball, 2005). Ohland et al. (2012) show the relationship between a student's socioeconomic background, gender, and race/ ethnicity as it relates to college access and graduation rates in a large sample of engineering undergraduates. Using Social Cognitive Career Theory (SCCT) as a framework, Strutz et al. (Strutz et al.) discuss the barriers at every stage of pursuing and completing an engineering degree— barriers that affect low

SES students in particular. Engineering is a high demand and high wage field, and by limiting access to and success in college for lower socioeconomic students, social class reproduction occurs – an issue of social justice. With the issue for low socioeconomic students primarily being access to college, it is imperative to study the low socioeconomic student experience at a grade school level. By studying the experiences of these students, we can better understand how to increase their participation in engineering.

2.5 Intersectionality

Feminist literature identifies that gender, race, and class influences experiences, and that this intersection is important to understand. However, it has not been explored among females in high school engineering. Feminist theories are underutilized within engineering education scholarship, and engagement with feminist theory is described to be a beneficial way to move the field forward (Kacey Beddoes & Borrego, 2011).

Identity and oppression of marginalized groups are complex concepts, and intersectional feminism seeks to understand gender in relation to other identities such as race, class, ethnicity, sexuality, and nationality. This theory asserts that gender alone is neither a total identity nor a universal experience, and it is thus advantageous to consider each of the intersecting layers of identity so not to privilege a dominate group as representative of all women. To address the gap in the literature, this study takes an intersectional approach, as it looks at the complete and complex experiences of young women in high school engineering – drawing from the influences of gender, class, race, and other intersecting components.

The intersection of gender, race, class, sexuality, etc. frame much of the human experience and are integral to individuals positions in the social world (Anderson & Collins, 2006; Arrighi, 2001; Berger & Guidroz, 2009, p. 1; Collins, 1993; Cyrus, 1999; Ore, 2000; Rothman, 2005; Weber, 2004). Primarily conceptualizing race, class, and gender as "systems of oppression," authors Berger & Guidroz (2009) reveal how the intersectional approach helps us see that these categories "operate in every social situation"(Weber, 2004, p. 131). These systems operate in the individual lives of young women, and in the classroom. For this study, the theoretical perspective, or the philosophical stance informing the research methodology is intersectional feminist theory. This section provides a rationale for and history of the theory.

The term intersectionality was coined by legal theorist Kimberlé Crenshaw in 1989 and was popularized by Patricia Hill Collins (Crenshaw, 1995), where intersectionality "denotes the various ways in which [social forces] interact to shape the multiple dimensions" of experience (Crenshaw, 1995, p. 358). Throughout the 1990s, researchers began to build on the idea that race, class, and gender were dominant factors that shape people's experiences and complex social relations (Berger & Guidroz, 2009, p. 6; Zinn & Dill, 1996, 1994). Scholars suggested that these intersections are hierarchical, mutually reinforcing, and simultaneous (Collins, 2000). In just two decades, intersectionality has widely transformed notions of both theory and research (Berger & Guidroz, 2009, p. 3; McCall, 2005; Schultz & Mullings, 2006; Weber, 2000, 2004; Yuval-Davis, 2006). Luft (2009) claims that "intersectionality has been the most important analytic and methodological tool in a generation for linking together discrete social histories, theories, and movements." Intersectional feminist theory is a powerful framework for examining the influences of larger social relations.

McCall (2005; via Perry, 2009) asserts that women's narratives or the qualitative research tradition has been at the heart of intersectional scholars' ability to understand the complexities of multiple and overlapping spaces of intersectionality. Dill (2009, p. 32) notes, "We must examine on an analytical level the ways in which the structures of class, race, and gender intersect in any woman's or group of women's lives in order to grasp the concrete set of social relations that influence their behavior." Symington (2004) aptly notes: "Using intersectionality in our work requires that we think differently about identity, equality and power. It requires that we focus on points of intersection, complexity, dynamic processes, and the structures that define our access to rights and opportunities, rather than on defined categories of isolated issue areas." Social issues are vastly complex, and intersectional theory provides the framework for both an analytic and a systematic approach to inquiry, enabling a more complete understanding of experience (Greene & Caracelli, 1997).

The use of intersectional feminist theory "will not only underline the significance of the intersection of race, ethnicity, caste, citizenship status etc. for marginalized women, but serve to highlight the full diversity of women's experiences (Center for Women's Global Leadership, 2001; via Yuval-Davis, 2009)." Intersectionality "forces us to recognize the points at which singular and multiple identities intersect and differently position us and vary our lived experiences" (Perry, 2009). This study aims to examine how the singular and multiple identities of intersectionality serve to highlight the full diversity of females' lived experiences in high school engineering.

2.6 Conceptual Framework

A conceptual framework is a system of concepts, assumptions, expectations, beliefs, and theories that supports and informs the research— and is a key part of the design of a study (Miles & Huberman, 1994). This section describes a descriptive, visual framework that evolved and developed out of the literature and the fieldwork. Thus, to understand the experiences of young women in engineering, we can begin to address the gap by drawing upon the literature from gender studies, sociology, psychology, etc., gathering relevant theories that may shed light on the diversity of experiences in the classroom. To do this, it is helpful to examine from three perspectives: (1) what do the young women bring to the class, (2) what happens in the class, and (3) what do the young women take away from the class. Based on these three perspectives, Figure 2.1 presents a model, or a conceptual framework, for examining the influences on female experience in engineering, where the grey bands represent the three perspectives for analysis.

What is unique about this conceptual framework is that the theories mapped to the bands of the model have never before been integrated to understand and explain the diverse, and complex experiences of young women in high school engineering. The theories introduced here will be explained in greater detail, as they appear relevant to the data analysis in Chapters 4, 5 and 6.

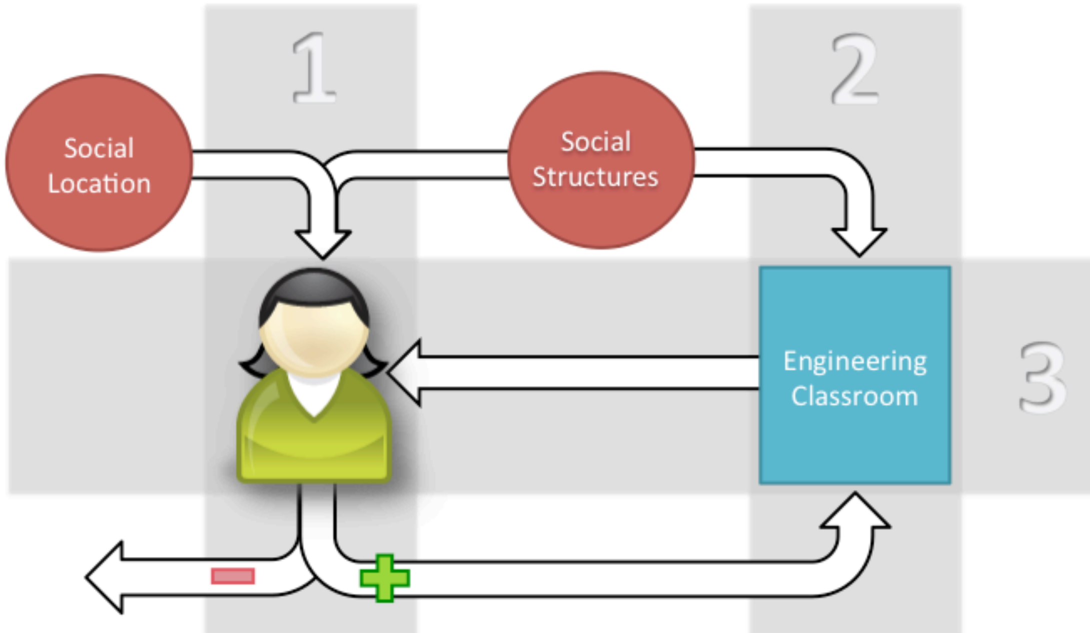

Figure 2.1 Model of Influence on Female Experiences and Persistence in Engineering

2.6.1 Band 1: What Young Women Bring to the Class

How we experience life is dependent on both internal and external forces. For young women in high school engineering, many external forces such as social location and the larger social structures of oppression in society influence an internal sense of self-efficacy and personal interest.

Social location, exhibited by the top left circle of the model, includes characteristics such as given traits of gender, race, and family socioeconomic status, as well as physical location. Macro social structures of race, gender, class, and sexuality, exhibited by the top right circle of model, exist and influence how the world functions. One's identity is formed based on given traits of gender, race, and family socioeconomic status in combination with influences from the larger social structures on one's lived experiences—affecting interests, self-efficacy, and behaviors. If these things are overall more positive than negative, then it can lead to a female student entering into engineering.

In essence, young women bring complex individual experiences into the classroom. This interaction is highlighted by the left grey vertical band labeled 1 in Figure 2.1.

Methodologically, this band elicits questions about family background and support network, personal interests, entry into engineering, lived experience, and home life. Some guiding questions might be: What sort of family or environmental influences introduced them to engineering? How supportive are their parents of their choice to be in engineering? Do their family members and friends encourage them be in engineering despite the lack of representation of other females and associated gender stereotypes? Do they have a network of people that can help them with engineering projects, or provide the tools to complete some of the projects? What experiences do these young women have in male dominated environments prior to or in tandem with engineering? What are their personal interests, and how does their environment influence these interests?

Relevant theories to help analyze what young women bring to the classroom are theories on self-efficacy (Bandura, 1977; R. Lent, Brown, & Larkin, 1986; Luzzo, 1996), self-efficacy as it relates to STEM (Betz & Hackett, 1983; S. E. Cooper & Robinson, 1991; Fantz, Siller, & Demiranda, 2011; Marra et al., 2009; Pajares, 1996; Zeldin & Pajares, 2000), parents as critical influence (Brinkman, Pollock, Jones, & Cardella, 2014; Juyeon Yun, Monica E. Cardella, & Purzer, 2013), interaction across gender boundaries (Thorne, 1993), and social capital (Lin, 2002; Martin, Simmons, & Yu, 2013).

2.6.2 Band 2: What Happens in the Class

Macro social structures are exhibited in the engineering classroom and frame the environment and developed culture, as influenced through the female student, and the overarching social culture. This perspective is exhibited by the right vertical grey band labeled 2 in Figure 2.1. Thus what happens in the class is influenced by macro social structures that create unique classroom environments dependent on all of its participants.

Methodologically, this band elicits questions about classroom culture, power dynamics, participation, engagement and comfort in the classroom. Some guiding questions might be: How does the classroom environment influence student experience? How is the classroom culture created and maintained? How does the teacher contribute to the student's experience? Does the student feel like they belong in the engineering class? How does the majority population of the classroom influence the classroom dynamic? What does this mean for the participants? How does the participant negotiate differences between home life and the classroom?

Relevant theories to help analyze what happens in the classroom are: masculinity (Connell, 2005), negotiating boundaries (Phelan, Davidson, & Cao, 1991), sense of belonging (McPherson, Smith-Lovin, & Cook, 2001), gender displays (West & Zimmerman, 1987), scarcity (Mullainathan & Shafir, 2013), social capital (Lin, 2002), and Micromessaging (Morrell & Parker, 2013).

2.6.3 Band 3: What Young Women Take Away from the Class

The experiences in the classroom influence young women's choice to persist. If identity, interests, self-efficacy, and behaviors are overall more positive than negative, then they can lead to a female student persisting in engineering. Otherwise, it is more likely for the student to leave engineering for other options more aligned with her identity and interests. This perspective is exhibited by the horizontal grey band labeled 3 in Figure 2.1. Because the study is not longitudinal in nature, it may not be possible to extrapolate enough evidence to explain band 3, however, it is more likely that we can make inferences about what the young women take away from the engineering classroom.

The Model of Influence on Female Experiences and Persistence in Engineering directs us to consider three key perspectives on young women's experiences in the engineering classroom. The conceptual framework (Figure 2.1) lays the groundwork for mapping relevant theories, and making sense of the data, in relation to the overarching theoretical perspective. Intersectional feminist theory is the ultimate lens through which the study is designed, conducted, and analyzed, but the conceptual framework (Figure 2.1) lays the groundwork for mapping relevant theories, and making sense of the data, in relation to the overarching theoretical perspective.

CHAPTER 3. METHODOLOGY

In a 2006 report, the Steering Committee of the National Engineering Education Research Colloquies (p. 261) declared the following:

> "Creating a workforce that is capable of thinking and working across diverse perspectives is imperative to the future of engineering. To achieve this goal, we must characterize diversity, build communities that value diversity, and develop programs and initiatives to leverage diversity."

To answer the call to characterize diversity, the purpose and goal of this study is to richly describe the diversity of female experiences in high school engineering as influenced by dimensions of intersectionality. Therefore, for this study, the overarching research question is: How do gender, class, race, and other components of intersectionality, influence high school females' experiences in engineering?

To quote Clandinin and Connelly (1998, p. 154), "In its most general sense, when one asks what it means to study education, the answer is to study experience."

3.1 Method

Crotty (1998, p. 3) articulates that the methods of a research study are the techniques or procedures used to gather and analyze data related to some research question or hypothesis. This includes a triune of the methodology, the theoretical perspective, and the epistemology. The latter two are described in the previous chapter, and the methodology is discussed in detail in this chapter. The methodology includes the strategy, plan of action, process, study context, setting, and design lying behind the choice and use of particular methods and then the linking of the choice and use of methods to the desired outcomes.

According to Olds et al. (2005), engineering education research can be categorized as two types of studies: “descriptive” and “experimental.” In their framework, experimental designs aim to determine the effect of a particular intervention, while descriptive designs aim to improve understanding of the people affected by engineering education (Koro-Ljungberg & Douglas, 2008). This study’s design is descriptive; that is, to improve the understanding of high school females’ experiences in engineering. Qualitative research tends to address research problems that require an exploration, where little is known about the problem, to produce a detailed understanding of a central phenomenon (Creswell, 2008). As a consequence, the nature of the research question is dependent on the views of the participant (Creswell, 2008) and the observations of the researcher. Therefore, to effectively portray a female’s experience, the central phenomenon in this study, the study must be qualitative.

Expounding on the theoretical framework presented in the previous chapter, this study assumes an identity of interpretivism. The purpose of such a theoretical perspective is to describe a situation, experience, or phenomenon. Methods and approaches emerge and are adjusted during the study, so that the research product is a situated description (Koro-Ljungberg & Douglas, 2008, p. 165). Koro-Ljungberg and Douglas (2008) define interpretivism as “a theoretical perspective that believes that truth is situational, and so it depends on the context of the environment, the background and prejudices of the observed, as well as perspectives brought to the situation by the observer.” Interpretivism is a broad category that encompasses many theoretical perspectives but generally aims to increase understanding of people’s subjective experiences (Case & Light, 2011; Koro-Ljungberg & Douglas, 2008).

Studies of situational theoretical perspectives generally involve fewer participants to allow for more in-depth investigation of each participant’s experience. Participant selection thus becomes purposive, rather than based on random or convenience sampling (Case & Light, 2011; Koro-Ljungberg & Douglas, 2008, p. 188). Participants are selected because their unique experiences or individual situations will provide important insights. In addition, all aspects of the research, specifically the analysis and interpretation of the data, are influenced by the researchers’ subjectivities, roles, assumptions, and theories. The subjectivities for this study are explicitly identified in a Chapter 6, to determine how my experiences and roles might shape the study.

I considered phenomenography as one potential methodology for this study. The term “phenomenography” was coined by Ulrich Sonnemann (1954, p. 344) to emphasize “a descriptive recording of immediate subjective experience as reported.” According to

Orgill (2007), phenomenography aims to define the different ways in which people experience, interpret, understand, perceive, or conceptualize a certain phenomenon or aspect of reality. In turn, phenomenographic research seeks a comprehensive record of the variation of people's experiences (Case & Light, 2011, p. 199), usually through an open and in-depth interview (Booth, 1997).

Because phenomenography is focused on understanding variation in experiences, it was appealing initially as a methodology. The differentiating factor, however, is that phenomenography seeks to uncover the different ways in which a phenomenon is experienced by people in a *particular* context (Case & Light, 2011, p. 206, emphasis added). In this study, the context becomes greater than the phenomenon of the engineering class alone. With intersectional feminist theory as the underlying framework, each participant's context is an embodiment of all of her experiences, not just those from inside the classroom walls. This study aims to understand not only each participant's experiences in engineering, but also her personal "context" that is framed by her gender, race, class, and sexuality and the influences of these demarcations on her engineering experiences. This variation in context translates to a variation in phenomenon, or each individual's experience. The outcome of a phenomenographic study does not become a record of individuals, but a collective record (Case & Light, 2011). A goal of this study is to emphasize the experiences of the individual first and foremost. Therefore, phenomenography is not the ideal methodology for this study.

I identified discourse analysis as another potential methodology for this study. Discourse analysis focuses on instances of socially situated communication and seeks to link those instances to the underlying cultural ideas that they represent (Case & Light, 2011; Hicks, 1995). Given the value of sociological influences on the research question, such an analysis seemed like an appealing means to get insights into the beliefs, values, and worldviews held by participants and reflected in their discourse. Gee (2011) articulates four tools of inquiry for discourse analysis: social language, discourses, conversations, and intertextuality. The scope of this study falls outside the limitation of mere discourse, because the observed experiences are also vital. Although I did not select discourse analysis to be the methodology for this study, its principles will be instrumental in the data analysis of transcribed interviews and observations.

The purpose of this study is to examine high school females' experiences in engineering, with consideration of the influences of their gender, race, and class. Understanding variation in experiences through observation and discourse is important, but the individual story of each individual takes precedence. Qualitative case study was developed to "study the experience of real cases operating in real situations" (Stake, 2006, p. 3), that is, by choosing to study a case, you inherently choose to study the situation.

Yin's (2009) two-fold definition of case study research demonstrates an "all encompassing" method, which converges the logic of design, data collection techniques, and specific approaches to data analysis. Thus, the case study is not limited to being a data collection tactic alone or even a design feature alone (Stoeker, 1991; Yin, 2009). A case study is an in-depth exploration of a contemporary phenomenon—in this study, young women's experiences in engineering, within its real-life context, that being the classroom with consideration of influences related to intersectionality (Creswell, 2008; Yin, 2009). Case study research is generally more exploratory than confirmatory

(Hancock & Algozzine, 2006, p. 16) and relies on multiple sources of evidence that will converge in a triangulating manner (Yin, 2009).

Sociological case study research examines the structure, development, interaction, and collective behavior of organized groups of individuals (Hancock & Algozzine, 2006, p. 32). Examples of case studies in education using a sociological perspective have explored student-teacher interactions, middle school social structures, and the impact of equity issues and student achievement (Lecompte & Preissle, 1993). Taylor (2009) summarizes that there are multiple approaches and methods for exploring intersectionality, but both Valentine (2007) and McCall (2005) highlight the use of the case study approach. These researchers used case study with intersectional feminist theory to define an individual's experience and then extrapolate it to the broader social location embodied by the individual.

Multiple, or collective, case study research endeavors to address an issue (research question) while adding to the literature base that helps to better conceptualize a theory (Hancock & Algozzine, 2006; Stake, 1995). Collective case design of a select few instrumental cases will enable greater transferability to a larger collection of cases. Statistical generalizability is typically not an aim of this research; rather the researcher aims to produce generalizability in the context of the study, with the responsibility on the reader to determine transferability to other contexts (Lincoln & Guba, 1985). Herriott and Firestone (1983) claim that "evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust."

In addition, a multi-case study allows the researcher to examine how a phenomenon operates in different environments, or (in this case) how females' experiences of high school engineering vary according to their different social locations. When cases are selected carefully, the study design can incorporate a diversity of contexts (Stake, 2006, p. 23). Flyvbjerg (2001) identifies a range of different strategies that can be used in the selection of cases: (1) choosing a set of cases with maximum variation to explore a range of different settings, or (2) identifying unusual cases that allow the researcher to probe particularly problematic situations, or (3) using critical cases that allow for logical deductions of the type "If this holds for this case, then it will hold for all other cases." Particularly for this study, flexibility is beneficial initially, because the diversity of options within the available pool is not certain.

This introduction to the methodology of this research study describes the rationale for a collective case study. Based on this review of several methodologies, I determined a collective case study design to be the most effective means of answering the research question, while enabling the completed study to add to the literature base for future theory development. Subsequent sections will describe the study context, population, data collection, and data analysis methods. As Eysenck (1976) justifiably imparted, "sometimes we simply have to keep our eyes open and look carefully at individual cases—not in the hope of proving anything, but rather in the hope of learning something!" (p. 9).

3.2 Study Context

The setting for the study is the engineering classes of a 10-year veteran high school engineering teacher, Mrs. Jones at Unnamed High School (UHS). Unnamed High School is located in a suburban area in Central Texas. The community is largely composed of business, technical, and professional people who commute to jobs in and around a large city. At the time of data collection, the school was in its 16th year of operation and had 2,634 students in grades 9-12 and a staff of more than 200 professionals. The ethnic population of the school was White 53.8%, Hispanic 20.9%, Asian 11.6%, African American 9.9%, and Other 3.8%. The dropout rate of UHS is <1%.

A unique characteristic of UHS is the existence of four academic academies within the school: Academy of Science, Technology, Engineering and Math (STEM); Academy of Health Science; Academy of International Business and Economics; and the Academy of Professional Studies. Each Academy has various programs of study, and students who complete a program of study will receive a certification on their diploma. Students must choose at least one program of study, but can complete as many as they like. For example, The Academy of Science, Technology, Engineering and Math is made up of the following programs of study: Engineering, Arts, Audio/Video Technology, Computer Maintenance, Computer Programming, Jr. Reserve Officer Training Corps, Transportation, and Metal Technologies. The requirement to select an academy is new for UHS, and the juniors and seniors that participated in the study did not have to do so.

The Engineering program of study introduces students to the world of engineering and engineering technology. Through hands-on projects, students learn to apply the engineering design process and are introduced to the various fields of engineering. The recommended sequence for grades 9-10 is Intro to Engineering Design, Principles of Engineering, and Technical Writing. Elective options in Engineering, primarily for grades 11-12, are Computer Integrated Manufacturing (Project Lead the Way [PLTW]), Civil Engineering & Architecture (PLTW), Digital Electronics (PLTW), Engineering Design and Development (PLTW), and Engineering Our Digital Future (Infinity).

3.2.1 Recruiting the Volunteer Teacher

In September and October of 2011, I observed five high school engineering classes (see Table 3.1) with the objectives of framing the research questions and methodology for the study and finding a teacher to volunteer his or her classroom for the study. Of the dozens asked, three teachers agreed to volunteer their classrooms for initial observation. I also informally conversed with each of the teachers before and after class, with some discussion occurring while the students were working. These conversations were documented with brief content logs. Of the three that volunteered for an initial observation session, only one invited me to conduct the study in her classroom, Mrs. Jones (Teacher A, see Table 3..

Table 3.1 Classes observed for teacher volunteer recruitment

Teacher	Course	Grades	Date
A	Intro to Engineering	9, 10	9/30/2011
A	Computer Integrated Manufacturing	11, 12	9/30/2011
B	Principles of Engineering	9, 10	10/3/2011
B	Principles of Engineering	9, 10	10/3/2011
C	Principles of Engineering	9, 10	10/6/2011

3.3 Study Population and Sample Size

Identity and oppression of marginalized groups are complex, and intersectional feminism seeks to understand gender in relation to other identities such as race, class, ethnicity, and nationality (Berger & Guidroz, 2009). This theory asserts that gender alone is neither a total identity nor a universal experience, and it is thus advantageous to consider each of the intersecting layers of identity so as to not privilege a dominate group as representative of all women.

Yin (2009, p. 54) writes that each case in a multiple case study "must be carefully selected so that it either (a) predicts similar results (a *literal replication*) or (b) predicts contrasting results but for anticipatable reasons (a *theoretical replication*)." With this replication logic, a minimum of 5 and a maximum of 10 female high school students were to be selected as case studies, with an objective to select females across various dimensions of race and class. This is in line with Stake's (2006, p. 22) claim that the benefits of a multi-case study will be limited if fewer than 4 or more than 10 cases are chosen. Ideally, selections were to result in as much diversity as possible, which were not necessarily proportionate to the school population. This variation goal was not explicitly defined, because its achievement depended on the population available. The complete permutation of discrete variables of race and class with a constant gender are too great for this introductory qualitative study (see Table 3.2), and a complete sampling is outside the scope of a case study design (Yin, 2009, pp. 52-58). Therefore the design of this qualitative experiment, per se, was to select relevant and diverse corners (Table 3.2) representative of the collective experience of females to which users may generalize (Miles & Huberman, 1994).

Table 3.2 Design of Experiment'

Basic Permutation of Participants*

Gender	Race	Class
Female	Hispanic	Low
Female	Hispanic	Middle
Female	Hispanic	Upper
Female	Black	Low
Female	Black	Middle
Female	Black	Upper
Female	White	Low
Female	White	Middle
Female	White	Upper
Female	Asian	Low
Female	Asian	Middle
Female	Asian	Upper
Female	Native American	Low
Female	Native American	Middle
Female	Native American	Upper

**does not factor in low-middle, or middle-upper classifications*

An Example of Selected "Corners"**

Gender	Race	Class
Female	Hispanic	Low
Female	Hispanic	Middle
Female	Hispanic	Upper
Female	Black	Low
Female	Black	Middle
Female	Black	Upper
Female	White	Low
Female	White	Middle
Female	White	Upper
Female	Asian	Low
Female	Asian	Middle
Female	Asian	Upper
Female	Native American	Low
Female	Native American	Middle
Female	Native American	Upper

***limited to available population*

Note. (a) Basic permutation of participants. (b) Example of selected "corners."

I attended all of the engineering classes (grades 9-12) of the participating teacher, with the objective of selecting cases (female students) to invite to the study. After about 1 week of observations, I decided to send letters of invitation to participate in the study home with all of the female students to review with their parents, requesting a response (and signed consent, if applicable) within 1 week. The teacher asked me to explain to each class why I would be present for the next few months and to give a brief overview of the study. After each class, in an adjoining room (lab), I described the study in greater detail to all of the female students and invited them to participate. Twenty female students were offered an invitation packet. Nineteen packets were disseminated across five classes, because one White ninth-grade student immediately refused to participate. The invitation packet included a letter describing the voluntary study (purpose, timeline, forms of data collection, compensation, confidentiality) and consent forms for the student and their parents.

The teacher advocated, without being asked, on behalf of the study in the recruitment of participants. She approached some of the females about participating and put reminders on the daily agenda to return the invitation packets. I discussed this with the teacher, because I was concerned that students would feel pressure to participate to please the teacher. In response, together we were even more explicit with all students that participation was voluntary and would have no influence on the course grade.

A study goal is to make generalizations about females' experiences in engineering. Therefore, to capture the female experience, five was identified as the minimum number of case studies needed to adequately document the breadth of experiences, and 10 was the maximum amount of case studies to maintain manageability by a single researcher. Participation was open to all female engineering students, from grades 9 to 12, of one teacher.

Ten females volunteered for the study; one dropped out after 2 weeks, leaving nine case studies to be analyzed and discussed in this study. Table 3.3 lists each participant's pseudonym, race, age, grade level, class period, and case footnote code (to be described later). Two students were age 14 years, three 16 years, two 17 years, and two 18 years. The students were in grades 9 (2), 10 (2), 11 (1), and 12 (4). All five different class periods, all with the same teacher, were represented. All but two participants (*) chose their own pseudonym.

Table 3.3 Participants: pseudonym, age, race, grade, class period

Pseudonym	Race	Age	Grade	Class Period	Case Footnote Code
Cathy*	White	14	9	3	A
Morgan	White	14	9	4	F
Charlie	Mixed Race	16	10	4	G
Max	Hispanic	16	10	4	E
Madeleine	White	16	11	8	H
Kassie*	White	17	12	5	C
Isabelle	White	17	12	7	B
Luna	White	18	12	7	D
Amanda	White	18	12	8	J

Of the 20 female students invited, 60% are White, 15% Asian, 10% Black, 10% Hispanic, and 5% Mixed Race. It is clear that the majority of students who chose to participate are White (78%). It is unclear why the other 10 students chose not to participate, as well as why no Asian or Black students chose to participate (although they were present in the classrooms).

3.4 Description of the Classroom Setting

The classroom is approximately a 20 ft. x 40 ft. room with a 20 ft. x 10 ft. lab, and the teacher's office is in the back. Computer desks (2.5 ft. deep) are in place along the exterior walls and in a front/back-facing row in the middle of the room. Two sets of three tables for collaborative work are situated between the computer rows. The front of the room includes a worktable with papers, calculators, paper cutters, and tape dispensers for student use and a teacher work table with a laptop and overhead projector. (See Figure 3.1 Classroom diagram)

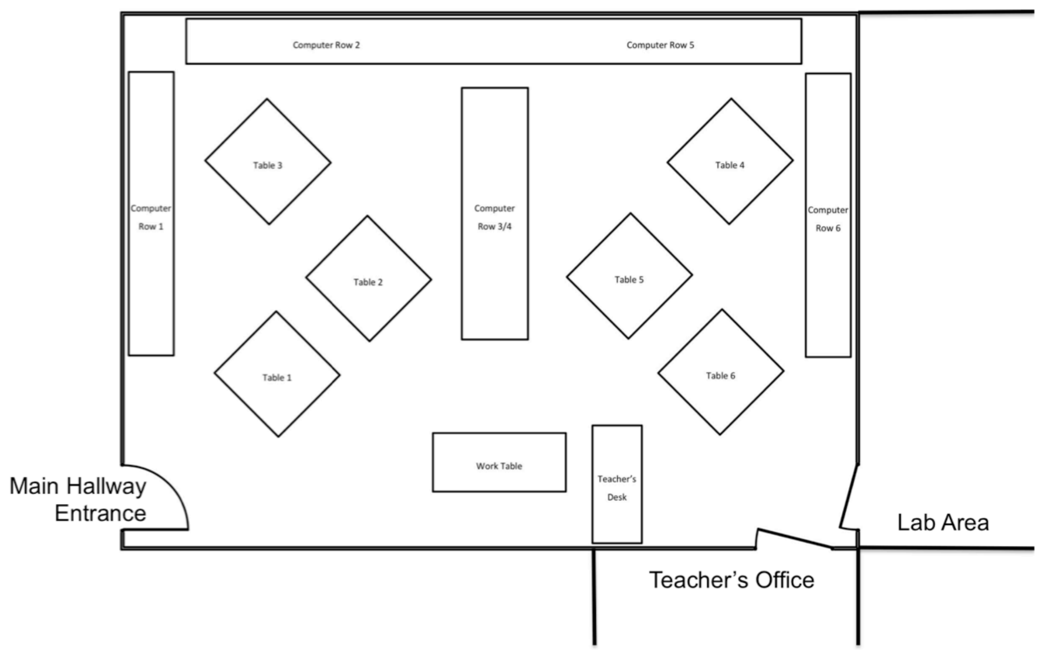

Figure 3.1 Classroom Diagram

Bulletin boards on the left and top walls display building information next to the main entry door, pictures of students on field trips, a 2 ft. x 3 ft. poster with three keys to professional success (1. be on time, 2. over deliver, 3. play nicely with others), a 2 ft. x 3 ft. poster with classroom rules (RESPECT: others, the lab environment, yourself), an 11 in. x 15 in. PLTW poster, a TV with scrolling school announcements mounted in top left corner, printouts of student work on the bulletin boards, and large post-its with handwritten/drawn notes by students about research ideas and how engineering improves lives.

The right wall is half windows looking into the lab. Three more student posters about engineering are displayed on the front wall under a row of windows into the teacher's office. A small poster of the engineering design process is on the front/bottom wall, next to the projector screen. The classroom includes a long row of bookcases with some empty shelves to hold student projects (bottom left of the diagram, in the front of the classroom). Robot arms line the top of the bookcases. The lab contains all of the large equipment (3D printer, laser engraver, CNC mill, and pieces for VEX robotics system) as well as storage for other classroom materials.

3.5 Data Collection

The three kinds of qualitative data—interviews, observations, and documents (Patton, 2002, p. 4)—are the cornerstones for this study. Stake (2006, p. 29) notes that for single-case and multi-case studies, the most common methods of case study are observation, interview, coding, data management, and interpretation. An objective of this study is to encapsulate a comprehensive story of the female's experiences in engineering. Because case studies rely on multiple sources of evidence that will converge in a triangulating fashion (Yin, 2009), this study focuses on three data sources (student, parents, teacher) and three data formats (interviews, observations, documents). Figure 3.2 visually details each individual case design. In each case, the contextual conditions are analyzed in relation to the "case," with the dotted line between the two signaling that the boundaries between the case and context are unlikely to be sharp (Yin, 2009, p. 46).

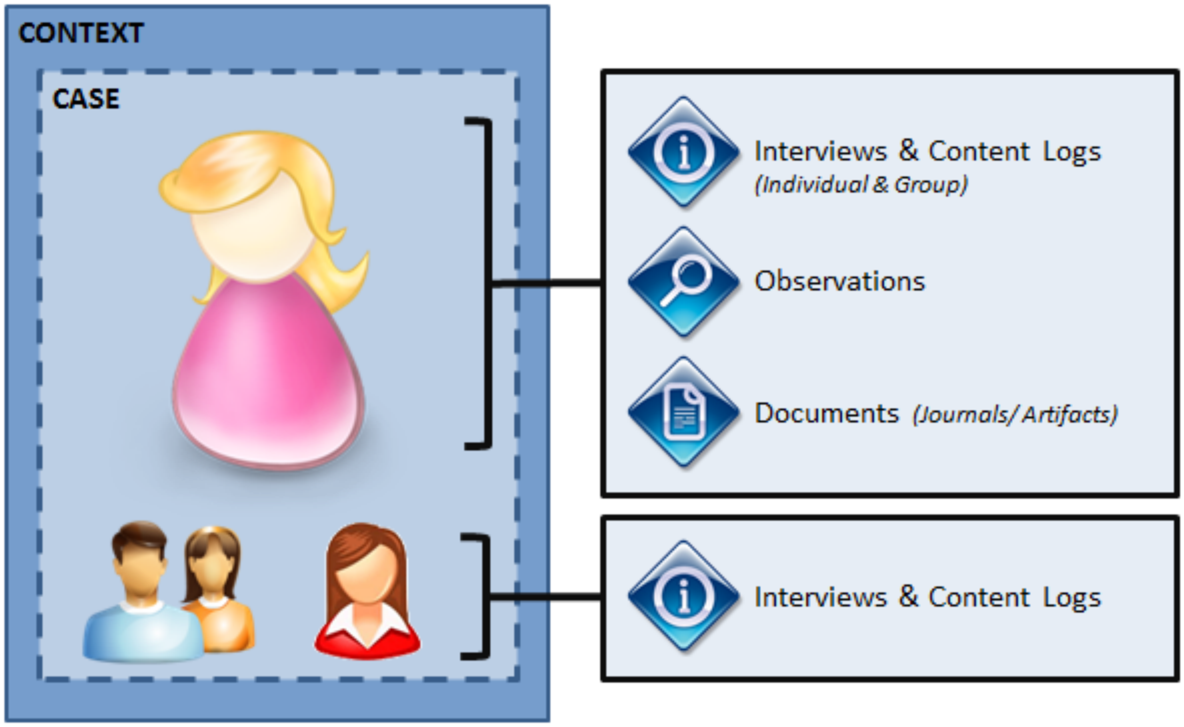

Figure 3.2 Individual case design.

3.5.1 Interviews

I conducted interviews with the student, parent(s), and teacher for each case. Interviews took place after school, during lunch period, or at the convenience of the participant. Classroom observations helped to frame the semi-structured interviews.

I conducted student interviews twice per month beginning mid-March and continuing through May of 2012. I interviewed each student five times, and each interview lasted from 12 to 37 minutes, with the average interview lasting 26 minutes. Interviews were semi-structured. I asked each student several common questions, but approximately 75% of the questions were derived from classroom observations, allowing for each interview to be unique to each student's context.

I conducted two teacher interviews averaging 112 minutes in length. During the interviews, I asked the teacher to reflect on and review each student, or case study. The teacher was very gregarious and almost daily reflected on the classroom environment, the student participants, and her experience with me. This correspondence, with the teacher's permissions, was logged in the observation notes. Some comments were used to solicit deeper reflection during recorded interviews, and some comments were taken for the immediate and face value.

I conducted one parent interview for each case study, lasting an average of 54 minutes. I invited all parents of the student participants to participate in the interview portion. Both parents for Amanda chose to participate together in the interview. The case study for Charlie did not include a parent interview because of scheduling difficulties, to be discussed further in the analysis of the case. Interviews were semi-structured, and I asked each parent a set of common questions, as well as questions derived from classroom observations and student interviews (although in a way that did not compromise the privacy of the student data).

Initially, I proposed the conduct of two group interviews among the female case studies. The purpose of the focus groups was to allow students to answer questions about their experiences in a collaborative manner and to help them develop deeper reflections about their experiences. Stake (2006, p. 29) and Hancock (2006, p. 39) both agree that group interviews can be advantageous because of the benefit of ideas being shared and created, but run the risk of not being productive exchanges aligned with the research questions. That being said, group interviews were a possibility if the design of the selected case studies proved there to be value in this method of data collection. I determined that focus groups should not be conducted because (1) most of the participants did not know each other well enough to allow for a productive group interview and (2) I wanted to protect the privacy of each student's experience.

In addition, I documented detailed content logs from candid conversations between the female students and myself, teacher, and parents, which occurred during the process of the study.

3.5.2 Observations

I observed each case study in her engineering class, approximately 1-3 times per week, from March to May. The nine case studies were students in five class periods. Each class period was observed on average 16 times.

The purpose of classroom observations was to observe how the students engage and their experiences with the engineering activities, teacher, and other students, specifically related to the research question. Observations were primarily descriptive in nature, with some reflective notes correlating observation alignment over time (Hancock & Algozzine, 2006, p. 46). Initially, my role was primarily that of observer; however, as the semester progressed, my role adapted in many cases to become that of participant-observer.

3.5.3 Documents

I collected and analyzed two forms of documents in this study, journals and artifacts. I asked the student participants to write three journal entries throughout the course of the study. Journals were semi-structured (with some continuity among all cases) and open ended in nature. I received three journal entries from each participant except Kassie (2) and Charlie (0). The written journals were designed to be a form of internal validity for the triangulation of the data (Hancock & Algozzine, 2006, p. 51).

Journal one consisted of questions regarding classroom experiences, or deeper questions stemming from the first interview. Journal two challenged the participants to take the Harvard Implicit Association tests for Gender-Science and Gender-Careers and answer reflective questions about their results and experience. Journal three asked 10 questions regarding perceptions of engineering and design.

I copied or photographed for further review select artifacts from engineering experiences, such as engineering-related projects at school or at home. However, no artifacts proved to be relevant to the research questions and will not be discussed further in this study.

3.6 Data Analysis

The primary strategy for the data analysis relies on the theoretical propositions that gender, race, and class influence the experience of every human being, likewise in high school engineering. Originally, the focus was to remain only on gender, race, and class, a common subset of analysis for intersectional feminist theory. However, it became evident at the very beginning of data collection that sexuality, another key component of intersectional feminist theory, could not be excluded because the influence of sexuality demonstrated itself in the classroom and in the lives of several of the participants.

Three analytic techniques—pattern matching, explanation building, and cross case synthesis—guided the analysis. (See Yin, 2009, pp. 130-160. for analysis strategies and analytic techniques) Pattern-matching logic compares an empirically based pattern with a predicted one (Trochim, 1989). If the patterns coincide, then the results can help to strengthen a case study's internal validity (Yin, 2009). Explanation building is a special type of pattern matching, with a goal to analyze the case study data by building an explanation. I used this technique because it typically occurs in narrative form, or the telling of the case "story," in a way that the explanations have reflected theoretically significant propositions. Cross case synthesis creates a more robust study (Yin, 2009). The technique treats each individual case study as a separate study, and findings are aggregated across the series of collective cases.

3.6.1 Triangulation

Stake (2006, p. 34) describes triangulation as mostly a process of repetitious data gathering and critical review of what is being said. It is expected to lead either to confirmation that the observation means what we think it means or to ideas about how the observation would be interpreted differently by different people. Patton (2002, p. 556) discusses four types of triangulation in doing evaluation or analysis: (1) of data sources, (2) among evaluators, (3) of perspectives of the same data set, and (4) of methods. This study will include all types except for second, because this is dissertation research conducted by a sole researcher. Because case studies rely on multiple sources of evidence that will converge in a triangulating fashion (Yin, 2009), this study will focus on three data sources (student, parents, teacher) and three data collection methods (interviews, observations, documents), as well as intersectional feminist theory offering four perspectives (gender, race, class, sexuality). Luft (2009, p. 102) summarizes, "the best intersectional work utilizes intersectionality as an analytic framework that starts from this assumption about structure, power, and multiplicity, and then operationalizes it as a methodological principle for taking multiple interactive processes into account" (Bettie, 2003; Grewal, 2005; Roberts, 1999). The convergence of evidence among these three types of triangulation enables greater reliability and internal validity of themes and patterns drawn from the data.

As previously stated, the case study is not limited to being a data collection tactic alone or even a design feature alone (Stoeker, 1991; Yin, 2009). Is its own research method. There are, however, tools to help in the analysis of a case study. The following sections describe some of the tools that were used for analysis in the study.

3.6.2 Software

I utilized Dedoose, a web-based platform for qualitative and mixed method data analysis, as the primary analysis tool. I uploaded all interview transcripts, observation notes, and journals to the program. While reading, I selected and assigned a code or codes to excerpts from the three types of sources relating to the research question. The list of codes evolved during analysis, because some codes were more relevant and prevalent in some cases than others. I assigned one or more of these codes to the excerpts to help classify the data, and allow for sorting and filtering for deeper analysis later on. Dedoose also allows the researcher to write memos, or notes, in conjunction with an excerpt.

After completing the analysis in Dedoose, I downloaded and merged the excerpts, codes, and memos into a single Microsoft Excel spreadsheet for further analysis: coding, sorting, filtering, and theme development. This method was useful in organizing the excerpts into themes and in preparing an outline for writing.

The excerpts selected in Dedoose are the quotes in this study and are identified by a nomenclature noted as a footnote. Table 3.4 describes the components of the footnote. This method was used to allow me to refer back to the full excerpt and access its location in full context when necessary.

Table 3.4 Description of the footnote nomenclature

Footnote Code **A_I1_13:**
- where A represents Case Study A (See **Error! Reference source not found.**for Case Code), if the code is X, it was unassigned to a specific case - I1 or S1 represents student interview 1; or IP or P = interview with parent; J1 = journal 1; T1 = Teacher interview 1 - 13 is the number of the excerpt. Each expert could be divided into multiple quotes. Where the number is close to 1000 is of no significance, other than it was out of order.

3.6.3 Single Case Study Analysis

In interpreting information, Berg (2004) identifies words, themes, and characters as important elements counted in most written or transcribed messages (via Hancock & Algozzine, 2006, pp. 58-59). Words are the smallest element used in content analysis and are generally associated with frequency of specified words or terms. Themes can be simple sentences or phrases that are often more useful than simply words. (This sort of theme varies from the pre-identified themes of gender, race, class, and sexuality). The number of times a person or persons are mentioned (characters) can also be very helpful to the analysis. All of these elements will be useful in analyzing the data for each case study.

Based on the theoretical framework, gender, race, class, and sexuality are the primary themes for this study. However, I expected other related themes to arise in the course of analysis. Hancock and Algozinne (2006) list four guidelines for the determination of information-supported themes that address the research questions. I followed these guidelines for assessing additional themes.

1) The themes must reflect the purpose of the research and respond to the questions under investigation.

2) The themes must evolve from a saturation of the collected information.

3) Although themes are sometimes hierarchical and interconnected, novice researchers should seek to develop themes that represent separate and distinct categories of findings.

4) Each theme should be as specific and explanatory as is allowed by the data.

Chapter 4 outlines *key stories, or storylines,* from the experiences of each case study. The stories themselves evolved from the triangulated data as themes and are related to, and explained through, the lens of intersectional feminist theory. Each case concludes with a summary box and recommendations. Discussion of each case will be presented with the data and analysis.

3.6.4 Collective Case Study Analysis

The purpose of the cross case analysis in Chapter 5 is to draw connections among the collective themes of the individual cases and to convey the most important shared findings across the case studies.

The methodology should present the link between the choice and use of methods to the desired outcomes (Crotty, 1998). (See Figure 3.3 as an illustration for this study).

Within the context of a high school engineering program, I will examine the experiences of female volunteer participants on a case basis, with consideration of the influences of gender, race, class, and sexuality. A primary focus of attention within the case studies that compose a multi-case study is the characterization of the experiences, or the phenomenon, within the different personal contexts (Stake, 2006, p. 27). Each case is analyzed individually, and then a cross case analysis facilitates a more broad characterization, representative of the true diversity of experiences among high school females in engineering courses.

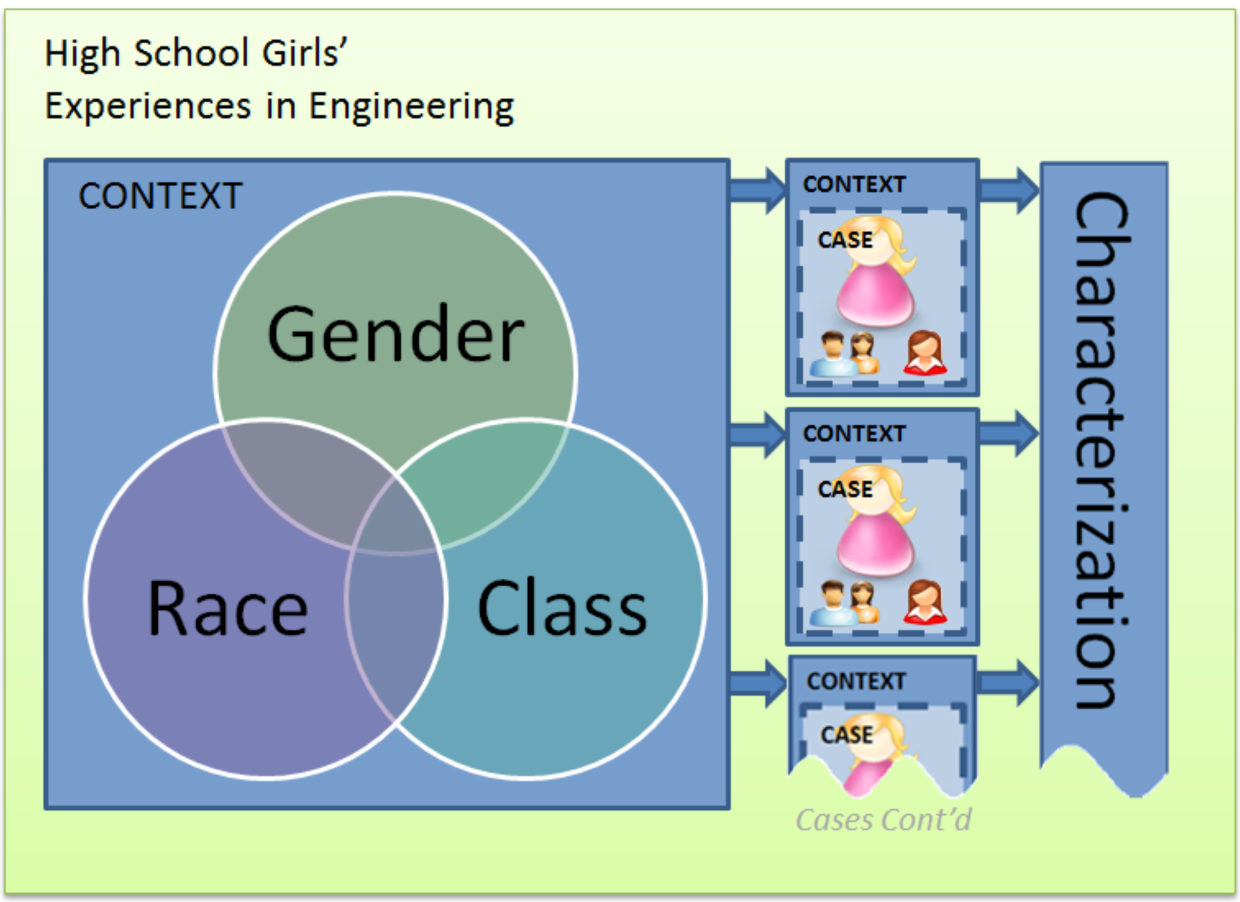

Figure 3.3 Linking the methods and outcomes

CHAPTER 4. THE NINE CASES

This chapter presents the nine case studies as individual analyses and discussions. Each section includes an introduction to the student, descriptions of her family and background, and stories detailing her experience within the engineering classroom. Some cases, specifically Cathy, are much more data-rich (i.e., longer) than others; however, each case tells a unique story of how gender, race, class, and in some cases sexuality influenced the experiences of these nine young women in high school engineering.

Although several of the case studies were in the same engineering class period as another case, the only two that interacted with one another at all were Luna and Isabelle. But for a point of reference on shared classroom experiences, Charlie, Max, and Morgan were in the same class period, and Madeleine and Amanda were in the same class period.

4.1 Cathy

Cathy is a freshman student in an introduction to engineering course. She is no stranger to engineering, because she comes from a family of people engaged in engineering, math, and science. In addition, Cathy took the pre-engineering elective courses at her middle school in seventh and eighth grade. A conscientious student, Cathy works hard to maintain high marks in her courses, and engineering is no exception. She is active in extracurricular activities. On campus, Cathy plays viola, regularly first-chair, in the junior varsity orchestra. She has studied piano for 6 years and Taekwondo for 7 years.

Her mother and younger sister participate in Taekwondo with Cathy. Cathy's family supports her both in and out of the classroom.

Cathy very supportive family has influenced her interest in science, technology, engineering, and mathematics. Her parents actively engage in her life, both in her education and extracurricular activities. They take a proactive approach to parenting, in that they shepherd her interests and abilities. Cathy has adopted her family's high valuation of hard work and education, as evidenced in all of her interests and pursuits. She makes her family proud and is a classified by her engineering teacher as an ideal student. Cathy is intrinsically motivated in engineering because she finds it interesting and fun. Finally, as demonstrated in her participation in Taekwondo and her persistence in engineering despite her early awareness of the gender disparity, Cathy is not intimidated by gender barriers; in fact, she is somewhat motivated to challenge those barriers. The cultural or social capital that Cathy gains from her family has privileged her with opportunities and options.

4.1.1 Family Support

Cathy has a younger sister and two parents at home. Cathy describes her father as a scientist, but her mother describes him as an environmental engineer. He tests, analyzes, and reports on smoke stack emissions all over the world, which means he travels up to 50% of his time. Cathy's mother is a proofreader for the courts and a bookkeeper for several businesses. Cathy's grandparents live nearby. Her grandfather works at a large Division 1 university in science education, and both of her grandmothers are retired teachers, one in math and one in English. Lightheartedly, Cathy describes her family: "It's like a competition between my math and biology grades. They're like 'so…?' because they like to have the higher grade in math and science."[12]

Cathy likes science and math, but she favors biology. When asked about her favorite subject, she explains, "I guess biology, more so 'cause I don't mind math because it's just hard this year."[13] She is enrolled in Algebra 2 and finds the course exams to be difficult, in contrast to the state standardized tests: "The tests are hard. I know how to do [math] because we take the standardized tests and those are fine, easy. But then I go take the [algebra 2] test and 'Oh, this is hard.'"[14] Her father and grandmother can help her with math homework, but she and her mother do not expect that to continue as she advances in her curriculum. Cathy's mother is dedicated to getting Cathy the help she might need in math, but perceives that it is difficult for Cathy to accept help. Even so, Cathy's mother is already thinking ahead for next year and is willing to do whatever it takes to help her daughter, no matter the expense.

> "Even when she needs help in math, it's very hard for her to accept it. The next year, she's going to do a pre-Cal or something like that. I think she's going to have to go to the Sylvan Learning Center once a week, twice a week, or something like that to get that help because that's beyond now, anything that my husband—he can't remember it. He did a lot of math and then my mother-in-law is a math teacher, but I think she taught it to a certain level, and that was it. [Cathy] will have to go to a tutor and she

[12] A_I1_13.
[13] A_I1_8.
[14] A_I1_8.

> realizes that and she's okay with that. I think she knows that if she runs into a big snag like that she will get help. Otherwise, she wants to do it herself. We will drop other things if that's what it takes [financially]."[15]

Cathy does not feel pressure from her family to choose any particular career, and she describes them as always being supportive of her. Given the strong influence of math and science from her father and his parents, Cathy notices that her family is extra supportive of her interest in those areas. "None of the people in my family really [encourage me one way or the other]. Which is good I guess. They just say, 'You do what you want.' They are supportive of it."[16] However, in the next breath of her first interview, Cathy laughingly describes her grandfather, "He doesn't really have a—he likes to pretend to push me one direction. Probably more in the science area. Just because that is what he likes to do. So he's like 'Oh yeah, you could do this!'"[17] She later wrote in her journal: "My family has always been supportive of what I have wanted to do. For example, I used to want to be a teacher (which may or may not have had to do with my family), but then I changed my mind. I don't really remember what my family's view was on that, but they never opposed it. However, it seems that they have always been pretty supportive of the science and math areas, meaning that they seemed happy to see me interested in it."[18]

Although Cathy does not identify her parent's support and encouragement as pressure, she recognizes that they value some professions over others. They have emphasized that she needs to find a career or job so that she can support herself. This accentuates extrinsic

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[15] A_IP_43.
[16] A_I1_14.
[17] A_I1_14.
[18] A_J1_1.

value over other work values, even though Cathy says she has not chosen engineering for the money.

> "[My family] thinks it is perfectly fine to do something else (other than math or science), I think. Except, now that I think about it, I don't think they think very highly of girls who go and get a degree in psychology, because there really isn't much to do with that degree (or at least not that I know of). They do, although, want me to make a decision that will benefit me. I know this because they always remind my sister, who wants to be an artist, that she may have to do something else to support herself. When I tell them about all I want to do in life, they tell me that I will have to get a job that will support that, which, by the way, is not why I want to go into engineering."[19]

In contrast, Emily (Cathy's mother) describes Cathy as being driven by money and believes that is a motivation for her career choice: "Whatever job she does I'm sure she'll do well. I think she's kind of driven by the money, too, and she's very conscious about it."[20]

Cathy acknowledges that technology is a part of her life, and she has a wealth of technological gadgets at her fingertips at home. Her father's interest in technology has spawned her interest because he explains how things work to her.

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[19] A_J1_2.
[20] A_IP_38.

> "I have grown up with technology. I believe that we personally have about seven computers in our house along with three iPhones, a few iPods, and an iPad, as well as a rather well-developed entertainment system (TV, projector, Xbox, etc.). This is nearly the same at my grandparent's house. Because of this, I have had exposure to technology, which has increased my fondness of it and things that have to do with it. Also, my dad has always been interested in that type of thing, so he explains how it works to me, which has also boosted by knowledge and enjoyment of the subject."[21]

Cathy acknowledges that her mother is helping to direct her in identifying her career goals and that she is supportive of her goal to pursue engineering. Cathy explains: "I went to the Women in Engineering event at UT, which my mom discovered. She thought it would be a good idea to go and see what it was like, which therefore shows that she believes in the path I am taking." [22]

The way that Cathy's mother describes her clearly demonstrates that she truly believes and supports her daughter. She wants the best for her daughter—holding high regard for her ability and high hope for her future.

> "She is driven."[23]

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[21] A_J1_2.
[22] A_J1_2.
[23] A_IP_33.

> "Cathy is iridescent…incandescent…shines on every angle she has. She is smart and she uses this. She's thoughtful, and she's kind. She's mature and self-aware and confident than any high schooler could be. She's just amazing. She does well at whatever she tries."[24]

> "I wish that she will be exceptional in whatever she does and [have] a very happy life and something where she can manage and take care of and be successful.…I hope that she finds a good job that she enjoys and can go far in it, wherever it may take her."[25]

Cathy's parents not only cared about her education, but also learned their daughter's strengths and observed her progression in school. They were strategic about Cathy's education in terms of where they lived and when they transitioned her from private to public school. "We have, from the very start, really prized the education about where the kids go.… We were at Montessori in Georgetown, and we were there until [Cathy] was in third grade. So that really fit Cathy well because of her natural ability to be self-paced and driven. She's very driven. That environment really did well for her. We decided to move her back to the public school system in fourth grade because there needed to be a time where she eventually went into the public school system."[26]

In the community in which Cathy lives, the families are able to choose which high school of seven to attend. Cathy's parents selected Unnamed because of its engineering

[24] A_IP_36.
[25] A_IP_38.
[26] A_IP_33.

program, safety, and diversity, and because it is less competitive than one other school, specifically Eastbridge.

When asked directly why they chose Unnamed, Emily's first response was: "The engineering. For Cathy, yes; and I'm still trying to decide about my younger daughter because I don't know if Unnamed is going to be the perfect match for her. As far as Cathy, it was a given. It was like a no brainer. She would come here because she was really interested, and I could see her natural abilities going towards engineering and I thought that would be a good field and so did my husband."[27] Of interest is that Cathy's parents see something in Cathy that makes her interested in engineering that they do not see in their younger daughter. In other words, they are assessing their children's interests and abilities and are actively guiding them toward a career.

Emily mentions diversity as an important reason for selecting the high school. Unnamed and Eastbridge are both diverse, but in different ways. Both schools have 51% White students. The second majority at Unnamed is Hispanics at 22%, while the second majority at Eastbridge is Asian at 28%. Emily describes: "I felt there would be a—it's a diverse school and I thought that—there's not, to my knowledge, not much problem area as far as being safe."[28] However, Emily was not under the impression that Eastbridge was not safe; rather, she was making a comparison to other options in the district.

Cathy's parents were also concerned about the level of competition at Eastbridge. Eastbridge is an International Baccalaureate (IB) school and was characterized by all of the study participants as being very competitive and having a large population of Asian

[27] A_IP_39.
[28] A_IP_39.

students. Eastbridge does have more than two times the number of gifted and talented students than does Unnamed. (Unnamed, 7.2% G/T vs. Eastbridge, 16% G/T), which, along with its IB status, could be the basis for its reputation. Emily compares Eastbridge to Unnamed:

> "Then [Unnamed] wouldn't be so much competition like Eastbridge. [Eastbridge] would be too much. It would be like all, 'Oh no, who's first? Who's second?' I didn't want that either. So I wanted something in between—more centered on the education and not about who's first. I think [Eastbridge] is a more competitive school. To me, I feel like it's even harder. I don't know how much harder it could be than this, because Cathy has so much work and so much pressure.… We go to this school because of where we live and engineering."[29]

When Cathy was in middle school, she had three choices for an elective: dance, theater, and pre-engineering. Her parents encouraged her to choose the drafting/shop class because her father loved that class and thought Cathy would as well. It appears as though Cathy really enjoyed the course, and Emily is engaged with and proud of Cathy's activities: "She just loved it. She didn't know what to take. And we said, 'Well, why don't you do that?' because my husband did that and he loved it. She loved it. It's really interesting all the things that she brought home. She made a beautiful pen…She got an award in the class, so that's good."[30] Cathy's mother specifically referred to the class as

[29] A_IP_39.
[30] A_IP_40.

"shop class," because that is what it was called when she was in high school. Shop has been historically biased against and not inclusive of women because of gender norms. Young men take shop; women take home economics. Despite this, Emily still viewed the class as an option for Cathy, thus challenging a gender bias and stereotype.

Based on her description, Emily and her husband have different opinions about college. She believes that college should be more for the experience and less about the degree. She describes her husband's view of college as a practical means to acquiring a good job. He wants Cathy to select a degree that she can use, such as engineering. Emily somewhat idealistically believes that Cathy could always find a job and that she could work her way up even if she doesn't have a degree. It would appear, then, that Cathy could be receiving conflicting messages at home, but the underlying current in either message is strong support from her parents for her success.

> "We're trying to help her decide what she really wants to do. I know my husband wants her to go to college and have a degree that she could use…He doesn't want her to go to school and just be there just to be there. For me, I think college—if you can get a degree in something that you can use, that's great, but then again, going to college is a whole experience in itself. I think you'll get a lot out of it even if you don't graduate or something. You can go directly to an awesome job. You can always get a job and work your way into whatever you want or whatever you find. I think going to college though is extremely important. I think getting a job is extremely important and choosing something that you can do to support

> yourself. I don't want her to jump from job to job. I would like her to find a career, but if that is the way up then that's great. If it's not, no." [31]

Regarding college for Cathy, Emily explains, "[Money] won't be a barrier, but it's an issue. We'll find a way. We haven't saved any so I can just see us getting loans, or scholarships. We're crossing our fingers for that."[32] This commitment demonstrates Cathy's parents' high valuation of a college education and their willingness to make sacrifices so that she can obtain one. However, Emily explained that their support will have limitations: they will financially support her as long as she has a plan, that is, not going to college to earn degrees just for the sake of doing so, even though Cathy has never expressed any goals for advanced degrees. "As far as being a career college person, I don't think that would be a good idea for her even though I think she would enjoy it. I think she would enjoy learning and learning, and learning forever, but that's something that she'll have to do in her own time and her own money later on in life. We would support her if she's like, 'Okay, I want to go and get a doctorate and this is my plan.' She has a plan and maybe we have looked at it and say, 'Okay. Well, this is what we can do.' If she's just going 'Oh, I just want to get a degree.' Then maybe—I don't know. Also, I know that won't work with my husband."[33]

Emily describes their family as supporting Cathy's education and career choices, but not pushing her one way or the other. She believes that Cathy identifies with math and science because of her family's influence and that Cathy considers herself to be "cut out"

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[31] A_IP_48
[32] A_IP_50
[33] A_IP_48.

for engineering, particularly because her grandmother was an engineer. Of interest is that Emily identifies her mother-in-law as the primary influence, rather than her husband or father-in-law. This could demonstrate an implicit bias toward women and the sciences. However, Cathy describes her grandmother not as an engineer but as a "technician of some sort at IBM (I think) and Siemens."[34] When asked specifically about the influence of Cathy's grandfather (the science education professor), Emily talks about both of her in-laws, as well as her husband:

> "They want her to go to college, but they don't want to be like, 'Oh, you need to be that or you need to be that.' When they heard that she chose [engineering] they are like 'Oh, that's a great choice,' and since mom is an engineer or she was. Yeah, she was. She got her bachelor's in math and I think her master's in engineering or something like that. She was an engineer for many years. She first taught and then she went on to do that. *She sees her grandmother as being an engineer and seeing that she definitely was cut out for that*. Then Jim is an engineer even though he didn't graduate in engineering. He graduated in physics…"[35] [emphasis added]

Because Cathy never uses the word engineer to describe her grandmother, it is unclear whether her grandmother has the influence that Emily suggests. In addition, Cathy describes her father as a scientist rather than an engineer. This

[34] A_J1_1.
[35] A_IP_51.

conflicting information could indicate that Cathy does not identify these people as engineers, these people do not identify as engineers, or their occupations were never really discussed at home.

Cathy's parents help manage her time and grades, but Emily believes that Cathy is independent, self-motivated, driven to succeed, and a little bit of a perfectionist.

> "We watch her grades just like she watches her grades, but she watches her grades every day. Online she's just, 'Oh my gosh, I have it. 90, I need to get that up.' We've tried to sort of help her and direct her as far as time management, but really she takes her own time and uses her own abilities to do everything. She's very driven. She wants to make good grades. It must be all A's and she does well. She does well, and so we can't complain that it takes her 6 hours to do her homework because she may be a little bit perfectionist."[36]

Cathy is extremely conscientious of her grades and confirms that she checks her grades often: "My dad gets annoyed when I ask for his iPhone to check. The grades (averages) change every day!"[37]

It appears as though they expect high grades, but Cathy's parents are supportive if she earns a B as long as there is evidence that she is doing her best. Consistency is key.

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[36] A_IP_33.
[37] A_O_71.

> "We like to make sure that she is on the right track as far as her grades are consistent. We're always telling her that if she makes a B, which I think she did this first time ever in math last semester, we're like, 'If you're trying your hardest and we're giving you tutoring, then that's okay. That's fine. We definitely know you're trying.'"[38]

Overall, it is clear that Cathy's parents value her education and homework more than other activities. Emily states that Cathy's education is more important than any extracurricular activities, and, at times, they have had to cut back on other activities so that she could complete her homework. In addition, she talks about getting Cathy the help or tutoring that she needs, even at any cost.

> "We put her homework first. We've had to have her Taekwondo and piano lessons dropped off significantly because she spends 4 to 6 hours a day on homework. She has to go to bed before 10. She has to get it finished for many reasons, but that's number one for her right now. She doesn't work outside the home like part time job or anything. We consider her education the highest thing on her list as the most important for her above anything else, and she knows that.[39]"

Emily encourages Cathy to have balance in life, but is concerned that she might become a workaholic because her family models that behavior.

[38] A_IP_43.
[39] A_IP_43.

> "She sees all of her family, they were either teachers or business owners or hard workers every single one of us. She sees that. I feel bad because I don't want her to be a workaholic. I want her to enjoy her life in other areas besides just work. Even she can find great enjoyment in it, that's awesome but I don't want her to miss out on being social. That's why I'm trying to push the Taekwondo and the piano and to make friends.[40]"

When Cathy faces challenges in her engineering class, she counts on her father to help her if she needs it. He helped her install software their home computers do that she could work on her CAD projects outside of school.[41] In addition, when her team had to build a prototype for its final design project, her father had a lot to offer the team if her partner had wanted to build a working prototype instead of a symbolic one. "I think we may have more tools and stuff than [my group member] does just 'cause my dad likes to do that and I would've wanted to make one out of wood because that would have been closer to the actual thing but we didn't really have that and also she didn't want to spend much money on it.[42]" Access to help from home can build confidence and efficacy.

When developing a design for a class project, Cathy considers whether she would need her power tools or sewing machine. First, she has access and help to use these tools at home. Second, she has experience solving unique problems using her tools at home. She once designed and created a headpiece to help her watch her iPod in the car. "In middle school we had the cutting machines and I can always ask my dad. Because we

[40] A_IP_52.
[41] A_I3_23.
[42] A_I3_24.

have a table saw but I'd be a little bit afraid that I'd cut my finger off. So, I'd want him right there, staring at me. It's not the type that stops when you touch it. I have a sewing machine, occasionally, like, I'll do a project."[43]

4.1.2 Early Engineering Awareness

Cathy was aware of engineering early on, and she knew that she wanted to explore the different types of engineering. She was able to eliminate some disciplines through research and exploration. When asked directly about her choice of engineering, Cathy responds that she just likes to do it, and fun is a factor. "I guess I just like to do it. I like to create stuff on the computer. In middle school I did the Tech Ed, which is fun, and I got to make a car, which was fun. It was a little CO_2 car, and we made a catapult. It was just fun."[44] For the long term, Cathy thinks she will to pursue a career in engineering, but she admits that her thoughts change on a weekly basis. "I think I want to go into engineering. That changes on a weekly basis of what I want to actually do. I don't know [laughs]."[45]

Cathy is very comfortable in all male environments, especially because of her experience with Taekwondo. She does not allow her awareness of the disparities in engineering to intimidate her from pursuing her interest.

Emily assesses Cathy's enjoyment of engineering: "She loves engineering…She does really well in this class…She wished that they had more engineering classes here to offer

[43] A_I2_22.
[44] A_I1_9.
[45] A_I1_11.

that she could take."[46] Altogether, Cathy is interested in engineering for intrinsic values—she enjoys the work and finds it fun.

4.1.3 Family Influence

Cathy's family is educated, and many of her relatives have or have had careers closely related to STEM. They play active roles in Cathy's life, helping her to select interesting and challenging courses and envision herself in a variety of STEM careers, and providing her with informal opportunities to explore her interests and options. Brinkman et al. (2014) examined five studies with parent engagement in K-12 engineering education, and they found that parents motivate interest in engineering in early childhood, provide support when their child is in the process of selecting a major at college, provide experience in learning engineering concepts and thinking skills, and serve as role models if they themselves are an engineer or STEM professional. Not all students have such supportive and active parents and therefore may not be subject to such remarkable influences toward engineering. Teachers and counselors must often "stand in the gap" for those students. Tools, professional development, and training can help prepare educators with the information and motivation to help every student consider engineering.

4.1.4 Design and Hands On

Cathy's favorite thing about her engineering course is design and seeing her ideas come to fruition on the computer and via the 3D printer. "I guess I like the design thing.

[46] A_IP_45.

It's fun to create it, like actually see it more so than just drawing it on a piece of paper."[47] Outside of class, she has spent time creatively designing items that would either make her life easier or help others.

> "I tried to design something to enable me to be able to watch movies on my iPod in the car. I tried to design an extension for my finger to be able to play certain chords that I couldn't seem to reach on the piano. I started trying to design a ramp thing for my grandparent's house, but I didn't get very far past the dimensions (which were a pain to get). Basically, I tend to try to design more practical things."[48]

Cathy did not expressly state that she wants to "help others," but her interest in designing "practical things" aligns with the research on what attracts young women to engineering (Committee on Public Understanding of Engineering Messages, 2008).

In comparison, Emily believes Cathy is attracted to engineering because of the hands-on activities. She lists sewing, beading, and knitting as Cathy's favorite hands-on activities, but she highlights the 3D printed projects as amazing activities that Cathy enjoys from her current course. Cathy describes her attraction to engineering to be centered on design, even though her designs often involve "hands-on" activity. Emily listed traditionally female-gendered activities as Cathy's favorites and did not mention Cathy's attempts to create "practical" things. Perhaps Cathy's interest in these activities as a child spawned her interest in design.

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[47] A_I1_10.
[48] A_J3_6.

> "I think she really likes the hands-on activity. She has always been hands on as far as making things. She's into beading, sewing, knitting. She used to draw. She's really hands on. She really enjoys that. Like, here when she makes the 3D thing that is the coolest thing I've ever seen. So, she just loves spending hours creating it and then seeing it in her hand."[49]

4.1.5 Math and Science

Cathy likes math and believes that she has "always been good" at it, despite receiving lower grades this year than in the past. She acknowledges her current course (pre-AP) as challenging but recognizes that, even if she does not earn a 100, she is still 2 years ahead of the norm. This residual confidence from her past experience is likely to carry her through the difficult math content. Had her mindset been the opposite, that is, that she is not good at math, she would not likely be as persistent. Her description of her internal discourse demonstrates a struggle between not being the best and yet still being good at math. If these dichotomies were a scale, then the scale would still tip toward her belief that she is good at math. Although each lower grade she receives rocks her personal perception, she has thus far been able to coach herself back to believing she is good at math. The conflict exists in the belief that she is either good or bad at math—this black and white perception—as if she was gifted with a special talent to do math. At no point does she talk about how her effort contributes to her grade.

> "It can be depressing in Pre-AP Algebra 2 when you get a random 75 on the test so you tend to start thinking that you're not very good at math

[49] A_IP_41.

> 'cause there's a ton of people in your class who do better.…I'm not bad at math, just we have hard tests.…I've always been good at math. Like in elementary school...we did a lot of math because that's what my friends liked to do. And so I did it with them and we did math all day. Then I got into [Talented and Gifted] math, which I was always pretty good at.… Yeah, I always had like a 98 in there. Like last year I went back and looked at my grades and was like, 'Whoa! How did I have a 97 throughout the whole year? Made a 100.' And this year I'm struggling to make an A. Which I know is still okay, but it makes you feel like you're not as good at it when you see so many other people doing really well in that class. But then you realize, 'You know I am in Pre-AP. I am still 2 years ahead. I still am good at math.'"[50]

When asked about science, Cathy's opinion is simple, direct, and without elaboration compared to her opinion about math: "[Science] so far has always been really easy.[51]" Regarding her choice of engineering, Cathy describes: "I wasn't turned off by [engineering] because I was open to doing math and science. Some people are like, 'Oh math and science, I don't want to do that.' I guess I was okay with it."[52]

Of interest is how Cathy's mother describes her daughter's ability in school subjects. Emily says Cathy is good at science. She says that Cathy has worked diligently at writing, which has made her good at "English." However, she says that Cathy has an "A" in math

[50] A_I4_30.
[51] A_I4_31.
[52] A_I4_32.

but has to work very hard to maintain that grade. Emily is likely projecting her own insecurities about math onto her daughter's ability. This raises questions about Emily's mindset and how it might limit Cathy if she continues to equate work to achieve in math with a struggle. Emily's strength lies English. And, in this subject, she believes that Cathy worked very hard, improved, and has produced some "amazing" writing.

> "I guess her science is probably up there with her strongest. She doesn't like to write which—she's come a long way. She used to sit for hours trying to just get it out of her. Now she's a lot better at just getting it out in writing. Once she gets it written down it's amazing when she writes down, but English is up there. Even though she may not think so, to me, I think it is. Science and English, geography, yeah…She likes math, but it's one of her hardest things that she does even though she makes an A in there. I mean it's like she struggles just to get it where it is. I would say that's her hardest or most difficult, one to keep constantly in an A.[53]"

Although Emily acknowledges that working hard helped Cathy to improve her writing, she observes that her daughter struggles to keep an "A" in math. So, she is less optimistic of Cathy's ability to still be good at math.

Growth mindset is a belief that, through practice and effort, one has the potential to learn new skills, increase knowledge, improve ability, and meet challenges. Individuals that maintain a "fixed" mindset believe that they are born with a predetermined amount of unchangeable ability and intelligence and that they will not be successful at meeting

[53] A_IP_42.

challenges, even with effort. Carol Dweck and colleagues (Good et al., 2012) found that a growth mindset promotes both achievement and persistence in STEM, even in spite of stereotype threat that females are not as good as males at math and science. Closely related, attribution theory deals with how one makes sense of his or her world or environment and how one attributes events to success or failure. Within this theory there are three dimensions of dualities: internal/external, stable/unstable, and controllable/uncontrollable (E. E. Jones et al., 1972). Research indicates that individuals who relate success toward the positive (internal, stable, controllable) tend to be more highly motivated and persist in their endeavor (Dweck, 2000).

Even though Cathy believes she is good at math, questions remain: Will this positive outlook continue along her math trajectory, or will her confidence wane? Is her confidence attributed to a gifted and finite intelligence in math, or her hard work in her classes? How much does this depend on her support at home, the teacher, or her friends who she does math with? Helping all students to develop a growth mindset in math and science, and to encourage them to attribute success to hard work and effort, will begin to influence female student self-efficacy by allowing them to overcome stereotype threat.

When asked identify all of the female engineers she knows, Cathy responds, "I would say that I know 5-6 [engineers], and the only ones that are female are either teachers or you."[54] Furthermore, Cathy noticed that the female engineers (i.e., her teacher and me) are not currently practicing. Although not clear based on the data in this study, what how does this realization affect her perception of females as engineers? Cathy's teacher left engineering and became a teacher to spend more time with her two daughters, and she

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[54] A_J3_7.

has not been shy about explaining her rationale to her students. In *Talking About Leaving: Why Undergraduates Are Leaving the Sciences,* Seymour and Hewitt discuss factors that contribute to attrition from math and science majors related to career, lifestyle, time, and money. One of those reasons is a desire to become a teacher (E. Seymour & N.M. Hewitt, 1997). Although it is important that Cathy has female engineers as potential role models, does the fact that neither of us has continued practicing allowed her to assume that an engineer's lifestyle is not worthwhile or rewarding? It is possible to working in the engineering field while raising a family and enjoying a certain quality of life. It is important that students meet a diverse continuum of engineers of all races, both genders, and various lifestyles, and be able to ask pertinent questions about life and work as an engineer. I have proposed a conceptual model and training for STEM role models (Pollock, 2013b) and educators (Pollock, 2013a) that prepares them to promote proper STEM messaging, challenge and dispel stereotypes, and appeal to student work values. Our educators are on the front lines with the students, and we do not want them to unintentionally send messages about engineering that do not align with student interests and work values. Training educators on effective messaging and how to recruit diverse role models for their students will begin to challenge stereotypes and broaden student understanding of all of the options and opportunities available in engineering.

4.1.6 The Teacher's Perspective of Cathy

To Mrs. Jones, Cathy is the ideal student—one that she wishes she could replicate so she would never have problems in her classes.

> "[Cathy's] just one of those all around great kids. She is polite, she's respectful, she is motivated and a hard worker. She will really bend over backwards to get her work done.… She's very conscientious about getting her work done. But she also has a great personality, gets along with everyone, I mean, she's just one of those dream students who you would love to have every kid in all your classes be like that and it would be like angels singing all the time [laughs] because there would never be any problems. I haven't found an area where she's weak…Making all A's…I guess I'd like to have a 120 of her."[55]

Mrs. Jones trusts Cathy and has confidence that she could be a leader in the engineering extracurricular activities. "Our JV [engineering robotics competition] team this year was very strong and I was really happy that Cathy took part in that and—you know, I feel like she's one of those kids that I can rely on to help sort of organize the, you know, okay 'You help me get a team organized' and she'll just run with it."[56]

Mrs. Jones truly likes Cathy: "Cathy is wonderful, and she's one of those kids I hope is in the program for 4 years.…She has so much potential; really super sharp student; just outstanding student all around"[57] and "I think Cathy has so much potential… I mean, she just has the whole thing going on."[58]

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[55] A_T1_53.
[56] A_T1_53.
[57] A_T2_57.
[58] A_T2_59.

4.1.7 In the Classroom

During the first day in the classroom, I announced my presence as a researcher for the next several months and provided a very brief explanation of the research study. In a simplified manner, I described that I wanted to understand young women's experiences in the engineering classroom so that we can encourage more women to participate in engineering, especially because so few are enrolled in engineering courses in high school and college and are practicing in industry. In response to this statement, one boisterous student loudly declared, "That is the way I like it!"[59] Not only did this assertion of preference set the tone for the observations of Cathy's third-period engineering class, but also its rowdy delivery was indicative of the normal environment for this classroom. Evidently, boys who engage in this sort of behavior too often take center stage in many school ethnographies, according to Barrie Thorne, which is not dissimilar to what was observed during data collection for Cathy. In fact, Thorne claims, "their style is often equated with masculinity itself" (Thorne, 1993, p. 168).

This section will describe both Cathy's and the teacher's perspectives of the class and will then paint a series of vignettes from classroom observations to allow the reader a sneak peak, as if a fly on the wall, into Cathy's engineering classroom environment.

4.1.7.1 Cathy describes her classroom environment

Cathy was ready for my inquiry about her classroom environment; it appeared as though she had prepared a statement. Her response was honest although a little vague, but become clearer with further questioning:

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[59] A_O_60.

> "SO [demonstrative], there are about 50% who are creepy…I've decided to put it this way, because it describes it nicely: They talk suggestively to each other. The whole class. And it is not very discreet. And even when they are talking to each other, it's like, how does that have anything to do with anything? And yet it probably does just because...Joseph is the head guy. The other people are his followers because he is cool. But...when he's not there, it's just really, really awkward, more so because they are doing the same thing, and it's just like...it's just kinda weird. If they actually <u>felt that way</u>, it wouldn't be as weird. But I don't think they do. I think they just like to be weird."[60] [underline added for reference to next quote]

When asked what she means by "felt that way," Cathy clarifies, "If they were actually gay. But they are not. I don't know about all of them, I'm not making judgments. If they actually were, that'd be different. But I don't think the whole class...[voice trails off laughing]"[61] Cathy surmises that so many of the young men act overtly homosexual, even though they likely are not, to garner attention in the class and to follow the lead of one popular student. Thorne suggests that young men use the specter of homosexuality as a vehicle for enforcing dominant notions of masculinity (Thorne, 1993, p. 117). Cathy adds the following:

> "Because it makes them—I don't know, it draws attention to them, of course. And they may get something out of it, I don't know. It may be fun

[60] A_I1_15.
[61] A_I1_15.

> for them. Who knows? Maybe some of them are. I think they just like to follow what Joseph is doing, and he seems to have a lot of friends, so they are like, 'OK let's do this, too.' And they might just think he is funny and go along with it."[62]

Although Cathy's states that the behavior is weird and awkward and lessens her desire to interact with the young men in her class, she adds that she doesn't care in a nonchalant, dismissive way. She may assert that the "super friends" do not affect her, but the environment that has been created does, whether or not she realizes it. Because she makes an active effort to avoid half of the students because of their antics, her experience in the classroom is indeed affected. "I probably wouldn't really interact with them anyway, but it doesn't make me want to interact with them at all. I just kind of—I don't know if avoid them would be the right word, I just don't really…I don't really care."[63] Thorne also writes in *Gender Play* that the behavior of young men using the specter of homosexuality "helps sustain hegemonic masculinity and the structuring of gender as opposition and inequality" (p. 169). Thus along the continuum of masculinity, femininity is devalued, and therefore, ultimately, girls and women. In this light, it is no wonder that Cathy works so hard to avoid those boys.

4.1.7.2 The teacher describes the classroom environment

Mrs. Jones describes the "touchers," a group of three male students in Cathy's engineering class who exhibit behavior that she has never witnessed in 10 years of

[62] A_I1_17.
[63] A_I1_16.

teaching. She calls them the touchers because they literally want to touch each other all of the time, and she has questioned their sexuality. She describes how she has tried to handle the situation over the course of the school year, with no results:

> "Okay, so in third period there's this very odd group of people. Okay, most of the class are very good students who stay on task most of the time. Of course, there's always the one or two that aren't doing their work, and then there's the touchers. And this class makes me crazy because in the 10 years of teaching I have never encountered this problem before. There are three boys who want to touch each other all the time. Usually, the first time I encounter that, I say 'no touching' and you can see the kids get a little bit embarrassed and then it never happens again. Well, in this class the second day of school, one of the other students asked me to move his seat because he said this kid was touching him and he didn't wanna be touched in so many words. And so, I thought 'Oh my gosh this is gonna be a real problem.' I have emailed parents, I've written them up, I have talked to the boys; I've tried to reason with them multiple times, I've done virtually everything I can think of—and, you know, when you write 'em up there's really no consequence 'cause they're good students!…to get the boys to stop touching each other. Not only is it inappropriate but it disrupts the class. It creates a weird working environment for the other students and so, anyway [sighs] I'm kind of at my wits end with the

> touchers, and I think really the thing that works best with them is reasoning. And I pulled two boys out in the hall one time and I said that. I wanted the sexual innuendo, all this talk, oh you know, his abs are so hard and everything's so hard, and this and that it goes on and on. I said 'All the sexual innuendo stops today and they were like 'Oh, we didn't think you got that.' [laughs] Duh. How stupid do you think I am? So anyway, apparently they think they're the only ones who think about sex or whatever [emphatically] and they thought they were just pulling the wool over my eyes, so in any case, yeah, it was very weird situation, very bizarre, and yeah I did wonder about the students' sexuality but I really don't think they're homosexual. [sighs] And I've asked administration to look at trying to change the schedule, even one of the boys, to not unravel his whole schedule but maybe switch him with another class so he could be in another one of my class periods because I felt like if these three were split up there would be significant improvement but they were unwilling to do that. So, that's the story of the touchers."[64]

The touchers are primarily a group of three, and when one is absent, they are less disruptive. However, together, the three students instigate trouble across the classroom. They engage several other male students who are on the fringe and frequently engage in the touching and vulgar conversation. This larger group self-identifies as the "Super Friends." Joseph is the ring leader of the "Super Friends"

[64] A_T1_55.

or the “Touchers.” Mrs. Jones describes him as an immature kid or a master manipulator. “He’s just kind of a rabble rouser and an immature kid. Either that or a master manipulator, and I think he’s probably a master manipulator as well.”[65] Joseph also happens to be one of the top-performing students in the class on exams and a standout soccer player for the school. She describes clamping down to be the only effective solution to this enigma.

> “There are a few others that are sort of on the fringe of those three, and really I just have to keep clamping down on all of them, and that’s the only thing that seems to be in any way effective, you know...yeah. I don’t know, it’s still, that’s still another enigma for me that I don’t, that I haven’t figured out the solution to that problem yet.”[66]

Mrs. Jones is perplexed by the student behavior. She wants to keep order in her class, but is concerned about the implications of making claims about the students.

> “So I don’t know what their deal is but...but, yeah I think next year I’m gonna do that. I’m gonna write ‘em up for sexual harassment. I have to make sure the definition of it can—maybe I’ll write ‘em a warning first and just say, ‘Next time you’re gonna be written up for sexual harassment.’ Because I don’t even know what that indicates…I don’t

[65] A_T2_56.
[66] A_T1_55.

> know what implications it has for them. Could they be fined for that? Because they can be fined for certain things."[67]

Mrs. Jones has struggled with how to discipline and control the touchers to minimize disruption to the classroom. "Clamping down" has not been effective. Truly at her "wits end," 6 weeks from the end of the school year, she isolated them together. Although they were still disruptive, because they were in the same groups, they at least did not interrupt other groups to talk with and touch one another.

> "We're about to start working on our final project, and I think the best thing to do is just isolate them as much as possible from the rest of the class and let them work with each other so nobody else is irritated by them…If they wanna touch each other, they wanna do whatever… I can't stop them, I can't. I've tried… But, yeah it's unfortunate that that's happened and, like I said, I just don't—as long as they're not touching the kids who don't wanna be touched I feel like that's a small victory. [sighs] But they are very disruptive. [sighs]"[68]

Mrs. Jones first rationalizes the poor classroom behavior as resulting from boundary changes in the district that increased the number of economically disadvantaged students, but then she backtracks by saying that the poorly behaved students do not fit that mold. In fact, one of the students is the son of a state

[67] A_T2_56.
[68] A_T1_55.

representative. The implications of class on Mrs. Jones's perspective reveal a stereotype assumption and that she is in fact challenged by her own stereotype:

> "We had some boundary changes, and we're starting to get more kids that are economically disadvantaged, which does lead to bad—worse behavior in general. However, none of those kids [in Cathy's class] fit into that category, really. Those were all kids who I think came from pretty much middle-class, upper-middle class families, and they weren't, you know, on what I—I mean, I don't know. I didn't look up all their statistics or whatever, but I would feel like most of those kids—well, Brian, his dad was a state representative!"[69]

4.1.7.3 Understanding the disruptive behavior

The social relations of boys tend to be hierarchical and competitive, and they repeatedly negotiate and mark rank though insults, direct commands, challenges, and threats (Goodwin, 1990 via Thorne, 1993, p. 92). In Cathy's classroom, there was a ring leader and a second and tertiary tier of boys. Their behavior constantly involved insults, threats, challenges, commands, and general deviance in direct defiance of the teacher. Boys more often publicly violate rules, and they do so to bond through the risk of rule-breaking and through aggressing other boys who are perceived to be weaker (Thorne, 1993, p. 93). There were instances in the classroom when the touchers tried to involve one of Cathy's friends, who did not want to engage and worked hard to avoid their group behavior. Touch among

[69] A_T2_56.

boys is rarely affectionate, but is rather an expression of solidarity through the ritual of hand slaps, friendly teasing, and mock violence (Thorne, 1993). However, the boys' behavior was not only distracting, but also disruptive because Mrs. Jones was been forced to yell "stop touching each other" and "move an arm's length apart from one another" on a daily basis.

The touchers are so overt, boisterous, and disruptive, that they invite an almost overwhelming haze of roguish sexuality in Cathy's class. In no other class did I observe such facetious sexual, and in many cases homosexual, behavior as that demonstrated here. The primary toucher offenders are Joseph, the ring leader, and Sam. Cathy's desk was in the middle of the classroom, and I observed from a group work table halfway between her desk and the touchers' usual gathering place. I chose this position so as to not crowd Cathy or make her nervous. Although I was in earshot of the touchers, there actions were rarely subtle and usually known by many in the class. Although Cathy's back was to this group while seated at her computer, she was not able to avoid all of their shenanigans, which set a tone for the classroom environment.

4.1.7.4 Andy

The disruptive students were a concern since the first day of school, according to Mrs. Jones, and their behavior influenced the experience of other students. One student approached Mrs. Jones with his concerns during the first week of school and asked to be re-seated.

> "And I had one student who complained literally the first or second day of school—'I don't wanna sit near him because he's touching me.' I moved him…I made sure that they were light years apart, and then I sat him with Senal and Cathy once I saw that he was gonna be a good worker. And they were just happy as all get out over on the back side of that row."[70]

This student, Andy, was placed next to Cathy, but Joseph continued to harass him throughout the school year. During one specific observed occasion, Joseph approached Andy during class and asked him if he had a boyfriend. Andy did not respond or acknowledge him; he basically ignored him.[71] When asked about this incident, Cathy describes how she and Andy had talked about the harassment in the past.

> "At the very beginning of school he asked me, 'Do you think that they actually think I'm gay?' and I said no, because they do the same thing to Donald and they know that it bothers Andy a bit and so that's why they do. They used to try to hug him before, and that's kind of why we moved seats 'cause, yeah. So that time I think he realizes that they're just being immature…I think it makes him uncomfortable. It seems to. Like when they do stuff like that because I guess he doesn't get the humor of it as much? But I think he brushed it off more."[72]

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[70] A_T2_56.
[71] A_O_74.
[72] A_I2_20.

Cathy is Andy's friend, and they frequently work together in class. Although the sexual harassment is not directed toward her, Cathy is involved because Andy, who sits directly next to her, is involved, although unwillingly, and he brings his concerns to Cathy. Because Andy was sequestered with her in the prized "back side of [the] row," she often became tangentially involved.

4.1.7.5 Sam

Sam walked into class, flamboyantly greeted Joseph, and proceeded to straddle his lap, coupled with a tight embrace.[73] Another day, the three touchers were seated together around the same computer. Sam hugged Joseph with arms hooked in a strange embrace, while petting him and smelling him. He did this by running his nose closely along Joseph's body.[74] Later, on the same day, the touchers discussed their right forearm strength from regular masturbation. Mimicking masturbation and fellatio through hand motions and facial expressions was a regular occurrence. [75] A fringe student to the touchers joined the conversation, having heard it from across the room. Sam embraced his biceps, grabbed his abs, and commented with emphasis on how hard everything about him was.[76]

Several days later, Sam once again straddled Joseph. In this position, he said, "You smell like coconuts," then leaned into Joseph's ear and said, "Go ahead, shove it in." A later conversation between these Sam and Joseph focused on what someone, perceivably me, thought about their sexuality. Joseph: "Women are gross." Sam: "[*indistinguishable*

[73] A_O_62.
[74] A_O_65.
[75] A_O_61.
[76] A_O_66.

identifier] thinks we are gay." Joseph in false shock, responds, "Thinks it?!" in a tone indicating that the person should know they are gay, not just think it.[77]

Strangely enough, Sam does talk about girls in the class. In this same class period, Sam kept repeating over and over again, "I like girls." Joseph inquired one time, "Why?" to which Sam replied, "Because I find them attractive." Another day, the touchers spoke about girls several times: "Who likes Beyonce for her singing?" and "Do Shakira's hips lie?"[78]

4.1.7.6 Joseph

Joseph asked Ty one day if he's ever made out with a guy. I didn't hear Ty's response, but Joseph retorted, now assuming Ty said no, "Oh my God [emphatically]. You are such a loser Ty because you've never made out with a guy."[79] Although this may seem playful, it is a form of both bullying and sexual harassment and was common instigating behavior that I observed of Joseph in Cathy's class.

4.1.7.7 Super Friends

Five of the "super friends" were seated at the first row of computers, closely huddled against one another and with lots of touching and hanging onto one another. This lasted for about 2 to 3 minutes before Mrs. Jones instructed them to move apart by one arm's length. She catechized, "I don't know why you feel the need to hang on and touch each other." After Mrs. Jones finished her classroom announcements, the students were sent to work independently in their paired groups. However, the super friends did not disperse

[77] A_O_70.
[78] A_O_68.
[79] A_O_82.

and remained seated at the first row of computers. Mrs. Jones continued to instruct Sam to move across the room to sit next to his partner. Finally he did, but not without Mrs. Jones first having to go over to the super friends to “whip them back into shape,” as she told them. She asked them to stop singing and stated that they were getting out of order again, presumably because she had been gone for a few days. Despite these demonstrations of chastisement from the teacher, in front of the class, these students never seemed to be phased by embarrassment, shame, or simply by authority.[80]

One of the activities that many students did throughout all of the classes was to change the desktop image to display some expression of their interests. One day, Joseph created a rough image in an application such as Paint and saved it as his desktop image. The background was white, with dark lines that drew out the phrase, “I’m Joseph and I <3’s [sketched male stick figure],” where the <3 symbolized a heart, typically meaning love in teenage colloquial terms. After doing this, his behavior indicated an invitation to everyone to see the image: he closed all applications and rolled away from the front of the screen so that others could clearly see what he had drawn. Ty, who sits across the desk from Cathy, loudly shouted across the room to Joseph, asking him what his computer screen said, in a facetious and obvious manner. Cathy believes that Ty did this “to get him in trouble, virtually. I’m sure Mrs. Jones probably saw it but [Ty shouted] to get him in trouble and to get the whole rest of the class to see it and then the whole rest of

[80] A_O_80.

the side of the room to freak out about it and started accusing him."[81] Even with this stir in the class initially, Joseph maintained this as his backdrop for a couple of weeks.

4.1.7.8 The Privileged

A primary scenario, which played out regularly in Cathy's classroom and highlights her experience, is one of an elevated position of respect, prestige, and power within the classroom. This is demonstrated by a nickname/label of a privileged student that she received from another student and the special and preferential treatment that she received from the teacher. In addition, Cathy often mentions how her dad can help her if needed. Although this may be most appropriate in describing the support that Cathy's family offers, it is mentioned in this section because it provides access and advantage not available to all students in her class.

One day, Donald and Cathy were comparing grades from another course in a way that made most of the class aware. Donald seemed bothered and distressed that his marks were not as high as Cathy's, and the difference was two-tenths of a point. Joseph, while observing this scene, kept saying loudly, "She is privileged! She is one of the privileged!" Mrs. Jones responds with "everything should be fair but not necessarily equal." Cathy tried to defend herself and her effort to earn her grades.[82] Her reaction indicates that she works hard as a student to earn high marks, and she values the reward.

When asked about the origin of the nickname coined by Joseph, she responds in wonder, "I don't know, really. 'Cause I think he just mean it cause—he doesn't really

[81] A_I2_21.
[82] A_O_72.

know me. So, I think he just put a label on me."[83] Cathy later tries to describe why she believes she, Andy, and Sonal have been labeled as the privileged from Donald's point of view: "I think what [Donald] meant is that we do our work kind of and we would, may be a better partner than some of the other people. And because we are always doing our work we get to sit at those three computers, the only three that she can't see [the screens] from her desk, because she trusts us…And when she moved seats we were the only three that didn't move."[84]

I observed that Donald, the only Asian student in the class, displayed a progressively negative attitude during the course of my data collection in the classroom. A seemingly good student, he appeared to want to be associated with the privileged students, but their number was limited by there being only three prized seating positions. Donald often talked with the three privileged students before, during, and after class, but perhaps as he felt increasingly excluded from the privileges and associated respect from the teacher, he acted out and exacerbated the issue among his classmates.

Just as boys bond through the risk of rule-breaking and through aggressing against other boys, they also bond by aggressing against girls (Thorne, 1993). As girls cross into groups and activities of the other gender (e.g., engineering), they are essentially challenging the structure of traditional gender arrangements. Teasing and labeling Cathy as one of the privileged can be a strategy "for containing the subversive potential (Thorne, 1993)" that she and other females have of reaching parity, or even worse, power in the classroom. No one would agree that aggression has any place in the classroom. However,

[83] A_I2_19.
[84] A_I2_19.

teasing and labeling is a form of aggression. Labeling should be avoided at all costs in the classroom if it causes barriers to an equitable learning environment, particularly dichotomous labels—good/bad, smart/struggling, etc. Labels, by students or teachers, lead to bias and inequitable treatment.

4.1.7.8.1 Final Design Project

Mrs. Jones explained to the class that she would group students for their final design project. I left the room for a minute and returned to a discussion about the privileged. Joseph bellowed, as if a threat, "If the privileged are grouped together again…" and expressed exasperation and seemingly artificial anger. Donald agreed, and said that he wanted to be grouped with the privileged. The privileged, according to the other students in the class, are Andy, Senal, and Cathy.[85] Moments later, Donald asked Mrs. Jones when she approached him with a handout if he could work with the privileged. She explained that she assigned him to another group of two students and did not address his remark about the "the privileged."[86]

Several weeks later, Mrs. Jones began class with information about the final. Cathy held her head in her hands, with her elbows on the table. Mrs. Jones asked if she was stressing and told her not to do so. Ty, who was doing very poorly in the course as the teacher anecdotally shared with me, attempted to comfort Cathy. "Don't stress. You are privileged. You automatically get college credit for everything you do." At this point, he turned and looked at me and said, "It's true."[87]

[85] A_O_75.
[86] A_O_76.
[87] A_O_79.

Close to the end of the school year, the students presented their group design projects. After the first four pairs presented, Mrs. Jones, exasperated, exclaimed to the entire class, "I expect better work, and I expect it right now! Who is going next?"[88] Ty responded with "the privileged," referring to Cathy and Sonal. Another student piped in, "No Pressure." Cathy and Sonal gave a very nice presentation. They alternated speaking about each slide about their designed product and their use of the engineering design process. Although their product was nothing remarkable, they followed the design process, had good documentation, and presented well. The conversation in the classroom immediately after Cathy's presentation in front of all the class went as follows:[89]

> Ty: "How did y'all get so great?"
>
> Cathy: "We followed the instructions."
>
> Mrs. Jones: "Yes, let me comment on that. THAT [said with strong emphasis while pointing to Cathy and Sonal] is how it is done, people."
>
> Joseph: "We showed how it was done first."
>
> Mrs. Jones: "Let me be the judge of that."

Later that day, Mrs. Jones approached me to talk about what happened in Cathy's class. I had stepped out of the classroom during the presentation before Cathy's, and Mrs. Jones wanted to fill me in. Mrs. Jones explained that she made that group sit down in the middle of the presentation because they had not taken the project seriously. They threw

[88] A_O_84.
[89] A_O_84.

together their prototype and copied the demo slides without even changing some of them. Evidently this was the point when Mrs. Jones exclaimed that she "wanted better work."

Mrs. Jones then explained that she told Cathy after class how well she had done. Mrs. Jones elaborated with many laudatory comments on Cathy's and Sonal's amazing work. Mrs. Jones said that she usually likes to have the best students go first to raise the bar for the rest of the class, but Cathy and Sonal weren't able to that day because of some technical difficulties that left them scrambling to pull their presentation together between the other student's presentations. Mrs. Jones didn't seem to mind this issue and lack of preparedness. Because of their privilege, they were given extra concessions that some of the other students were not allowed.

4.1.7.8.2 The teacher discusses "the privileged"

Mrs. Jones said that she had not noticed the talk about "the privileged" that I observed. However, after paying closer attention, Mrs. Jones mentioned that she heard students refer to Cathy and others as the "Chosen" (although I assume she meant "privileged"), but she wasn't sure why that was happening. She told me of her intentions to explain to the students next time it happens that students are treated based on their behavior.[90]

In a later interview, Mrs. Jones describes how she initiated a class discussion after more commentary about the privileged and explained the three prized seats:

> "I was like, 'What is this? What is this about the privileged?' I said, 'You know you guys keep saying,' of course Donald's the biggest one, 'Well, they are the privileged.' They're all like 'They are the privileged,' and I

[90] A_O_85.

> said, 'Well, you know what? If you act like adults, then'—I said, 'They're the ones I trust, that's why they sit over there and they haven't moved all year.' Because I did move all the seating, but I left the three of them in that spot. So I do trust them, so I let them sit there all year long.… I think [Donald] was a little miffed that he wasn't in the group. I think that was maybe the thing that started this. And I said 'You know, you behave like an adult, you get treated like an adult. You behave like a 5-year-old, you get treated like a 5-year-old. Go figure it out.' I said, 'Yes, they are the privileged because they've earned it' or something like that. But, we had a discussion about that. Then they continued to call them the privileged even more but whatever I don't care. I explained my reasoning and it wasn't—if they wanna say it like—if they wanna call them the privileged, they are the privileged."[91]

Mrs. Jones acknowledges that Cathy, Andy, and Sonal are the privileged students in the class. She gives them special treatment because she believes they have earned it by acting maturely, in contrast to the majority of the class. Mrs. Jones often spoke about how poorly behaved this particular class was. During an interview she describes one incident to me and laments its effect on Cathy and the "good" kids:

> "I kinda snapped at them all the other day. And I was like, 'You know, you guys are gonna want a letter recommendation one day for college. You're gonna want me to sign off for NHS. You're gonna want something

[91] A_T2_56.

> and this immature behavior isn't gonna get you very far' or something and I just kind of 'grrrr.' But I kinda feel bad 'cause Cathy and Andy and the good kids, the privileged as they call them, had to put up with all that. I mean, had to be scolded along with them and that ended up of course in no way was I directing my scolding towards them and I wasn't even looking at them during it. But it never feels good when you're in a class where people are being scolded."[92]

It appears as though with the seating arrangement, and the dynamic in Cathy's class, there was only room for three privileged students. Had there been four seats, perhaps Donald, who is also a high-achieving student, would not have been on the outside instigating the repetitive privileged commentary.

4.1.7.8.3 Cathy as "the privileged"

When asked how she felt when Joseph initially proclaimed her as the privileged to all of the class, Cathy explains, "I guess I think he was kind of kidding. I mean it's not like I really get special treatment."[93] With this statement, it is clear that Cathy doesn't acknowledge her receipt of special treatment as a "good kid" in her class. However, this separation of social class within her classroom alters the learning environment and thus influences Cathy's experience in engineering.

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[92] A_T2_56.
[93] A_I2_19.

One day,[94] Joseph made a loud remark to the classroom, “I’ve never made a mistake.” Cathy laughed, and Mrs. Jones called this out to Joseph, “Cathy is laughing at you.” Joseph, defeated, responded, “That is not very nice.” This scene was interesting because Cathy engaged with Joseph, something she rarely did. Joseph was being his seemingly normal, disruptive, and incendiary self, when Mrs. Jones herself poked fun at Joseph through Cathy’s reaction. This is an example of how Cathy is established as a star student, on a pedestal above others, and how Mrs. Jones uses Cathy, in a way to admonish Joseph.

On another day,[95] Mrs. Jones instructed the students to finish an assignment from the previous class. Cathy and Andy stated that they thought it was homework and already finished it. In front of the entire class, Mrs. Jones proudly dubbed them as “over achievers” and told them to work on their portfolios, a year-long project to document their work in the course. Scenarios like this one are what further separates Cathy from the others in the class, and what gives them the impression that she is special, privileged, or more respected among her peers.

4.1.7.9 The touchers vs. the privileged

The dichotomy of behaviors between “the touchers” and “the privileged” manufactured a social structure and hierarchy within Cathy’s class, and she was at the top. With this placing came special treatment from the teacher, advantages and concessions not provided to other students, and pressure from other students to perform. Cathy acknowledged that she worked hard and therefore received a prized seat in the classroom, but she didn’t think she received special treatment. Her motivation to work hard and earn

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[94] A_O_69.
[95] A_O_73.

good grades does, however, standalone from this treatment and classroom environment, because she demonstrated this ethic in her other school work and extracurricular activities.

4.1.7.10 Cathy makes sense of the classroom

In spite of the deluge of suggestive behavior and language in the classroom, Cathy describes that she chooses not to be offended by her classmates. She believes that a class of 98% males (her exaggeration) will not pay attention to manners with a female in the room. This statement relays an expectation for a certain decorum that she does not see in her Tech Ed or engineering classes. The way she describes what "they" might be doing or thinking, elicits a feeling or sense of exclusion. The content may be sexual, but the exclusion from the "male clubhouse" is because of her gender (McIntosh, 1988). Although she does not describe exactly what the young men say, or search online, she notices that something is wrong with it, but she chooses not to be offended. Although she may not be offended, this behavior creates an environment in which she is the outsider, inevitably influencing her experience.

> "Some of it is disturbing, like there are some other people who, you know because when you are in a class of you know, 98% guys, they don't really take that into account that they might be saying some stuff...they're just like 'OK.' But you know what they might be thinking, and they all like to go on Google [laughs]. They like to search, I don't know what they do because I can't see, but it is kind of weird, but I was in Tech Ed[96] too, and

[96] Tech Ed was Cathy's middle school engineering program.

> you heard that too, and it is just like ‘ok.’ You just kind of [sighs] accept it, I don't know.”[97]

Cathy describes their actions as immature or an effort to be humorous. However, she believes that if the action were between a male and female then the consequences would differ from “joking”[98] between male students. This expectation that “boys will be boys” is okay, as long as it is among young men, and not immature humor directed toward women, could indicate some relief that she is not at the end of any of the sexual farce.

> “He doesn’t do anything to the girls because that would lead to more trouble. If he actually said anything like that to a girl he would be in so much trouble…I guess it’s just America, how that works, just being rude like that. I guess just naturally we seem to think that it’s not as bad if they say it to a boy.”[99]

4.1.7.10.1 Accustomed to male-dominated environments

Cathy was aware of, and almost encouraged by, the gender disparity in engineering before beginning. She states that having male friends and doing Taekwondo in a mostly male environment helped her to feel more comfortable in pursuing engineering. Because she is accustomed to interacting with young men, she does not feel intimidated by the lack of young women in the environment.

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[97] A_I1_18.
[98] A_I2_20.
[99] A_I2_20.

> "As far as the gender barrier, I guess have not really felt that there was exactly a barrier as much as a slight separation. When I first did an engineering type class at school, I knew what I was getting into as far as the unequal distribution of males and females. Also, I wouldn't say that I minded. Sometimes guys are easier to get along with and easier to work with. I have also always had a few boys who were my friends. In fact the person I would consider to be my best friend is in fact male, so that has helped me become more comfortable. Also, since I do Taekwondo, which usually has about a 7:1 ratio of males to females in class, I am used to interacting with guys…Overall, I guess I am just used to interacting with guys."[100]

4.1.7.10.2 Women in engineering

Cathy has one close female friend who is interested in engineering and participates in a program at another school. She believes, however, that her other female friends, many of whom are in a health sciences program, would not have felt a barrier to participate in engineering if they were really interested. What Cathy does not realize is that they may have been discouraged by the anticipated environment and a limited understanding of what engineering might be. Many social barriers limit females' interest in engineering (Hill et al., 2010).

> "I actually have a friend that was interested in engineering and she actually is in the engineering program at another school. As it happens, a

[100] A_J1_3.

> lot of my friends are in the health academy and things like that. Also, knowing my friends I don't think any of them would really not choose to participate in engineering if they were sincerely interested."[101]

Cathy's mother describes how it is good that Cathy had a good female teammate on the latest project. This highlights Emily's belief that relating with other young women in engineering is important as well as her acknowledgment of the rare opportunity to pair with a female, particularly one who can work well with Cathy. "She said that the partner that she had turned out to be really good, a girl… I'm glad that she found another girl that she could work with that's into it and helped with the project a lot of times."[102]

4.1.8 The Teacher Feels Sorry for Cathy's Experience

Mrs. Jones feels sorry that Cathy has to be in this class because of the "whole immature boy scene" and surmises that Cathy would have had more fun in another class.

> "But, yeah I just feel sorry for [Cathy] having to put up with that whole immature boy scene. And that's why I say it's so weird because fourth period was like a third more kids, mostly ninth graders and yet look at how much difference there was in those two classes. You know? And I

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[101] A_J1_3.
[102] A_IP_47.

> think it would have been a lot more fun for Cathy to have been in that class rather than to be in the third period class.[103]"

Mrs. Jones laments that Cathy's experience is influenced by such a "weird" classroom atmosphere. Although she cannot control everything the students do, she hopes to make Cathy's experience more positive. Mrs. Jones expresses concern that the experience could potentially drive her away from engineering. Besides the fact that Cathy has proven that she is an excellent student, perhaps Mrs. Jones's feeling motivates her special treatment of Cathy, which perpetuates the behavior cycle from the male students.

> "Cathy's in there with the touchers, which is a strange class to begin with, but Cathy herself is awesome.…Cathy's just one of those kids who I just wanna hold onto her for the 4 years because she has such a talent and we—she is motivated she's a very hard worker, and she's got a lot of aptitude towards engineering. I mean she has the potential to be a great female engineer as an adult, and I wanna do everything I can to foster that interest in her now, which unfortunate-wise she's in that class, the weird class, 'the touchers'.…In every class there's weird personality things that go on and unfortunately I can't control what every student's doing all the time as much as I'd like to.…All I can do is to hope to make her

[103] A_T2_57.

> experience the best that I can make it so she's never, never feels like she was driven away from the thing she wants to do."[104]

4.1.9 Summary of the Classroom

Because of the lack of participation of females in engineering, perhaps they can be given special treatment, much of which is likely implicit, to keep them "happy" and having fun so that they stick with it. Although there is nothing inherently wrong with this notion, when it is amplified, as in Cathy's class, it could be detrimental to the female student and further the gender divide within the culture of engineering. Cathy is very resilient, tough, and seemingly unscathed by predominantly male environments and the "immature" behavior that may be associated with those environments. Even though she may feel like an outsider, her interest keeps her engaged. However, the question remains, how long can she or will she persist as an outsider?

Mrs. Jones occasionally asked me for a strategy to discipline the rowdy boys. At the time, I did not have an answer, and even now, I don't have a perfect solution. I do know, however, that allowing this type of behavior to continue inhibits creation of the safe learning environment that every student should be afforded. The result of allowing such overt forms of masculinity to dominate the classroom culture and discourse is an incredibly inequitable classroom. No student, particularly those underrepresented in an engineering context (females, students of color, non-heterosexuals) should be forced to learn in an abrasive

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[104] A_T1_53.

environment where the demonstrations of masculinity constantly oppress their existence and identity.

The young men in Cathy's classroom not only adopted the conventional stereotype of masculinity, but also, likely in response to powerlessness, laid claim to a gendered position of power through an exaggeration of masculine conventions (solidarity touching, bashing gays, teasing girls and weaker boys). Connell suggests that the behavior is a collective practice and not something inside the person. "The growing boy puts together a tense, freaky façade, making a claim to power where there are no real resources for power" (Connell, 2005, p. 111). Joseph, like Connell's case Patrick Vincent in *Masculinities*, is concerned with maintaining a front, a false-self system, and a personality compliant to the demands of the environment he created. Perhaps helping Joseph to feel a sense of real power in the classroom would diminish his need to grasp for straws and disrupt the class.

4.1.10 Summary of Cathy

Cathy is a high-achieving freshman engineering student with a supportive family that has instilled in her the value of hard work and education. Because of her personality and work ethic, she quickly built a strong rapport with the teacher as a star student. Cathy is not intimidated by, and is somewhat motivated to challenge, gender barriers, including in engineering. Her engineering class has a unique social order between the misbehaving "touchers" and the overachieving "privileged." This dynamic is unique and is not representative of all high school freshmen engineering classes. However, the "immature boys" contrasted with the privileged elite could be an amplified version of common currents in an early high school course with predominantly male students. The intersectionality of race, gender, class and sexuality discussed in this case all play a role in influencing Cathy's experience in her high school engineering course.

4.1.11 Key Points and Recommendations

- Not all students have as supportive and active parents as does Cathy, and therefore may not benefit from such remarkable influences regarding education opportunities, to include engineering. Teachers and counselors must often "stand in the gap" for those students. Tools, professional development, and training can help prepare educators with the information and motivation to help every student consider engineering.
- Although Cathy believes she is good at math, her belief is measured against how well others are performing. Helping all students to develop a growth mindset in math and science, and to encourage them to attribute success to hard work and effort, will begin to influence female student self-efficacy by allowing them to overcome stereotype threat.
- Although Cathy knows a handful of engineers, she may be making critical assumptions about what is like to be an engineer based on a small sample. Our educators are on the front lines with the students, and we do not want them to send messages about engineering that do not align with student interests and work values. Training educators on effective messaging and how to recruit diverse role models for their students will begin to challenge stereotypes and broaden student understanding of all of the options and opportunities available in engineering.

- Cathy's classroom was defined by two labels: the privileged and the Super Friends (or the "touchers" by the teacher). Labeling—particularly dichotomous labels such as good/bad, smart/struggling—should be avoided at all costs in the classroom because they create barriers to an equitable learning environment. Labels, by students or teachers, lead to bias and inequitable treatment.
- Mrs. Jones failed to find a solution to control the rowdy boys and acknowledged how their behavior affected the classroom experience of the other students, particularly Cathy. The result of allowing such overt forms of masculinity to dominate the classroom culture and discourse is an incredibly inequitable classroom. No student, particularly those underrepresented in an engineering context (females, students of color, non-heterosexuals) should be forced to learn in an abrasive environment where the demonstrations of masculinity constantly oppress their existence and identity.

4.2 Charlie

Charlie is a mixed-race, female sophomore taking Introduction to Engineering. Charlie is kind, liked by her teachers, and conscientious about her work. Mrs. Jones, the teacher, describes Charlie:

> "She is always worried about getting assignments done on time…She's just really a perfectionist and so she's very slow and methodical about what she does but

> very conscientious and super polite and super respectful. Just a really, really nice girl."[105]

Charlie's family is complex in that her parents' divorce was tumultuous and both parents have since remarried and had more children. Charlie has several siblings, biological, half, and step, two of which she is responsible for caring for at home. Her family is multi-racial, which is seemingly important to Charlie's identity; her mother is White, father is Black, and stepfather is Filipino. Charlie was even quoted in the year book about her mixed-raced identity. Charlie's mother is a hairstylist, and her father is some sort of business owner.

This was Charlie's first year in the school district. Because her parents serve in the military, and because of their divorce, in her 16 years of life, Charlie has lived in more than 14 places across the United States and Europe. She mentioned not remembering all of the places she has lived.

4.2.1 Choosing Engineering

Charlie chose to take an engineering course because she learned about it as a career in a previous course. In determining her course schedule for the year, she was "excited they had [engineering]" and signed up for her elective credit. However, Charlie's career interests are very broad, and her work-life goals are idealistic:

> "I would love to be a chef, nutritionist, engineer, something with computers, model (high fashion), and a linguist. With my life, I would like to travel the world,

[105] G_T1_32.

> meet tons of people, teach others, have fun, help others, and experience different cultures—and make the world a better place! I have no doubt that I won't."[106]

> "I don't really see me working my whole life and then retiring and then just living. I just see myself traveling, having fun, meeting people going everywhere and just living my life like that. That's how I'd like to do it."[107]

Charlie is drawn to engineering as an opportunity to help the environment. This is not uncommon, because most females' entry into science and engineering careers is motivated by a helping factor (Committee on Public Understanding of Engineering Messages, 2008; Miller, Slawinski Blessing, & Schwartz, 2006).

> "I don't really remember when [I became interested in engineering]. I just remember that I wanted to help the environment and to invent things, for example, the solar powered… I forgot what it's called… solar powered panels. [inflection rises like a question] That's like the concept that I want to invent."[108] "I don't like how [companies] think all about money and not about the world. I would use my knowledge and my...and my background to help others and to make the world a better place."[109]

Charlie enjoys and desires travel, meeting people, and inventing things, and she realizes that even an altruistic nature can be a part of an engineering career. For students

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[106] G – From application to participate.
[107] G_S1_16.
[108] G_S1_14.
[109] G_S2_21.

such as Charlie, who have strong social-driven career ambitions, it is imperative to not limit their career potential by reinforcing longstanding stereotypes of engineering within the high school curriculum.

4.2.2 Charlie's Access to Extracurricular Activities

Charlie does not participate in extracurricular activities. She played softball but rationalized quitting because it affected her education. She later described that she did not like the coach and players. "I didn't really like the coaches and the people were really mean."[110] Charlie was often unavailable for interviews because of her ride situation, and she babysits her siblings, so it is likely that she is unable to participate in extracurricular activities because of familial time demands and constraints rather than simply the effect on her education. Because she depends on the school bus, she is not always able to attend tutoring sessions with her teachers.

Charlie was never able to meet for interviews before or after school like the rest of the participants. Her only available time was during her lunchtime. Charlie's mother withdrew from the study because she could not arrange for a time to do an in-person, phone, or email interview. She expressed in an email that she did not have time because of her work schedule and responsibilities for her children.

Charlie is responsible for caring for her younger sister and half-sister. "I think I do [have lots of responsibilities for my younger siblings]. I do. Either way I watch over them.

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[110] G_S1_7.

Like Paris and Francis, I call them my babies 'cause I love them and I take care of them."[111]

These responsibilities, in tandem with her mother's hectic schedule, could dictate her availability for tutoring or extracurricular activities. An issue of class, Charlie's access to opportunities for learning and engagement in school, and specifically engineering, are limited. In addition, the worlds are different, and the boundaries potentially difficult to negotiate. Phelan, Locke Davidson, and Thanh Cao (Phelan et al., 1991) present a model of the interrelationships between students' family, peer, and school worlds and of how meanings and understandings derived from these worlds combine to affect students' engagement with schools and learning. Charlie's experience is similar to that of Donna (Type III of their model), a student whose worlds are different and who crosses boundaries only under certain conditions and often teeters between engagement and withdrawal. The authors of this model state that "in classrooms where these students flourish, teachers know the students well, are attuned to their needs, and show personal concern for their lives" (p 22). Like Donna, Charlie does well in classrooms where she perceives the teacher as caring and where the norms and behaviors that characterize her family and peer worlds—group over self, listening and empathizing with others, and mediation skills—are required. Charlie's nature to help, and her efforts to belong (and be liked), become themes in her engineering classroom experience.

[111] G_S1_10

4.2.3 History of Being Bullied

Charlie has a history of being bullied at school by other female students. She recalls the impact of her many relocations on her effort to make friends:

> "It was awful to… well, now when I look back, I like it, but when I was younger I didn't like it at all. Well, more so building up the friends and I was a quiet, very shy person, so it was hard for me to make friends and then people were mean. They were like bully, bullying. They were mean. They were very mean."[112]

In *Odd Girl Out*, Simmons (2002) writes about the hidden aggression among girls and its effect on self-esteem. She writes, "Our culture refuses girls access to open conflict, and it forces their aggression into non-physical, indirect, and covert forms" (p. 3). When Charlie describes her former classmates as mean, very mean, she is referring to the same forms of behavior that Simmons references: backbiting, exclusion, rumors, name-calling, and manipulation to inflict psychological pain. Simmons claims that the hidden aggression among girls is exhibited in body language and relationships, and Charlie was not safe from that culture even within her engineering classroom.

During the observation time of this study, the students were assigned to small groups to work on a design project. Charlie was assigned to work with Emelia, a solemn yet dedicated female student, and Alex, an aloof, withdrawn, and poorly performing male student. They had three options for their project: table for coffee shop, locker organizer, or pet supply holder. Charlie brainstormed ideas for all three, but Emelia dismissed them and decided that the team would do the locker organizer. Charlie worked hard to include

[112] G_S2_22.

Alex and to help him feel able to contribute. When she actively engaged him, he more actively participated in the work.

Instead of working together, the three split up to work separately. Charlie brought back sketches and an accompanying YouTube video of a collapsible cardboard box as an idea to Emelia. Very excited about her idea, she tried to explain, and after no response or emotion from Emelia, she began to manipulate a piece of paper into the shape of a box. Finally, after being completely dismissed, she gave up and apologized for wasting Emelia's time. Defeated, Charlie went back to her computer to work.[113]

Emelia was in a regular state of disapproval of and frustration with her teammates. Although she took the lead for the group-work, she was not inclusive, communicative, or participatory. Her leadership centered on bullying and forcing the group to do the project she wanted, and her way. This was not overt behavior; it was subtle, yet aggressive.

In the peer evaluations, Charlie gave Emelia a 100/100, yet described in an interview that she "wished Emelia would be more communicative." Emelia rated Charlie 90/100, claiming that Charlie did not actively participate. This was very frustrating to Charlie, and rightfully so. Charlie rated Alex 100/100 and wrote on the form that Emelia would likely rate Alex very low (she did in fact rate him 20/100). In my opinion, Alex did not earn a full participation grade. Charlie was overly generous in her grade for him, likely to compensate for Emelia's meanness.

This long excerpt provides a snapshot of the data in which Charlie describes the awkward beginning of the group work, her effort to unite the group, and her frustration with Emelia and the peer evaluations.

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[113] G_O_5.

"Well, [the group work] started out where it was very awkward and like they didn't get up and try to get together and I had to go get them [inflection rises] and then they didn't know where to go or what to say to each other so I felt like I had to be in charge and be in lead and then I would, well we would be discussing or brainstorming on an idea and then Emelia would go off and look and say, 'Okay well I'm gonna go check this out' and I would say 'Okay well come to me if you find anything' and I like try to check up on her but I felt that she would be able to come to me and talk to me about it. But she didn't and I felt like there was a lack of effort and communication and—on Alex, well I know that she, I think that she felt that Alex didn't do anything but he did do something he started on the Powerpoint when nobody said to start. He was just waiting to see what we had to say and I tried to check up on him and without that they wouldn't have talked at all. That was one thing that kind of upset me with the peer evaluations, she said that I was lacking of speaking but I was the one like trying to talk to everybody and try to bring them all together and I tried to talk to her. I called her, I text her, to make sure the project was done on time. I was kind of shocked that she said that. I didn't really see her trying to put any effort and I just remember myself putting in a lot of effort to bring them all together."[114]

[114] G_S4_28.

The solution to hidden aggression among females is not to have them "play nice," which is what Charlie tries to do. Simmons concludes in *Odd Girl Out* (2002), "To expect girls to play nice with everyone, despite what they want, is to enforce upon them precisely what we are trying to stop: a tyranny of the nice and kind, that will stifle the girls' voices, shuttle them into idealized, alienating relationships, and impress upon them the belief that their own needs should be subverted to others' an any cost" (p. 259). The solution is "we must encourage girls to embrace respectful acts of assertion" (p. 231).

4.2.4 Charlie Dislikes Group Work

Before the group project was assigned, Charlie explained that she does not like group work. Her description of group work in general foreshadowed the description of her group work with Emelia and Alex. Attitudes are important to the educational process because they are hypothesized to influence learning behaviors (Kouros, Abrami, Glashan, & Wade, 2006).Thus, negative attitudes toward group work may jeopardize group interactions and relationships, as well as student learning. Attitudes, once formed, influence how students think, feel, and behave. Koures et al. (2006) found that the manner in which students are assigned to work in groups evokes strong student attitudes, and resulting behaviors are useful in explaining academic achievement. Although Charlie's academic achievement was not in question for this project, if her aversion to group work is in any way related to the hidden aggression from other female students, then it could become an issue at a later time and potentially discourage her from engineering, because of its collaborative nature.

> "I don't like to work in groups.…I don't really like having to depend on other people to do something and they don't get it done, or just having like nobody knows what to do and so it's that awkward moment who's doing what, who's in charge and then I sometimes end up having to direct everything. I don't really like that. I would just rather prefer to work by myself."[115]

In this quote, Charlie is expressing a discomfort with taking the lead. A study by the Girl Scouts Research Institute (2008) found that "one-third of girls who do not want to be leaders attribute their lack of motivation to fear of being laughed at, making people mad at them, coming across as bossy, or not being liked by people" (p. 19). For a young woman who has been bullied, and who has spent her lifetime trying to make new friends in new locations, leadership could be a terrifying obstacle if these same fears hold true for Charlie.

4.2.5 Queen Bee Syndrome

Charlie was bullied by "bigger" females with "huge curves" for being so skinny. Because she was still attracting the attention of male classmates who she thought were cute, she didn't care what the girls thought.

> "A lot of the girls, they were bigger, like much bigger, and huge curves and they'd always say 'oh, you're so skinny; put some meat on those bones.' But it was funny well, I found it funny because I liked, I thought a lot of the guys were

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[115] G_S1_9.

> cute. A lot of them thought I was cute, too, so I'm like apparently it doesn't matter about my size."[116]

Although there are varying definitions, according to Cooper (1997) the theory of the Queen Bee Syndrome "suggests that women are threatened by other women, ultimately for the attention of men; thus, they evaluate other women negatively and attempt to subvert their success" (p. 486). Although the theory that intersects gender and sexuality exists more for adult women, women were once girls, and thus the behavior and practice was most likely learned and adopted in adolescent years. Because Charlie has had previous experience with women competing with her for the attention of men, she could make the implicit assumption that all women act this way in an effort to justify interactions and behaviors (e.g., her experience with Emelia). In contrast, Charlie's poor experiences and lack of deep friendships with females could turn her into a "Queen Bee" and prove detrimental to future working relationships.

Although there is research to indicate the importance of assigning groups with a critical mass or at least more than one person of the minority gender or race (Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo, 1994), in situations with aggressive or noncooperative young women, could this backfire? The idea is to create less isolation or spotlighting of women or men of color, but the issue becomes complex when we consider the intersections of race and gender for a minority woman. In theory, women who do not like to compete with other women would benefit from an environment like such as engineering, where there are so few. However, if those Queen Bees fill the ranks of the

[116] G_S2_22.

high school engineering classes, could they not edge out the other women through their hidden aggression in a form of reverse stereotype threat?

4.2.6 Helping Others

Charlie has suffered from bullying, many relocations, divorce, and a new family, making it difficult for her to make and sustain friendships. When you consider her responsibilities at home, it is easy to understand why the boundary lines blur and her nature from home shows up in school. These challenges likely lead Charlie to be a people pleaser, as demonstrated by sycophant behavior with the teacher, generously evaluating her colleagues, and helping her classmates to the point of doing their work for them. She wants to help and care for even those who bully her.

> “The words that they say, the things that they did to me. I don’t think they punched me like not like that. They were very mean, and I didn’t really let their words get to me as in bring me down. I was still nice to everybody. I still helped them out and they’re like ‘ugh, you’re always a give in or let people boss you around.’ Like, no, that’s not it, I’m helping you. I’m taking the time to care for you.”[117]

Gender stereotypes and norms foster and perpetuate a nurturing and caring helpfulness associated with the female gender role. Eagly and Crowley’s (1986) social-role theory of gender and helping claims the female gender role fosters helping that is nurturing and caring, in comparison to the male gender role that fosters helping that is

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[117] G_S2_22.

heroic and chivalrous. Charlie's coping mechanism, in an effort to fit in, be liked, and belong, is to help and nurture. This approach likely helped her at home in tough transitions, and she believes it will help her at school as well (Phelan et al., 1991).

Charlie helps Mike, a Korean student who sits next to her, daily, and often allows him to cheat off of her. Sometimes she helps at the expense of finishing her own assignments. She feels empathy for Mike because if he cannot catch the bus, then he has to walk 3 miles home. This empathy could be sourced from her own tumultuous home life and inaccessibility to tutoring because of rides from her mother or stepfather. Charlie feels rewarded when she can help her classmates.

> "I like to help [Mike] and/or other people.… I know [the teacher] is busy sometimes, and if I know how to do something and I'm done with everything, or I just pause, I'll help them. But I like helping because it's something I can do just to teach.… I don't know how to phrase it…help somebody else understand something. By just showing them."[118]

Despite the discriminatory assumption that someone from another country would speak English well is surprising, the teacher describes how grateful she is for Charlie helping Mike. This belief is evident in the teacher-student interactions, because Charlie is rewarded, praised, lauded, and thanked for being such a good helper. When her helping state is rewarded, it reinforces the gender norm that aligns with her home life, and thus likely encourages her to continue helping, no matter the cost.

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[118] G_S1_11.

> "[Charlie's] sitting next to Mike who, while he's a great student, he just moved here from Korea or someplace like 2 years ago and you wouldn't think it because his English is very good but I think sometimes he has trouble understanding the assignment. Even though he speaks English almost flawlessly I think because he does still struggle a little, not much, but it's a little bit of a language problem. Charlie is just, well she's just ready to step in and help him and I love that about her."[119]

4.2.6.1 Solace in the struggle

Charlie is often discouraged when she struggles to understand some of the assignments. She found solace in the fact that Mike struggles in a similar way. She doesn't feel alone in the hard work. Charlie could feel connected to Mike for several reasons: they are both new and non-White students, they share transportation issues, and they share some struggles with class lessons/activities.

> "I didn't understand how to create some of the items or parts… and I guess that was it, I had a hard time creating it. I felt like it was just me a little. Like, I saw some people struggling. Oh, Mike, he made me feel at ease with it because he was having problems with it. If I'd find something out I'd try to help him out so he doesn't feel bad."[120]

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[119] G_T1_32.
[120] G_S4_27.

4.2.6.2 Loneliness

Like many children of divorce (Wallerstein, 1991), Charlie felt alone during the family transition from the divorce to the blending of families.

> "I didn't like [my father] not being there. I wanted his attention. I craved it and especially being with a new family and more kids I felt really alone and by myself."[121]

Feelings of loneliness can translate in the classroom in how she interacts with other students. Easterbrooks, Ginsburg, and Lerner (2013) observe that most military children turn out just fine, and the hardships of military life offer many sources for developing resilience. However, in combination with her parent's divorce and blending of families, the residual effects of her family life are exhibited in the classroom in her effort to belong in the class at all costs, to not to make waves, and to help others.

4.2.7 Key Points and Recommendations

- For students such as Charlie who have strong social-driven career ambitions, it is imperative to not limit their career potential by reinforcing longstanding stereotypes of engineering within the high school curriculum.
- Interrelationships exist between students' family, peer, and school worlds, and how meanings and understandings derived from these worlds combine, affect students' engagement with schools and learning. Charlie does well in classrooms in which she perceives the teacher as caring and in which the norms and behaviors

[121] G_S2_19.

that characterize her family and peer worlds—group over self, listening and empathizing with others, and mediation skills—are required.

- Charlie experienced hidden aggression from a female group-mate, but she did not feel empowered to tell the teacher, or provide honest evaluation. Educators can work to create a safe space that incites respectful interaction and open communication, and discourages passive-aggressive behaviors, particularly among females.
- For a young woman who has been bullied, and who has spent a lifetime trying to make new friends in new locations, leadership can be a terrifying obstacle if the "fear of being laughed at, making people mad at them, coming across as bossy, or not being liked by people"(Girl Scout Research Institute, 2008) hold true. Creating opportunities to nurture Charlie's leadership skills instead of these fears will prove beneficial to her future.
- Because Charlie has had previous experience with women competing with her for the attention of men, she could make the implicit assumption that all women act this way in an effort to justify interactions and behaviors. Engineering could be the survival of the fittest, when it comes to women who can overcome stereotype threat. Women who do not adopt traditional gender stereotypes could be at risk of "Queen Bee" behavior, which is exclusive to those who adopt traditional gender stereotypes. Identifying and discouraging "Queen Bee" behavior in the classroom, often exhibited as hidden aggression, will foster a better environment for every student in the classroom, particularly underrepresented females in engineering.

- Charlie is a helper, both at home and at school. Although there is nothing inherently wrong with helping others in the classroom, equitable discourse with both males and females who help, and equitable expectations for both genders to help will begin to challenge the stereotype.

4.3 Isabelle

Isabelle is a White female senior student taking Introduction to Engineering as an elective. This is typically a freshman-year course, although almost one-half of the students in her class are also seniors. Isabelle is an honors student and a professional actor. Her acting sometimes takes her away from the classroom, and she has had a few minor roles in small films and commercials. At home, she speaks both English and French, because her mother is a native of France. Isabelle's mother teaches French and English at a university, and her father is a chemical engineer.

4.3.1 Choosing Engineering

Isabelle's best friend Kassie, also a participant in this study, took engineering for 4 years. Kassie showed Isabelle some of her 3D printed items and other projects. This knowledge sparked an interest, and Isabelle signed up for engineering to determine whether she likes it. Even though they are the same age, Kassie served as a role model for Isabelle. Role models are an effective way to counter stereotype threat and increase self-efficacy (Hill et al., 2010), and recruiting females together is effective for STEM (Milgram, 2001).

After the beginning of the semester, Isabelle's experience was so positive that she chose engineering as her college major.[122]

> "Kassie showed me the stuff she printed out. I was like 'What is a 3d printer?' and she was telling me about all the things she was doing. She was like 'hey, it's fun!' I was like ok, I'll try it. It looked cool; it would be a good class to take. I was just going to try it to see if I like it. I liked it at the beginning so that is what I chose for my major."[123,124]

4.3.2 Change in Class Dynamic

During the period of observation for this study, the class seemed very well behaved, calm, and significantly more quiet than any of the other classes. Evidently, a group of problem students regularly disrupted the class during the first semester. The primary troublemaker was removed from the class, and the classroom dynamic underwent a significant shift, according to the teacher, Isabelle, and Luna. Mrs. Jones describes the change in the classroom:

> "Well, ever since we got a couple of the kids out that were trouble makers, one student was sent to the Opportunity Center at the end of the semester, last semester, and then he returned so late that he couldn't rejoin the class. He was a super trouble-maker. Then he was whipping up another kid who now has moved away. So, that has reduced that class to really very quiet

[122] B_S2_8.
[123] B_S2_8.
[124] B_S1_4.

> kids. They would feed on each other and they were big buddies and they would just cause all kinds of trouble in the classroom and it was all about them, because I was constantly on them. Then, when the first kid left the second kid got a lot quieter, still wasn't a perfect student but was much more manageable. So, what I mean was he was just...he was kinda creating that atmosphere with the other student. But, now they're both gone so that class is a dream class, now. They just sit and work and they're on task and they barely talk to each other. But they're all doing what they should be doing, so it really is a dream class. Seventeen students doing what they should be doing 100% percent of the time."[125]

The class really was well behaved, quiet, and almost always on task—even when there was a substitute teacher. As a point of reference, the lack of interaction in this class rendered the observation notes quite thin for the cases for Isabelle and Luna.

4.3.3 Classmates

Although Isabelle does not identify Luna as a friend outside of the class, they are very friendly toward one another during. Of the same race, gender, and class, it is not uncommon for homophily (McPherson et al., 2001) to have played a part in this self-selection of in-class friendship. Isabelle and Luna were not assigned seats together during the first semester, but they frequently spoke with one another and chose to join one another for group work when the opportunity allowed. At semester break, the seating arrangement was changed, and Mrs. Jones placed them together. Isabelle describes on

[125] X_T1_9.

multiple occasions how well she and Luna work together and how she enjoys partnering with her in the class.[126] However, Isabelle says she does not like most of her classmates because "they say stupid things and are unreliable." She mentioned to her mother how annoying many of her engineering classmates are. It is not uncommon for upper-class students to avoid or ostracize less mature underclass students, particularly in a class with such an age divide.

> "I didn't like anyone else. I like a few people that sit next to me. But a FEW [participant emphasized] of them…They say dumb things!"[127]

> "I don't like working with people I can't trust. That's happened before. They were just unreliable. They wouldn't do their work. I just ended up doing it by myself." [128]

Isabelle is very articulate about what she does not like: classmates, volleyball (coach and players), etc. She is attracted to theater because she believes that those who participate in theater are nice, as opposed to volleyball players. Throughout the course of the study, Isabelle shared stories of two experiences that led her to dismiss an activity or group based on the people.

> "I did sports a lot when I was younger. I did volleyball. I didn't like the coach. She is mean. She was evil. And the girls were mean.[129]"

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[126] B_S2_9.
[127] B_S1_14
[128] B_S2_9

> "I had friends before this group and they were kind, but it was always me who was initiating any sort of activities to do and after a while, I just got really tired of always being the one who was planning. With my [new] theatre friends, we are all open to doing whatever the others want to do and it's not just me inviting to go do things."[130]

What is curious is how her disdain for most of the other students in her class does not turn her off from engineering in a similar way that it did volleyball and her old group of friends. Perhaps she is able to dismiss their behavior because they are younger or perhaps her connection with fellow senior Luna creates a more positive experience. This could be a positive result of pairing females on a team to combat marginalization via tokenism and stereotype threat.

An engineering environment, where there are so few females, could be a place where one is as likely to find a friend as a foe among the few. If Isabelle had experienced bullying from other females in her volleyball team, and potentially other hidden forms of aggression, then the fact that she made a friend in Luna—even if only within the classroom—contributed to a positive experience. The experience could have easily gone the other way and turned her off from engineering.

4.3.4 Noninclusive Collaborative Environment

Luna and Isabelle created a noninclusive collaborative environment when they worked on the puzzle project in class, which spanned a week. Luna and Isabelle work

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[129] B_S1_18
[130] B_J1_4.

together and practically exclude the younger Asian male student in their group. He had to physically place himself between Luna and Isabelle to be engaged, because the two of them had turned to one another to work. Isabelle, seated between Luna and the other student, could have moved to include him, but did not. In their group interactions, the two young women were in control and dominated the hands-on portion of the project. The young man is quiet and, although not overly engaged, he is not welcomed into the fold when he does try to assert himself.[131]

> "He is super quiet. He doesn't speak at all. I think once he said a word to me. I will ask him for something…'Hey how do you do this?' and he will just point. I think he is just really shy. A few times I forgot him. I feel like he would have contributed more if he would have said something."[132]

Isabelle, unlike several of the other cases, did not display an active interest in helping her classmates, other than Luna (who never seemed to need help). This is in contrast to traditional female gender norms of nurturer and helper. The bond between Luna and Isabelle was often to the exclusion of others in the class. They sat in the privileged seats (see Cathy's case), and Isabelle often maintained an air of apathy toward her classmates. Perhaps as a way to protect her identity in engineering, she surrounded herself with someone who was like her and likely to face the same implicit issues of stereotype threat. Isabelle, although not perceived to be unpopular, aligned with Luna, who did seem to be popular. Although their families have similar economic means, Luna enjoys a higher

[131] X_O_2.
[132] B_S1_17.

social standing in the high school. Because Isabelle made it clear that they were not friends outside of class, it did not seem as though she befriended Luna to climb the social ladder, but instead to survive the class.

4.3.5 Math and Science

Isabelle enjoys math and science, but her self-efficacy varies across courses. A disinterest in biology and a belief that she is not good at chemistry turned her away from initial career goals in the medical field, and a belief that she is good in physics led her to engineering.

> "I have had to put aside nursing and medical stuff because I thought I wanted to do that. Physical therapy was a big thing. Then I decided I did not like dissecting things and I was like…so engineering. I had always been good with muscles and stuff, which pushed me in that direction, but going away from it was probably chemistry. I was not very good at it. I thought you needed a lot of chemistry to get into medical. I took physics and I was really good at it. I was like 'hey, what can I do with physics and math, oh wait, engineering?'"[133]

Isabelle believes that physics and math are gatekeepers to engineering. Self-efficacy plays an important role in her choice to enter into engineering, and ultimately to choose it as her college major. She took the Introduction to Engineering course as a senior to

[133] B_S2_7.

determine whether engineering would be a good major to elect for her first year of university.

> "I have always enjoyed math and science, even when I was little my mom would tell me that I should go into engineering so that always made me want to get into engineering. At the beginning of this year I had to start applying to colleges and pick a major, so I just chose engineering because it was broad and if I didn't like it by the end of the year, then I could change my major. This class definitely sealed the deal, just because I really enjoyed the projects that we did and I was pretty good at it!"[134]

Because of the encouragement Isabelle received from her mother as a young girl, she was able to picture herself in an engineering career, but this choice was not a straightforward one. Was her mother's encouragement more influential than her father's career? Despite her encouragement, Isabelle's mother has doubts that engineering is the best choice for Isabelle. She is concerned that Isabelle will not be able to handle the math and will not be able to apply her creativity adequately in engineering to be satisfied.

> "I thought it was a good idea [that she major in engineering]. I am not sure she is going to be able to handle the math class. A problem I see with Isabelle, she is very creative. I think she needs that in her life a lot and if she can apply creativity into engineering that is great. From what I heard, when you are in the university it is pretty hard to do so. She may miss this.

[134] B_J1_2.

I don't know. That's great if she can be; it is good money if you do. She can pursue that. It is wonderful."[135]

It is unclear how Isabelle's mother's displays her doubts and misconceptions in their interactions with one another. Contrary to common stereotypes, engineers need not be extraordinarily talented in math and science, and engineering does in fact require creativity (Committee on Public Understanding of Engineering Messages, 2008). This misconception regarding math and science may have initially influenced Isabelle's decision to enter into engineering, but the misunderstanding about the importance of math ability and creativity in engineering could cause Isabelle to make a different choice in the future if her self-efficacy becomes more fragile. In contrast to her mother, Isabelle never expressed concern about her ability to succeed in math (although she explicitly mentioned biology, chemistry, and physics). Her mother describes:

"No, I don't think she is very confident [in math and science]. She is good [at math], it's just a problem to the public school. The advanced placement courses, they make it to a very high level. Which is great but sometimes she feels discouraged. One of the classes she was taking, every time she would flunk the test. So she ended up a few times telling me 'I am bad at math.' I said, 'No, you are not. You are not bad in math.' She is not mature enough right now to understand all of the concepts. I think that the maturity is still working negatively, she understands the concept but applying it sometimes is a little much. I have asked her why doesn't she

[135] B_P_1.

> take a regular class like Kassie did? 'No I want a challenge, I want to take it.' So she wants a challenge. She is very serious. She works really hard."[136]

Isabelle's mother encourages her to believe that she is good at math, but she has doubts. She could be projecting her own math anxiety onto her daughter, as well as her misconceptions about engineering. When asked whether she is aware of what Isabelle does in engineering, she replies, "She brings a few projects here and there but I am not mathematical. So my husband is. It is really not my strong point. She seems to enjoy it."[137] Of interest is that the question as posed did not mention math, but the response seemed focused on math, almost as though prepared.

Improving public understanding of who gets to be an engineer, and what it takes to be an engineer, will begin to challenge some of the longstanding stereotypes, misconceptions, and perceptions of engineering.

4.3.6 Perceptions of Engineering

In her final journal, Isabelle wrote that she likes engineering because it is creative, collaborative, and makes the world a better place. These ideas are directly aligned with the *Changing the Conversation* messages (Committee on Public Understanding of Engineering Messages, 2008).

> "Engineering to me means making the world a better place by using technology and your brain. An engineer is someone who makes use of

[136] B_P_2.
[137] B_P_2.

> their abilities and works as a team to make the impossible possible. I like that we are doing both group work and individual work [in class]. I also like that we get to do a lot of hands on activities. I like to do things that most people wouldn't normally do, because I am a really creative person."[138]

Isabelle was in theater with some of her first engineering friends, who seemed to challenge the stereotypes. Isabelle, although quiet and reserved in class, is a social person, which is evident when she talks about her friends and the type of future career that she desires.

> "We [in theater] are all kind hearted people. We have a lot of kids who come into theatre as a freshman or just want to be a part of something and our group is really accepting to anyone who gives the same kindness we give. A few of the people in theatre are doing engineering and at first I thought all engineers were as open as them, but then I realized that most engineers are super reserved and I didn't want my job when I get older to be very isolated."[139]

Aware of stereotypes, Isabelle finds some of them to hold true. However, she is currently able to see past the stereotypes, which often discourage young women from participating in engineering.

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[138] B_J3_1.
[139] B_J1_4.

> "Some stereotypes are that [engineers] are nerdy and are not really social men. I guess I do associate these stereotypes just because in my math and science classes there are not a lot of girls."[140]

There exists a tension between Isabelle's intrinsic interest in engineering and her perception of the social value of engineering, or isolation and personality of engineers. Her mother's concerns contrast the arts with the sciences, both areas of interest for Isabelle. Helping Isabelle to continue to identify creativity and design as key parts of engineering will likely be critical to her continued interest.

Isabelle is very open about who and what she likes and dislikes, and she has often chosen to participate in activities based on the other people who participate. A sense of belonging, therefore, is important to Isabelle. She found a sense of belonging with Luna in her high school engineering class, but will that continue as she advances in her education? Helping students to build a sense of community and belonging is important.

Isabelle entered into engineering based on her interest in math and science, the early career encouragement from her mother, and the experiences of a female friend in engineering. Her experience in the high school engineering course proved positive because she enjoyed the projects and the teamwork with Luna, and she came to believe that she is "good" at engineering. In summary, Isabelle's family and chosen network of friends and classmate were influential in her choice to study engineering. Not all young women have access to this sort of career awareness and support, and it is important to provide those opportunities and engagements for every student.

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[140] B_J3_1.

Isabelle participated in engineering late in high school (as opposed to the entire 4-year program or STEM Academy), but she liked it and made it her college major. What would have happened if the high school class turned her off? It could have changed her life trajectory. Ensuring students have an accurate and positive experience in K-12 engineering is imperative to attracting future engineers.

4.3.7 Key Points and Recommendations

- Improving public understanding of who gets to be an engineer, and what it takes to be an engineer, will begin to challenge some of the longstanding stereotypes, misconceptions, and perceptions of engineering.
- Helping Isabelle to continue to identify creativity and design as key parts of engineering will likely be critical to her continued interest.
- Helping students to build a sense of community and belonging is important.
- Not all young women have access to career awareness and support for engineering, and it is important to provide those opportunities and engagements for every student.
- Ensuring students have an accurate and positive experience in K-12 engineering is imperative to attracting future engineers.

4.4 Luna

Luna is a White female senior student taking Introduction to Engineering as an elective. Luna is a high-ranking honors student and a dancer. Her mother has stayed at home with her and her brother, and her father has worked for most of his career at Dell Computers in various engineering, technology, and management roles.

4.4.1 Choosing Engineering

Because Luna is an AP tracked student, taking non-AP electives is not helpful to maintain a high GPA and rank. Although she wanted to take engineering earlier, it was not a priority in comparison with higher-marking courses.

> "I wanted to take [engineering] other years, but it never really fit into my schedule. So this year, I actually get to take it. I wanted to take it earlier, so I could take some of the cooler engineering classes, some of the design classes. But this is a prerequisite for those classes. So that never worked out because I didn't get to take it until this year."[141]

The teacher, Mrs. Jones, adds that she suggested to Luna and her mother that Luna take Introduction to Engineering when the course Luna wanted to take was not offered. Both Madeleine and Luna were interested in taking the Civil Engineering and Architecture course, but it was not offered this year (or the next) because Mrs. Adams, a civil engineer, left education somewhat suddenly to start her family. She was the only one trained to teach the course, and her departure left a vacuum for students hoping to take the course.

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[141] D_S1_39.

> "I know Luna wanted to take the Civil Engineering and Architecture class but it wasn't offered this year, so I suggested to her mother and her over the summer that she take this class. But it's a good, you know, for the kids that are going to go through the whole series; it's the first class, so that's why we get the younger crowd. But also it's a good introduction to sort of mechanical engineering or engineering design for the kids who are older. And they learn to use the CAD software, which is a good skill."[142]

Luna was registered to be a dual major at the largest public institution in her state: Architecture and Architectural Engineering, both known to be very competitive programs for acceptance. She comes from a family that helped her to understand and believe that engineering was a choice for her. Other AP tracked students may not have the same opportunity or access to engineering as Luna has. Even though she took this freshman-level introductory course, she preferred to take a more challenging course. To attract more students to engineering, schools could require a certain number of career exploration electives throughout high school, or design an engineering curriculum that is at an honors or AP level.

When engineering is presented as an elective (not affecting the GPA), it is perceived as Career and Technical Education (CTE) historically has been. Many K-12 engineering classes are considered a glorified "shop" class, which derives from stereotypes and social gaps between the working and business class. Organizations such as the International Technology and Engineering Educators Association (ITEEA) are working to change the

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[142] X_T1_9.

image of CTE. However, parent understanding and associated implicit biases against women in STEM or women in "shop" can serve as a barrier to access to K-12 engineering when the courses are offered in the way there are in this school. It is important to align the image of the engineering program with modern standards (Committee on Public Understanding of Engineering Messages, 2008), while not excluding the breadth of opportunities within engineering or engineering technology, or the STEM economy as a whole, available to a wide range of students (Rothwell, 2013).

4.4.2 Change in Class Dynamic

At the beginning of the school year, the students in Luna's class were seated alphabetically. As described in Isabelle's case, a group of regularly disrupted the class during the first semester:

> "Yeah, it was [a little rowdier] whenever…it was those three boys all sat next to each other, and one of them is not in the class anymore, but now they're like across the room. So, it's not that bad any more, but in the first semester, they sat next to each other and they talked the whole class."[143]

Half of the students in the class were freshmen, and all of the freshmen are male. This was bothersome to Luna, and her annoyance with them was a recurring theme:

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[143] D_S2_56.

> "I don't like—there is a lot of freshmen—but it is a freshman class, so I can't really get around that. They don't really know what to do with high school yet, so they are kind of annoying sometimes."[144]

Luna believes that others wanted to work with her, particularly after they saw the quality of her team's work. Although those students may be "annoying," she appreciates the respect she earned in the classroom.

> "In the beginning of the year people gravitated towards me to be in my group and I was like, 'Okay you can be in my group; that's fine,' and they saw that…on the first project we did it was like…come up with their various pictures of it on the wall, or come up with a design for a cup that you would sell. My group won and people saw how good I was to work with and they were like, 'Ooh I want to be in her group next time!' [That] made me feel good, like they appreciated me, which is nice."[145]

This demonstrates that despite the quality of her group mates, either she was able to lead and help the group create a more than satisfactory project or she pulled the weight of other students. Although this was good for the other students, it was not an enjoyable experience for Luna.

[144] D_S1_48.
[145] D_S2_58.

The classroom experience was so disruptive, that Luna discussed it with her mother. During the parent interview, Luna's mom brought up the younger male students in the class.

> "They're freshmen, [laughs] freshmen boys... I told her this would be this way. She's the senior girl so the freshmen boys first of all, she's a senior girl in freshman class.… When they do teams they all want to be in her team because her team does well I guess."[146]

4.4.3 Working with Isabelle

Mrs. Jones changed the seating arrangement at semester break, which improved the experiences of Luna and Isabelle. Luna wrote in her journal how much more enjoyable it was to sit next to Isabelle:

> "Earlier in the year, Isabelle and I did not sit next to each other in engineering class. That was not very much fun. I was surrounded by younger high school boys who talk non-stop. I really think they just liked to hear their own voices. It was awful. Isabelle and I—she was on the opposite side of the boys—would listen to their comments and make faces at each other when one was particularly bad. Now, with her next to me, class is much more enjoyable! We can collaborate on our work and we are

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[146] D_P_22.

> always partners on projects. It is lovely not having to listen to those annoying boys talk, and having my friend next to me."[147]

> "I think [sitting next to Isabelle helps my experience in class], because I am not—before I was next to four freshman boys, so I was like [makes eek sound], yeah. But it is a lot nicer being next to Isabelle."[148]

Luna believes that working with Isabelle has increased the quality of the work they produce because of their age and experience. Luna and Isabelle made a good team, which differs from just accomplishing group work (Adams, 2003). This was demonstrated in the quality of their final design project. They went above and beyond the requirements and created a superior project compared to the rest of the class. Jones (1996) states that a well-structured, robust system for teams can overcome flaws in the traditional classroom model and can energize the learning process. Simply arranging the students in alphabetical seating order and having them pair with their neighbors is an improperly structured team system that can undermine the goals of education and learning, fostering an attitude of contempt among students toward future learning experiences (D. W. Jones, 1996). Luna and Isabelle held great contempt for the "annoying boys" in the classroom. Once they were able to sit next to one another and regularly team together for their classwork, the classroom experience improved for both.

[147] D_J1_2.
[148] D_S1_48.

> "I feel like … because we've been partners in other projects and feel like whatever we come up with just is on the different level than the rest of the class, just because we're older and we know more about everything."[149]

The maturity level between freshman males and senior females is very different. Although one can easily ascertain that the first semester behavior was disruptive from talking with Luna and Isabelle and their mothers, the power structure of social status by grade classification influenced Luna and Isabelle's experience. Recognizing this barrier, and creating a haven, or an all upper-classman section in this case, could improve the student experience.

Luna found relief from the classroom antics through a bond with Isabelle, which did not exist outside of the classroom. To the teacher's credit, she recognized this bond and made concessions that allowed them to work more closely. Allowing students to build relationships within the classroom can support the student experience.

4.4.4 On Being a Smart and Pretty Girl

Luna is very intelligent, and she is a hard-working and highly ranked student. She is also very beautiful by modern Western standards. There exists a tension in Luna's discourse between what people expect of her, presumably as a "pretty woman," and what she is capable of, particularly within the realm of engineering, where there are so few women. She prides herself on being the "smart girl," and this is part of her identity.

[149] D_S2_53.

Her mother has warned her to be cautious of how she is perceived among the male engineering students in university. She speaks in a way that is doubts the success of a female engineer, much less a pretty female engineer.

> "She likes to be the smart girl. She likes that people that don't know her don't know what she is [a smart girl]. Surprise them! I told her that if she did go to engineering and she will have some engineering classes at University, I said, 'Watch how you're perceived there.' I said, 'When Daddy went to school, there were'…I'm sure there were more but it seemed like there were three, 'three women engineers in his whole class and they were an oddity. If you are,' I said, 'stereotypical,' I said, 'You're the tall blonde [declaratory statement, a pause, then a question) engineer? They're just going to look at you like…' [shocked face]."[150]

Because Luna's parents warned her about the difficulties she might face in the engineering environment because she is a tall, blonde, beautiful female, it is clear why she may have developed some fears regarding the culture of engineering.

> "I often imagine the male engineers trying to hit on or take advantage of the female engineers, solely because they are females. I'm worried about that, but hopefully that image is just in my imagination."[151]

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[150] D_P_29.
[151] D_J3_12.

> "I kind of expect that [guys are going to hit on me] if I'm like the one girl and like they're a group of boys."[152]

Luna expects that she is going to be hit on or taken advantage of as an underrepresented female. Longstanding heteronormative discourses have allowed for men's limited accountability for aggressive and harassing conduct; however, it is unacceptable for a woman to be presumed a justifiable object of sexual exploitation at any point, but especially not because she is outnumbered (Hlavka, 2014). Luna is an extremely confident young woman who likes being the "smart girl" and challenging people's expectations of her capabilities in contrast to her beauty. How is this perception of normalized harassment and abuse within the engineering culture a deterrent to young women who are less confident and bold? How sustainable is this environment for a woman who seeks meritocracy but is limited by social standards of beauty? Although Luna does not believe she experienced harassment in high school engineering, which she presumes is likely because the majority of the male students were freshman, could harassment eventually be exhausting enough to deter her from engineering? Ensuring that sexual harassment does not occur in the classroom (or lab or work areas) can be critical to improving the female experience in high school engineering.

Luna's mother said several times that Luna "likes to be the smart girl."[153] Why not just smart? This statement could reflect an implicit bias that girls are neither good at nor belong in math and science. Luna acknowledges the stereotype that women are not good at math and science, but she prides herself in being different. She was very happy with

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[152] D_S2_57.
[153] D_P_26.

her results from the Gender-Science Implicit Association Test, because, according to the test results, she does not hold an internal bias that aligns with the general population that associates males with science more than with females.

> "My data suggested I have a slight association of female and science and male and liberal arts. I expected (or hoped) I'd get these results, because I adore math and science…My results make me feel happy, because I am so math and science oriented. Also, I like that I didn't get the "expected" result, of associating male with science and female with liberal arts, because I hate that stereotype, and I am going against it. Women are allowed to have brains and think scientifically too!"[154]

Luna has experienced firsthand the stereotype that females are less associated with math and science than males. She says that people are often surprised by her love of math and science. In addition, Luna values her intelligence and appreciates the respect she receives from her classmates, particularly from the male students because she is more than the average girl.

> "It often surprises people that I love math and science so much, and I do not like the girls that say, 'Oh, math is too hard, I can't do it.' The girls that act dumb to impress boys. I on the other hand, make the boys try to keep up with me. I like

[154] D_J2_8.

> when I'm smarter than they are, or more knowledgeable in calculus or physics, and the males in my classes respect me more than the average girl."[155]

Luna believes that her mother's encouragement to value her intelligence and ability has been an influence. As a result, Luna has strong confidence and self-esteem, as well as high self-efficacy for achievement in math, science, and engineering.

> "My mom has encouraged me to never dumb myself down, and that has probably influenced my results as well."[156] "We had a conversation I think in middle school about girls dumbing themselves down, I said, 'Don't you dare do that!' Because I saw some of her friends doing that. Even last year, there was one of her friends that wanted to fit into a different group and started to do that. I'm thinking, 'What are you doing? What are you doing? Can't you be the smart kid in with these other ones?' It's a confidence issue too. Luna is very self-confident. She has good self-esteem and she likes being the [smart] one."[157]

4.4.5 Math and Science

Luna (as well as most of the other cases) has a very high self-efficacy in math and science, and she believes that being good at math and science is required for engineering. Despite the fact that she has not used a lot of math in her engineering course, she believes

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[155] D_J2_8.
[156] D_J2_8.
[157] D_P_27.

that if she did not have such a strong math background, it would be harder, although not impossible.

> "[Being confidence in my math and science abilities] makes engineering class easier. If I was bad at math or science, it would be a lot harder. [We don't use a lot of math and science], because it's a freshman-level class, so it's not like any advanced math or calculations or anything, but we did dimensional analysis and finding surface area of stuff, so I knew how to do that. I didn't really have to pay attention to the lesson. I did, but I didn't have to because I already knew how to do that."[158]

Her perception and understanding of engineering as a discipline is that ***it is*** math and science.

> "I know that in engineering, that you use a lot of math and science… that's what engineering is. It's coming up with new things and using math and science to create them. [I believe this because] lots of people [told me], and I looked it up on my own, and that's what everything tells me."[159]

The fundamental issue with this common belief is that math and science becomes the gatekeeper to engineering. Luna is able to pass through the gate because of her strong self-efficacy, but most females succumb to stereotype threat and lack the self-efficacy to

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[158] D_S3_63.
[159] D_S3_62.

pursue engineering. When we change the conversation away from an emphasis on math and science to the value of engineering, we will begin to see more females interested in engineering (Committee on Public Understanding of Engineering Messages, 2008).

4.4.6 Key points and Recommendations

- Engineering as an elective can limit participation by high-achieving students opting for more rigorous coursework. Framing engineering as one of several career electives, where one might be required, or designing an engineering curriculum so that is at an honors or AP level could increase participation and access to students such as Luna.
- The age and maturity barriers between Luna and much of her class were significant, so much so that they disrupted her learning experience. Recognizing this barrier, and creating a haven, or an all upper-classman section, could improve the student experience.
- Teamwork should take precedent over group work in an engineering classroom. Strategic organization of students can allow for effective teams and improved learning experiences. Luna experienced an improved experience and quality of work by being teamed with another student similar to her, Isabelle, with whom she built a rapport in the class.
- Luna has an expectation that being in engineering, as an outnumbered female, would mean that she would be hit on and likely taken advantage of by men. Although her perspective was of college and the workforce, this same fear of sexual harassment could exist for females considering high school engineering as

well. Ensuring that sexual harassment does not occur in the classroom (or lab or work areas) can be critical to improving the female experience in high school engineering.

- Math and science should not be the gatekeeper to engineering, when we know that females consistently have lower self-efficacy than males. When we change the conversation away from an emphasis on math and science to the value of engineering, we will begin to see more females interested in engineering

4.5 Madeleine

Madeleine is a junior honor student in her third year of the STEM Engineering Academy at her school. Madeleine is reserved and very quiet, yet a go-getter of a student. She plays varsity basketball and softball, which causes her to miss class often, but when she is there she works quietly, almost always on task. She does not socialize in the class much, only chatting with the two male students she sits between or the occasional male student who goes to talk to her. Madeleine makes no effort to connect with the other female in the class; in fact, they did not interact at all during the observation period. Madeleine was often observed trading help with her neighbors on engineering, as well as calculus and physics, assignments. She enjoys helping others to demonstrate her knowledge.

Madeleine is the second oldest of seven children. Her mother stays home with the children, because her father travels extensively for his work. With a PhD in manufacturing operations research, Madeleine's father works as an engineering consultant, traveling to different client job sites for months or years at a time. He has regular phone and video chats with his family and is home almost every weekend. Madeleine's parents chose to live in that community because of the schools, rather than have the family relocate.

4.5.1 Math and Science

When Madeleine began high school, she had to choose an academy. "Well, I just chose the [engineering] academy because it sounded the most interesting out of all of them. I like doing math and stuff and I thought maybe I'd want to be an engineer. So I decided to try it."[160] Like most of the other study participants, math and science was the entry point to engineering. Madeleine is "pretty confident"[161] in her math ability because she makes high grades and is doing well in her classes.

Math and English have been Madeleine's two standout subjects. Her father believes that she is almost equally talented in both, but that she enjoys English more.

> "You know, probably overall, her strongest subject has been mathematics. Although, English runs a very close second. She does very well in both of those subjects. In fact, up until this year I would have thought that mathematics was probably her best subject but she's done very well in the last two English classes, and this year AP English and she's actually enjoying that more than the mathematics because it's become a little more less structured and more creative thinking and understanding concepts. I

[160] H_S1_42.
[161] H_S3_53.

> would say those two are her strong subjects and she enjoys English more than she enjoys mathematics."[162]

Madeleine enjoys English, but has never admitted to liking it more or less than anything related to STEM: "I like English a lot because I like writing."[163] According to Madeleine's father, she is drawn to AP English because it is less structured and allows for more creative thinking, two key components of what engineering should be in a K-12 setting (Committee on Standards for K-12 Engineering Education, 2010). Writing as a form of communication is also one of the engineering habits of mind. Thus, in theory, because she enjoys math, science, and writing, Madeleine should really enjoy engineering.

4.5.2 Preferred Course Not Offered

Madeleine enjoyed the first year engineering course, but she did not like the second and third years. Madeleine planned to take a Civil Engineering and Architecture course that centered on design, but the teacher trained in that curriculum left to raise her children. To satisfy the requirements to graduate from the STEM Academy with an Engineering Certificate, she had to take whatever other engineering course was offered. Madeleine's father explains that she was disappointed in the scheduling issue and was not interested in the manufacturing course, and overall, not that interested in engineering:

> "She was disappointed this year because they cancelled the course that she had signed up for originally which was some kind of design [Civil

[162] H_P_3.
[163] H_S1_38.

> Engineering and Architecture] course, but they didn't teach it and the only course that she could take was the engineering course. She was extremely disappointed she didn't get to take the course she signed up for and had to take this manufacturing course which she's just not that interested in." [164] "But I don't think [engineering] is something overall she's very interested in."[165]

That Madeleine loved her first year engineering course but not the second and third years was a recurring theme. She enjoyed creativity, design, and creating a product.

> "I know we talked more about it in her freshman year because she had took that engineering design course or whatever the name of that course was I can't remember, where they used a lot of the design software and did creative work. She really enjoyed that. The last two engineer courses particularly manufacturing, we talked about it, she doesn't really care for it at all. She realized it's not something she's interested in. And the stuff she did last year, she did well in it but she wasn't really excited about it and we talked a little bit about it but overall her interest wasn't that high in it."[166]

> "I like designing things and when we took the introduction course as a freshman you have to use Inventor and I really like that. I was going to

[164] H_P_27.
[165] H_P_23.
[166] H_P_28.

> take the architecture class but then it got cancelled. I like building things and drawing and see how they turn out and stuff."[167]

Even the teacher was aware of Madeleine's frustration with not being able to take the course she wanted:

> "She really wanted to be in that Civil Engineering class that didn't make because Priscilla left. So, she was just kind of like [sighs] 'Now I'm in this class.' You know?... I remember her coming and talking to me about it the last week of school last year saying [speaking in a weak voice] 'Well, maybe I should take this class' and yeah, she was not enthused about it for sure. But I was happy to have her because she's such a good student, and I think she could get a lot out of it."[168]

With multiple sources of information converging, it was very clear that Madeleine did not care to be in engineering class. Yet, either she was interested enough to stick with it, or she remained only for the graduation certification. However, from her discourse, she very much enjoys using the CAD software and creating a product with it. She likes to see the product of what she's designed using the 3D printer, laser etcher, and CNC mill.

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[167] H_S1_36.
[168] H_T2_64.

> "Some of the stuff we did freshman year was fun where we just made stuff on Inventor and she printed it off on the 3D printer. It was fun. I just like if you can take something home like the name plate or something."[169]

For her senior year, Madeleine was scheduled to take the Senior Design class, in which the students spend the entire school year solving a problem of their choice and creating a product or procedure. I believed that Madeleine would enjoy her final year of high school engineering, spending the entire school year with minimal structure, creativity, design, a product, and writing. I have no data from her senior year experience, but Madeleine sent me an email on her own to tell me that she had chosen English as her college major, instead of engineering and architecture. Perhaps if Madeleine had only taken first-year engineering as a senior, like Luna and Isabelle, she would have still been encouraged to stay in engineering or a similar field. She was interested in engineering, but she changed her mind. The curriculum and manipulatives of mid/later years in the program were clearly factors that discouraged her from persisting.

4.5.3 Manipulatives

The use of Fischertechnik was a key component of Madeleine's second- and third-year engineering courses. These are construction toy kits that allow for assembly of realistic, working models (basically another form of Legos). Madeleine enjoys learning new things, but dislikes working with the Fischertechnik, so much so that she lets her teammates manage the system and she does the reporting.

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[169] H_S2_49.

> "In my engineering class I like learning new things but dislike working with Fischertechnik."[170] "I usually, okay, when we did the Fischertechnik, I'd let [my teammates] do all that, and then I'd just write up the report and stuff. Because I don't really like the Fischertechnik."[171] "I like that we had to make a castle on Inventor [CAD software] the first year, and we had to... we had a lot of design projects on Inventor, and then last year we didn't really use Inventor, we used Fischertechnik. I didn't really like those. I don't really like…I think they are kind of inefficient. Like Legos. This year, I am not really into manufacturing. I just wish we'd use Inventor more."[172]

Exactly why Madeleine had such a distaste for the Fischertechnik is unclear, but we know that many young women may refuse to participate in scientific activities that are incongruent with their gendered identities (Carlone, 1999). Like Kassie's experience, if Madeleine associates Legos/Fischertechnik with masculinity, then she may refuse to "play." Although Madeleine is no stranger to male-dominated arenas, it is possible that as she learns to "do gender" she walks a tight-rope, balancing between gender-crossing activities. So instead of engaging in the Fischertechnik, a construction toy that is steeped in masculinity, she takes over the traditionally more feminine role of note-taking and reporting.

[170] H_J3_59.
[171] H_S1_1.
[172] H_S1_35.

4.5.4 Background in Sports Helped in Engineering

Madeleine's father believes that she has entered into and persisted in engineering, despite the low participation of women, because of her previous mastery experiences in crossing gender barriers in sports.

> "I think for one, I think [engineering] is a field that she does well in. And so since she naturally does well in something I don't think it bothers her as much that...most of it's male or there aren't a lot females in it or people say there shouldn't be women in that field. I don't think that bothers her too much. I think the thing that really that...probably puts her in a situation is where she can fend that off, is that she's played sports all her life and most of the time growing up whenever she was real young, 6, 7 years, 8 years old, she was playing against boys because they didn't have girls teams in some of the areas that we lived in. And she played baseball with boys. And she played basketball with boys. And I think that she realized then at least at that age, I mean, she was as good or if not better than a lot of them. Now obviously as they grew older and the boys get stronger and you know probably physically wise were able to outperform her, then she realized that she couldn't compete athletically with the better boys. But she can definitely compete even with some of the not the elite athletes but some of the boys now. And she plays basketball with them all the time. I think sports has taught her that she can compete on equal footing with a lot

> of the boys and sports is not in the—that's somewhat outside the realm as well and so she's somewhat used to it I think."[173]

Successful crossing over to a male activity early in her life and throughout her adolescence developed a strong self-efficacy through repeated mastery experiences, the most powerful of the four sources of efficacy. Thorne uses the word "crossing" to allude to the process through which a girl or a boy may seek access to groups and activities of the other gender (Thorne, 1993, p. 121). Crossing over in baseball and basketball could have allowed her the confidence to do it in engineering. However, this does not seem to be enough to sustain Madeleine in engineering.

4.5.5 Gender Displays

Children are not only socialized Mrs. Jones the adults in power. Power plays a role, no doubt, but children are not passive or without agency: they act, resist, rework, and create their identities among their peers and in all environments (Thorne, 1993, p. 3). Thorne describes this process or activity as "borderwork," a term that helps to conceptualize interaction across gender boundaries. Madeleine actively moved into and out of gender-based groupings, but I propose that she has a limit (which she did reach and, as a result, excluded herself from engineering).

Madeleine wore very sporty attire: gym shorts, t-shirts, running shoes, hair in a ponytail. She occasionally wore Sperry boat-siders and a headband to modestly dress up the active wear. On only 2 days out of the almost 3 months of observations did Madeleine wear something out of this norm. On one day she wore a pair of coral-colored shorts and

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[173] H_P_19.

a sweater, and on the other a ruffled blue skirt and blouse. On both days she wore sparkly or gold sandals, a glittered headband, and her hair in a long braid. On the days that she "dressed up," she received various comments from several of her male classmates about how nice she looked. Two of her classmates regularly flirted with her, in almost a competitive fashion, by compliments, teasing, many offers to help, and shoulder massages. Madeleine's somewhat perfunctory displays of femininity could be her attempt at gender display, a periphery choice as she negotiates her gender role. West and Zimmerman (West & Zimmerman, 1987) describe gender role and gender display as the behavioral aspects of doing gender: "a complex of socially guided perceptual, interactional, and micropolitical activities that cast particular pursuits as expressions of masculine and feminine 'natures'" (pp. 200-201).

Thus, if high school engineering is organized to routinely display and celebrate behaviors and activities that are conventionally linked to males, then when females engage in high school engineering, the routine nature of "doing gender" is challenged. A compromise could be demonstrations of "essential" femininity, such as dress or note-taking roles. The result is a "role conflict," where one must manage her "essential" nature, a continuous accomplishment of gender. Such environments can cause young women to clearly see that they are out of place and that if they were not there, then the trouble of managing and accomplishing gender would not exist (West & Zimmerman, 1987).

4.5.6 Key Points and Recommendations

- Because of scheduling issues, Madeleine was unable to take the engineering courses that she wanted and was thus relegated to two courses that focused on manufacturing through the use of Fischertechnik. This ultimately turned her off from engineering. To retain students such as Madeleine, who are motivated by design and creativity, offer more high school engineering courses that do not provide such a myopic view of a large discipline with many opportunities.

- Acknowledge that engineering, even in high school, is dominated by masculine culture, both by the majority of students and how the curriculum is written. This can be a challenging milieu for even the boldest females who have successfully crossed gender boundaries, because routinely doing gender becomes an overwhelming task in an environment in which one feels out of place. The solution is not to have the students design pink castles or use robots with braids and bows. The immediate solution would be disallow young women from sitting on the sidelines and taking notes and requiring them to dive in and find ways to work on projects in a way that aligns with their gendered identity. If young women feel a gender role conflict in high school engineering, then allow them a safe space to display their gender through their work. This can be facilitated via projects that allow for creativity and personalization.

4.6 Amanda

Amanda is a senior her fourth year of the STEM Academy taking Computer Integrated Manufacturing (CIM), and she is president of two engineering clubs: the Robotics Club and Junior Engineering Technology Society (JETS). Outside of school, Amanda is a training instructor for her Taekwondo school. She has studied Taekwondo for 8 years and is a third-degree black belt. Amanda's mother stayed at home with Amanda and her younger brother for their early childhood, and returned to work as a teacher 5 years prior. Her father works from home as a software engineer for IBM. (Both of Amanda's parents participated in a joint interview.)

Amanda is an independent and determined young woman. Although self-driven and resilient, she tends to "bite off more than she can chew" and can struggle to get things done at times. According to her parents,

> "She's very over the top with independence. I mean that's good, for the most part, it's very good, but it can also be bad 'cause it limits some of the involvement that she might get from others. She's very determined I guess would be another thing to say about her. If she decides she wants to accomplish something she'll work very very hard at it and usually she'll succeed."[174]

> "She is very independent. She never wants help. She probably bites off more than she can chew and if you try to tell her, she doesn't want to hear it. She thinks she can handle everything so, you know? As far as like time management and stuff she struggles in getting stuff done but she's good

[174] J_P_27, J_P_28.

hearted and wants to do everything she wants to please she definitely is a pleaser and is always trying to please us."[175]

4.6.1 Math and Science

Amanda's parents believe that she has always been naturally able to see mathematical perspectives and that she is very logical, creative, and analytical. Ever since she was a little girl, they believed she has been mechanically inclined or at least curious. When asked about Amanda's strongest subject, both parents immediately responded with "math."

> "[Father] Math. [Mother] Math is her strongest. [Father] Definitely. [Mother] She's very logical and sees things that way. [Father] She's always been able to just naturally see mathematical perspective on things. Just comprehends it very well. [Mother] Even as a little girl, we went to the circus one time. She wasn't like into the circus, she was like 'How did they do that?' She was more of the mechanics of what was going on and how things were accomplished. She's always been like that. She's more analytical. [Father] Things that are creative and logical she does great at that."[176]

Amanda does enjoy math and science, and because of the explicit encouragement of her father, those interests became her entry point to engineering.

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[175] J_P_27.
[176] J_P_30.

> "And I really like engineering and math A LOT! I'm also really into physics and sciences and stuff like that."[177]

> "I know the reason I chose engineering was because I liked math and science. So my dad was like 'Oh! You should be an engineer' and I was like 'Oh, I'll try it.'[178]

4.6.2 NASA Summer Engineering Program

The summer before her senior year, Amanda participated in a summer engineering program at NASA Johnson Space Center in Houston. Her team project was related to robotics. "I'm really into robotics so designing robots and stuff is really cool to me. I have designed a robot in robotics club as well as during my internship at NASA."[179] Her vicarious experiences with robots at NASA bolster her self-efficacy and thus interest in robotics. At the start of her senior year, she attended the first Robotics club meeting of the year (her first ever), ran for president, and won (she said she was the only senior, so it was a natural choice). In her CIM class, the students used several different types of robots and controlling software throughout the year. Her experience at NASA really set her apart with experience, interest, and confidence.

> "Then, [in CIM] we started going into robotics stuff [for the] the history of automation PowerPoint but everyone was given a specific topic. I chose

[177] J_S1_42.
[178] J_S4_64.
[179] J_J3_20.

> robonauts because I've already—I already knew a lot about them from my NASA trip because that was what my group did was robotics."[180]

The most remarkable part of the experience for her was meeting all of the other students and professionals. Girls' attitudes regarding scientists and engineers have been influenced by the lack of female representation in the media and in their worlds, and with this absence of role models, many girls tend to view science and technology as an unsuitable career choice and personally irrelevant to their lives. One way to alleviate this concern is to expose students to role models, specifically females, to dispel stereotype threat for young women in math and science (Else-Quest, Hyde, & Linn, 2010; Fancsali; Huber & Burton, 1995; McIntyre et al., 2005; McIntyre, Paulson, & Lord, 2003). In Amanda's case, the role models were also her peers.

> "We went on a lot of field trips...So we got to meet like engineers and learned about their jobs and what to expect in the future and stuff and help us decide where we'd want to work. So that was cool to really see what it was all about."[181]

> "I think [the most life changing thing about that experience was] seeing all of the amazing kids. Like there were all these other kids, they were exactly my age, and they were brilliant—like some of them were already taking college classes, some of them were at these like amazing advanced schools, some of them just had perfect grades. They were all just so

[180] J_S4_61.
[181] J_S4_61.

> brilliant. It was cool, because I was with all these kids, and I was like 'Man! I should be getting signatures from these people because they are going to be famous one of these days.' That just really blew my mind. There is all these people who are probably going to do all these great things, and I want to be one of them."[182]

Amanda has an incredible optimism that does not create a barrier or a perceived deficit between her and some of the other higher-achieving students. She is not a top student as far as grades go, but she possesses lifelong learning traits, fueled by passion, determination, and interest. She does not see barriers between her and the other students who participated in the NASA summer camp. She observed her campmates to be superstars destined for great things, and she wanted to be one of them.

Amanda has an incredibly strong STEM self-efficacy, which allows her to be a bold leader in her school clubs and to try new things in her engineering courses. Her vicarious experiences have greatly influenced her self-efficacy in her discourse and her observations of successful peers and role models help her believe that she can do engineering. In addition, her parents are incredibly supportive in fostering her engineering interest and ability. These experiences allow for mastery. In addition, her efficacy beliefs are in part fueled by the positive social messages she receives from others that help her believe she can succeed.

[182] J_S1_39.

4.6.3 Family Influence

Amanda's father had a tremendous influence on her interest in engineering. Amanda describes that liking math was the trigger, or a gatekeeper, to engineering for her father's encouragement and that she initially only participated to please her father. However, she discovered after trying and having a positive experience in engineering that she loves engineering.

> "My dad. Big time [influenced my interest in engineering]. Right from the start. Once I mentioned that I liked math, he was like, 'Oh! you should be in engineering!' He's the one that encouraged me to get into the engineering academy stuff. But I am so glad that I did, because I fell in love with it. Initially it was just because my dad wanted me to, but then I fell in love with it myself."[183]

With an engineer father, who believes in his daughter, there is a strong effect of cultural capital on Amanda's occupational inheritance (Egerton, 1997). Her parents spoke from their own backgrounds and relate Amanda's interests and skills to careers.

> "We do talk to her from our own backgrounds, course you know being a school teacher, engineering and you know how those things can relate.

[183] J_S1_41.

> You know art and math and that aptitude does look like it's a there's a lot of areas that those combine real nicely in in the engineering field."[184]

Amanda benefited from another unique piece of cultural or social capital, that is, the freedom that her family had to anywhere because her father works from home as an software engineer. Amanda's parents were able to relocate based on "school/education, crime, and cost of living." This is certainly a privilege of an elite white-collar field. How does it influence her *in* the classroom? The fact that she gets to have *any* experience in the classroom is due to her parent's choice. Amanda's father describes some of the lengths they went to do find a good place to raise children:

> "Whether it's the school district we live in, different things like that we'll do whatever it takes to help make it possible for her to achieve her goals and ambitions. We actually lived originally in Raleigh, North Carolina. And part of the way we ended up here is some analysis of different features of places to live. I said I work from home, and so pretty much could live anywhere. And so we picked this area for primarily three main areas: for school education, crime and cost of living being the three…And then of course, things to do, nice fun area. And then of course looked at the statistics on the different schools to see what was likely to be a good school for the kids. This area at least numerically looks really good it was

[184] J_P_35.

> a good balance with crime and cost of living. So, that's kind of how we ended up here."[185]

Amanda's family support provides access, direction, and encouragement. Her parent's awareness of engineering created a pathway that allows Amanda to explore engineering. Her parents have the means to pay for whatever it takes, and they are able clear obstacles from her path. They help her find extracurricular and informal learning environments that help her stay on a "positive track."

> "For me it's doing whatever it takes to clear the path. If it means paying for school, or whatever. I look for the things that are potential obstacles and make sure those aren't there. If she has something she wants to do that would help her in those areas, we tend to encourage it and pay for it. Be it for example a NASA internship she did a little while back - we encouraged it and did whatever it took and ensured that she had the time to do those things. We took her—we always like UT had something going on for women in engineering—took her to those kinds of things—even girl scouts—pushed her to stay in girl scouts because you know, on a positive track—just try to keep everything positive for her—even Taekwondo, you know."[186]

Her father created hands-on engineering activities at home to coach and teach her. For example, he taught Amanda how to build a computer from spare parts. Then he

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[185] J_P_31.
[186] J_P_33.

challenged her to build one for each family member. This sort of tacit engineering knowledge at home serves Amanda well in her engineering classrooms. The experience of working on projects such as this with her father provides her with strong skillset of experience to draw on for improved self-confidence in engineering.

> "I know there at one point we did a little project where we, I ordered parts for her, 'bout three or four computers so we could all have computers and I had her actually end up taking them from parts and building then all with me. I helped her with the first one and she did the rest from parts you know. So she understood and learned all the pieces and parts. It kinda gave her an idea of the fun in that area she enjoyed that and loved the success there just done various things like that."[187]

Students whose parents are not engineers, or knowledgeable about the true value of a strong STEM education, are less likely to have the same level of support and influence at home. Creating programs to educate parents is advantageous; however, counselors and both formal and informal educators must help students who do not have cultural capital from which to draw to learn about careers and opportunities in engineering. Introducing them to role models and mentors is one way to do so.

Amanda had a strong influence outside of her immediate family as well. Her uncle has a PhD in math and teaches at a university. His wife, is one of the "top mathematicians

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[187] J_P_34.

in the world."[188] Amanda's Taekwondo instructor, with whom she has a special friendship, is one of the highest ranking female black belts in the United States, as well as an engineer. Amanda's mother describes: "They've got a strong friendship. I think that throughout this she's been an encouragement to Amanda."[189] Finally, Amanda had a special bond with another female engineering teacher at her school. This teacher was a former practicing civil engineer and taught for a few years at the high school. Amanda had her for 2 years, and the teacher was very supportive and encouraging. Strong role models are truly a key to building female self-efficacy in engineering.

Amanda's mother expressed concerned that she chose engineering solely to please her father. She describes how she regularly and deeply questions Amanda's motivation and interest in engineering. This form of doubtful questioning potentially underlies an implicit gender bias against women in engineering or women in careers, particularly because Amanda's mother encourages her to consider teaching, a traditionally female occupation. For a woman who stayed home with her children while they were young, and returned to the workforce as a teacher, it is possible that she maintains deeply rooted gender stereotypes for women in work and career. Otherwise, why does believe that Amanda is interested in engineering only to please her father? Certainly, Amanda's father did have a strong influence on Amanda's interests and choice, but to not allow Amanda the agency to make a decision as a strong, independent female succumbs to a hegemonic patriarchal power as the only rationale for her choice.

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[188] J_P_36.
[189] J_P_36.

> "[Mother] I mean I've always been worried that she was trying to please her dad about that [Father laughs] I've always, over and over, to her 'Are you sure this is what you want to do?' and she 'yes, yes, yes.' Really I was worried that she was trying to please him about that. But she stuck with it and she seems sincere and genuine about it for herself and I'm pretty convinced about it now. You can do this here, the engineering academy, but it doesn't mean you have to continue in that, you know? I mean, she wants to continue down that road. She's great with little kids, I mean she could easily be a teacher if she wanted to or something else."[190]

Although Amanda's mother is "pretty convinced" that her daughter is sincere and genuinely interested in engineering, it is likely that the discourse at home is woven with messages that signal shock in Amanda's interest. These negative micromessages will accumulate, but hopefully not overcome and outweigh the positive messages Amanda receives from her father. The reality is, we all have biases, and they are deeply rooted in the fabric of our being. However, by understanding our biases, we can begin to recognize how they manifest in our interactions with others and begin to change them. As we interact with young women working to find their STEM identity, we must be cognizant of the micromessages we send as a result of our bias.

4.6.4 Working with Guys or Girls

Amanda likes and believes she is good at working with males. She does not mind being the only female, or one of a few females, in her engineering classes or clubs. She

[190] J_P_23.

describes: “I was also the only girl in that club [robotics]. I still am…I feel like working with guys, like I am good at working with guys, and like they are younger than me, so they all listen to me, which is great, but yea, it is fun. I like working with guys. It’s fun. I don’t mind it.”[191] Most of the other students in Robotics club are freshman, and she believes they are always trying to impress her. That makes her feel “a little weird.”[192] “I don’t mind. It doesn’t bother me [laughs]. They aren’t like looking down to me. They are looking up to me. So that is a good thing.”[193]

She notices that the behavior of her male classmates differs when there are fewer females, describing it as “pervy” and contributing to an awkward environment for females. Her language about the “other girls” is dismissive in a nonchalant way. I get the impression that Amanda enjoys being one of few girls in a classroom.

> “I have one class where there’s just one other girl. And like the guys are constantly mentioning it there. It’s an electrical engineering class. But yeah they often mention it and stuff but they’re really silly in that class and kind of pervy but that’s just because you have a giant group of guys and all of a sudden a girl is in there and it’s just...awkward. But like I work well with guys, I feel like. In SIM in computer manufacturing I’m usually teamed up ‘cause we usually get in groups of three, I’m usually teamed up with these two guys and I work great with them. I don’t even know how

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[191] J_S1_45.
[192] J_S1_45.
[193] J_S1_45.

> many other girls are in that class. I think there's just one or two. Yeah, there's two. But it doesn't bother me that I'm the only girl or anything."[194]

Amanda does not feel as though she works well with the female students and even finds herself short tempered with them. She believes that many of the female students take engineering to flirt with the male students and that those who look at prom dresses together in class are in engineering for the wrong reasons. Amanda finds this behavior to be frustrating and giving females a bad name.

> "I feel like I'm slightly more short-tempered [with other females]. [slight giggle] But I feel often that a lot of girls are in engineering to like flirt with guys and stuff. It's kinda like that one guy in the dance class kinda thing where it's just like he's just there to flirt with the girls. Some of them I get annoyed with. I mean, it's just like, I've had a lot of classes with a lot of girls and stuff like especially last year. I was in this architecture class it was part of the engineering academy. I don't know there was this group of girls who looked at prom dresses the whole class. I was so annoyed with them. I was just like Really?! What are you doing here? You're not working on any of your work! You flirt with the guy next to you and you don't do anything. [That gives] girls a bad name. That also frustrates me."[195]

[194] J_S1_52.
[195] J_S1_40.

However, Amanda later explains that she was behind on planning an activity for one of the engineering clubs she leads because her "head was in prom." This excuse counteracts her previous dismissal of girls who look at prom dresses in class, making her not much different from them. "This [engineering club activity] was kind of last minute also because I think we forgot that it's already next week. For me my head's been in prom because that's tomorrow."[196] In addition, Amanda met her boyfriend in an engineering club, and they were classmates in other engineering classes (not observed as a part of this study). After she and her boyfriend broke-up, Amanda amped up her femininity and flirted with the boys in her class.

It may be that Amanda's frustration with the girls who flirt and look at prom dresses centers on the fact that she felt excluded by them, when she herself exhibited similar behavior. Amanda was negotiating her gendered identity in a masculine environment. Perhaps to feel like she fit in with the majority (males), she had to reject the norms of the minority (females). Young women should not have to act like men and shun femininity to be a part of engineering. Every student should feel comfortable to be his or her authentic self, even if that is still developing. Unfortunately, in a male-dominated environment, young women have to constantly and exhaustingly work at being invited into the proverbial boys' clubhouse. Amanda differs from others because she persisted when others would give up the struggle.

Amanda is not free from the struggle, as demonstrated in her group work in her CIM class. Amanda tended to step aside and let the young men manipulate the devices. She took a hands-off administrative role on several of the projects. She always went to work

[196] J_S2_56.

at her male teammates' desks; they never went to hers. At times, she almost played dumb or damsel in distress, reclining in her seat, playing with her hair, spinning her chair. All are examples of her feminine deference to masculine power. However, she considered it to be her responsibility to keep the group on task and get the work done because her male colleagues get distracted.

As an example of a team interaction, Amanda started class working on the large robot with a male classmate. He worked at the laptop, setting the program and coordinates for the position. The robot was to pick up four blocks, one a time and set them each gently in a precise coordinate. The robot was to return to home after delivering each of the blocks to their position. Amanda sat on a stool in front of the robot, directing her teammate for the most precise positioning of the blocks on their marks. She read the notes while he programed the robot. At one point, he got up to go look for something, and she dove in to control the robot, as if she had been patiently waiting for an opportunity.[197] When asked about how they share the hands-on time, Amanda does not consider the fact that she lets her teammate do the work as an issue. She summarizes, "We'd trade off and stuff it was fun it all worked out. And often I was looking at the papers and trying to figure out the papers and trying to figure out what we needed to do next 'cause he'd sort of get distracted and start playing rather than like doing what we're needing to do. So I was trying to keep track of all the papers and answer the questions and get everything done for the grade."[198] Young women should not feel as though they should have to sit on the sidelines, and they certainly should not feel or expected to be responsible for keeping the

[197] J_O_11, J_O_15.
[198] J_S4_62.

young men on task. Better facilitation of group roles and improved monitoring of group interactions to avoid traditional gender roles of power and deference can improve female student learning experiences in engineering.

When asked about the classroom interactions between Amanda and her male teammates, Mrs. Jones observed that Amanda allowed her male teammate to dominate her. However, it was after a comparison of Amanda and her teammate's mechanical skills. It should not that whoever has more mechanical experience gets to play with the "toys." By that definition, boys would dominate more than they already do in engineering classes because of the typical gendered toys and play of their childhood. In addition, Mrs. Jones added that she would have deferred to the male student when she was Amanda's age as well. There is no indication that Mrs. Jones feels the need to circumvent such behavior even though it cripples the full learning experience that Amanda and other female students need in an engineering classroom.

4.6.5 Influence of Teacher

In addition, Mrs. Jones expresses that, when she was a student, she was always happy not to do the mechanical part, letting the boys do it. If the teacher portrays her own discomfort with mechanical engineering, and an understated acceptance that girls submit to boys, then perhaps the young women pick up on those beliefs. In the same way that instructors have been shown to create and exacerbate math anxiety in students (Jackson & Leffingwell, 1999), Mrs. Jones could unintentionally be creating mechanical anxiety for her female students (such as Kassie and Madeleine). This is particularly relevant when you consider who is teaching the majority of engineering courses in K-12.

Generally for PLTW, the most popular and expansive K-12 engineering curriculum in the Unites States, there is no degree or experience qualification required other than a 2-week intensive training of the rigid curriculum. That means that any educator will bring his or her own anxieties into the classroom and unintentionally influence the students.

> "Amanda is very mechanical but see CJ, he's also been taking auto tech and welding and so he's super mechanical, too, and she just let him dominate her, you know, personality wise. Which I probably would have done too when I was her age...you know? It's probably how I woulda played it as well but, I don't know. I was always happy to not do the mechanical part but I'm not a very mechanical person, hence the chemical engineering degree."[199]

One way to avoid this interaction, or transferring of anxiety, is to teach educators about a growth mindset, have them teach students, and then have them hold one another accountable for discourse and behavior that suggests otherwise. This challenges the normal power structure in a classroom where the teacher is the all-knowing being, but it creates instead an environment that encourages and supports lifelong learning, as well as relieves pressure from stereotype threat when teachers attribute success to learning through the effort required.

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[199] J_T2_68.

4.6.6 Josh the Boyfriend and Ex

Josh and Amanda met during their junior year at an extracurricular engineering competition, where they traveled to another city to compete against other schools. They were in the same group and came to like one another. They started "going out" after getting to know each other better when working together as officers for JETS. Even though they were not in the same engineering class, I observed them together when he went to the classroom for another reason, such as club meetings. After dating for nearly a year, Josh broke up with Amanda just before prom, telling her it was because he would be moving to California and he did not like her anymore.

The hostility from Josh was palpable one day after school, post breakup. He gave Amanda a hard time for not knowing about the club meeting until the day before. Josh said she was a bad president and threatened to lead the meeting if she would not take charge. When asked about this outburst, Amanda describes Josh's jealousy over her being President. He was ribbed by some other young men for not being in a more powerful position than his girlfriend. This conflict and competition probably runs deeper than revealed during the observations and interviews. Because Amanda identifies the stereotype, it means it is likely something she regularly combats.

> "He felt like he should've been president and was like jealous 'cause I got it. And so he's been sort of, he was being hard about that. But yeah, I don't know, we talked and everything's cool now…Yeah, he didn't mind [when we were together/dating]. I feel it bothered him a little bit and like his friends would sort of tease him and stuff. That stereotypical couple

> where like the guy's the football player and the girl's the cheerleader or whatever? They were saying that he was the cheerleader and stuff. I mean it was fine. Like, it didn't like, it bothered him a little bit but not very much."[200]

Ely argues that "subtle yet pervasive forms of gender bias may impede women's progress by obstructing the identity work necessary to take up leadership roles (Ely, Ibarra, & Kolb, 2011)." As president of two organizations, Amanda has the confidence to assume leadership roles, but because she has not been a particularly strong leader of either, gender bias from her peers may accumulate and weaken her self-efficacy to take on such roles in the future. Perhaps in taking on leadership of two organizations, Amanda believed she had something to prove, as many women do in engineering (Henwood, 1998). The positions of power made her feel important and proud, but the title alone does not indicate leadership. I believe, however, that Amanda was not a strong leader because she did not know how to run an organization and did not have proper mentorship, not because she did not want to lead. I also believe that, despite expressing a wish to claim authority, she did not want to be considered bossy or disliked, which aligns with some of the prominent barriers to leadership for girls (Girl Scout Research Institute, 2008).

> "I always work hard and do my best. I don't know, I sort of find myself trying to be a leader every chance I can. Like in a group I'll try and like take authority. Partially just because I don't want to be like looked down

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[200] J_S3_59.

> on because I'm a girl, but also because I feel like I can be a good leader."[201]

4.6.7 Gender Display Post Breakup

Out of character, Amanda missed her interview session the morning after the break-up. When she showed up for class, visibly upset and emotional, she told me about how Josh had "dumped her" the day before. However, something else was different about her that day. Instead of her normal jean shorts, t-shirt, tennis shoes, messy hair, glasses, and no make-up, Amanda was transformed. Draped in a revealing blouse, her face was completely made up, including dark eyeliner and shiny lip gloss. Without her glasses, and in this façade, she appeared a different person. So much so, that student after student commented on her appearance. Even the teacher noticed and complimented Amanda. Mrs. Jones approached me shortly after the beginning of class to say, "Well, I guess Amanda has put herself back on the market."

> "After Josh and I broke up I want to dress up and feel pretty. But like everyone said stuff about it and they really liked it. I just decided to keep doing it 'cause it's fun. And yeah, I don't know. It feels really good [when people compliment me]. I don't know. I never really tried to dress nicely or anything [before] and like no one really said much about it. It's just nice."[202]

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[201] J_S1_40.
[202] J_S3_60.

The emotional rollercoaster post breakup continued for a couple of weeks, as emotions were dredged up on days when she had to see Josh at lunch or for club activities. Some days she would walk into the class, somber and full of sorrow, with her head just hanging in despair. The charade of feminine display continued consistently for the next month, and she explored various hairstyles, clothing trends, and types of make-up application. The enthusiasm behind her feminine effort eventually began to wane after a month or so.

Amanda's transformation post break-up was a ritualized gender display of conventional female portrayals. In Thorne's grade school ethnography, she determined that "cosmetics have powerful symbolic status in the gendered markings of age grades" (Thorne, 1993). An optional performance, Amanda "scheduled" her gender display at a juncture (Goffman, 1976) when she believed expressing a conventional "essential feminism" would help her recover, boost her self-esteem, and assert her feminine identity in a masculine milieu that she could have felt had collectively rejected her. West and Zimmerman say that "gender depictions are less a consequence of our 'essential sexual natures' than interactional portrayals of what we would like to convey about sexual natures, using conventionalized gestures" (West & Zimmerman, 1987, p. 203).

4.6.8 Psychology of Scarcity

Mullainathan and Shafir have proposed a new psychology of scarcity, in which scarcity is having less than you feel you need (Mullainathan & Shafir, 2013). For Amanda, and other women in engineering, this could mean acceptance into the "club," or the masculine arena of engineering. For engineering students, this could mean acceptance in the classroom, department, or the literal after-school clubs. For adult female engineers, the challenge still exists to fit into a man's world of engineering, including conference rooms, labs, fabs, and happy hours.

The authors suggest that "scarcity captures the mind, as the mind orients automatically, powerfully, toward unfulfilled needs." They believe it changes how we think, unconsciously imposing itself on our minds, capturing our attention. They propose that scarcity is a mindset that can help explain many of the behaviors and the consequences of scarcity. For Amanda, her behavior changed markedly during senior year, which was noticed by her parents and teacher and could have been a consequence of scarcity—concern over her boyfriend, responsibilities, and college selection. Mrs. Jones describes her concern for Amanda:

> "Amanda seems to be much more scattered this year than I remembered her being from the tenth grade. I don't know if it was the whole boyfriend breakup, not getting in to the colleges that she wanted, that kind of all threw her off the second semester but...I also think maybe she just bit off more than she could chew. Like she had just too many balls in the air and she was just starting to lose track of everything. I don't know. She seemed a lot less organized than she did two years ago when I had her. Yeah, I was surprised at some of the things that she was doing, like not turning in things on time, it just seemed kind of out or character for her."[203]

[203] J_T2_67.

When scarcity captures the mind, we become more attentive and efficient, but not necessarily in the most productive of ways. For a woman in engineering trying to fit in, a normal authentic self can work until she feels that she has been edged out, and then she compensates in the only way she knows how in a masculine milieu. Amanda reverted to "essential femininity" in order to regain access through attention and attraction. Thus beauty can become an economic transaction in engineering for a woman, using one's means to achieve access and acceptance with men. An extra challenge then exists for non-heterosexual women.

If we think of the bandwidth, or finite mental capacity one has, women—especially at the high school level—are at an automatic disadvantage in engineering when they must commit a larger section of their bandwidth to navigating their gender identity, that is, simply trying to fit into the middle-class white-privileged masculine culture of engineering. Dryburgh argues that it is more difficult to be a woman than a man in engineering because of the adjustments required of women with regard to the occupational culture, impression management, and solidarity with others in the profession (Dryburgh, 1999). Whereas most heterosexual white males do not have to negotiate their identity in the same way; they already fit-in in engineering. However, humans of every other derivative of race, gender, and class must expend mental capacity to navigate engineering with its own implicit rules and ethos of an identity not their own.

Scarcity creates its own trap, the consequence of which is further perpetuation of scarcity. Because young women may be preoccupied by scarcity, or acceptance into the male engineering club, their minds will constantly return to it instead of other more important things, such as learning.

Doing gender is unavoidable. However, creating an even playing field for women, people of color, and non-heterosexuals in engineering is possible. Learning to express one's gender identity as an adolescent, especially in the midst of borderwork and crossing (Thorne, 1993), should not be at the expense of learning and advancing in engineering. Parents and educators can learn to identify when students become preoccupied with fitting into the dominant culture and encourage them to be authentic and true to themselves. Intentionally creating an equitable classroom that does not favor one culture over another will help to alleviate some feelings of scarcity, freeing up student bandwidth to learn and succeed.

4.6.9 Key Points and Recommendations

- Students whose parents are not engineers, or knowledgeable about the true value of a strong STEM education, are less likely to have the same level of support, learning opportunities, and influence at home as does Amanda. Creating programs to educate parents is advantageous; however, counselors and both formal and informal educators must help the students who do not have as much cultural capital from which to draw to learn about careers and opportunities in engineering. Introducing them to role models and mentors is one way to do so.
- Although Amanda's mother is "pretty convinced" that her daughter is sincere and genuinely interested in engineering, it is likely that the discourse at home is woven with messages that signal shock in Amanda's interest. These negative micromessages will accumulate but hopefully not overcome and outweigh the positive messages Amanda receives from her father. The reality is, we all have biases, and they are

deeply rooted in the fabric of our being. However, by understanding our biases, we can begin to recognize how they manifest in our interactions with others and begin to change them. As we interact with young women working to find their STEM identity, we must be cognizant of the micromessages we send as a result of our bias.

- Amanda did not participate equally in hands-on activities but felt responsible for her team. Young women should not feel as though they should sit on the sidelines and they certainly should not feel expected to or be responsible for keeping young men on task. Better facilitation of group roles and improved monitoring of group interactions to avoid traditional gender roles of power and deference can improve female student learning experiences in engineering.
- Amanda's teacher shares that she would have let the male students lead in mechanical activities when she was a student, and this belief/anxiety has likely been transmitted via subtle messages. One way to avoid this interaction, or transferring of anxiety, is to teach educators about a growth mindset, have them teach students, and then have them hold one another accountable for discourse and behavior that suggests otherwise. This challenges the normal power structure in a classroom where the teacher is the all-knowing being, but creates instead an environment that encourages and supports lifelong learning, as well as relieves pressure from stereotype threat when teachers attribute success to learning through the effort required.
- Amanda constantly negotiated her gender identity in her engineering class, trying to fit into the male environment, yet still expressing herself. Young women should not have to act like men and shun femininity to be a part of engineering. Amanda differs from others because she persisted when others would give up the struggle. It is

difficult to know whether there is a threshold of tolerance for even the boldest of young women. Regularly encouraging young women in engineering and providing them with opportunities to bolster self-efficacy can likely prolong one's tolerance, thus persistence, in an engineering environment.

- Doing gender is unavoidable. However, creating an even playing field for women, people of color, and non-heterosexuals in engineering is possible. Learning to express one's gender identity as an adolescent, especially in the midst of borderwork and crossing (Thorne, 1993), should not be at the expense of learning and advancing in engineering. Parents and educators can learn to identify when students become preoccupied with fitting into the dominant culture and encourage them to be authentic and true to themselves. Intentionally creating an equitable classroom that does not favor one culture over another will help to alleviate some feelings of scarcity, freeing up student bandwidth to learn and succeed.

4.7 Morgan

Morgan is a freshman honor student in the Introduction to Engineering class. Friendly, outgoing, and free-spirited, Morgan is a member of the color guard and active in the Gay-Straight Alliance. Morgan is the youngest of two children, and her older brother is also a student at the high school. Her father is a computer game programmer, and her mother is a children's ministry director at a Presbyterian church.

4.7.1 Choosing Engineering

Morgan likes math and science, but she believes that math is difficult for her, even though she has always been in the advanced classes. She feels as though she has to work harder than some of her classmates. She did not originally plan to take an engineering course. She began the school year in an animal wildlife class, but within the first couple of classes she realized she would not like the course, and engineering was an easy switch for her schedule. She believes, "An engineer is someone who specializes in math and science, who works in managing, improving, or designing systems and items that are often necessary."[204]

Morgan has great dreams and ambitions for her life, and she truly wants to make an impact in the world by becoming an innovator. Although she is still exploring her career options, she believes a career at the intersection of health and engineering would be best for her.

> "I want to do something that matters. I don't want to end up in a factory or a restaurant somewhere. I want to be like the innovators out there. I am going to be a genetic engineer; I think that will be very important in the future. We are going need to start refining things like agriculture and healthcare. I want to be there to help advance everyone. I don't think I have anything else worth devoting myself to. Every one devotes themselves to something, like religion and art. All sorts of things. I feel

[204] F_J3_5.

> like being an innovator is one of the most important things you can do. If nothing changes then nothing improves."[205]

4.7.2 Parenting Choice for Gender Roles

Morgan says her ambition makes her a "weirdo." When asked why, she explains, "I love it! I feel like I am, I have ambition. I feel like as long as I am different there is no way I will get left behind by everyone else."[206] Morgan is a unique young woman. In my assessment, she is opinionated, kind, genuine, open-minded, well-read, and a deeply philosophical and reflective thinker. Her mother has intentionally nurtured these attributes in her and has encouraged Morgan to not be confined by gender norms. At times, she questions her decision, because it has made it more difficult for Morgan to find her place in the world. Although stemming from her own childhood experience, Morgan's mother wants her to have many choices and to accept everyone.

> "When I had Morgan I was very determined that she not be...I don't know... not feel like she needed to fit into a certain gender role. I don't know if that is a good or a bad thing, and sometimes I have looked at it and thought maybe I should have just...Because it is so much easier with the girls who know exactly where to go and what to do and how to act like a girl. There is kind of a comfort in that. But you know at the same time I think that maybe I felt kind of balled in, because there were portions of my family that were you know, 'you should only do this because you are a

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[205] F_S2_58.
[206] F_S2_58.

> girl.' And even choosing my major in college, I would have set out to do something totally different. But they were still just traditional enough to you know, 'you don't need to do anything that is too hard. Just do what you enjoy. Then you are going to get married and that will be your life.' And so I didn't ever want that to be a part of her thought process. To think as in 'this is what I have to do, these are my choices.' I wanted theeeese [sic, voice drawn out and hands opened wide] to be her choices. I wanted it all to be her choices, and to be accepting of everybody."[207]

Morgan identifies as a female, but strays away from being overtly feminine. She does not feel like a tomboy either. She prefers comfort and practicality in her attire, electing for clothing that does not constrain her in both the physical and emotional sense. She recalls being chastised for not "being a lady" when she was younger and realized that she did not care.

> "I identify as female, but actually as a young child, and still kind of now I still kind of flinch away from being overtly feminine. Just because, I felt I was constrained. I remember a particular instance in middle school [laughs]. I was play fighting with my friend like [whee! using hands waving in a slapping motion] like a little slap fight, and the teacher stopped us and was like, 'STOP IT! That's not lady like.' And I remember thinking, 'who cares?' Even before then, I would refuse to wear dresses for many years, because I liked running around. Dresses weren't very

[207] F_P_10.

> good for that. So I am not really a tomboy, I just reject things that I feel constrain me."[208]

Despite this self-awareness, Morgan still explores varying levels of femininity through several displays of gender (such as make-up, hair styles, glittery accessories), not unlike her peers. However, Morgan is unique in that is she is largely immune to the outside world's opinion of her gender display. So she neither tries to fit in with the boys or with the girls. Because she was not raised to believe she must be a certain way, she is free to be who she wants to be. In an engineering context, I believe Morgan is at an advantage because she does not fully subscribe to the same standards and expectations for feminine gender norms of behavior and style. Therefore, there is less negotiating between gendered identities, because she has a fluid border between the two. In a sense, she is somewhat inoculated in a way that Madeleine, Amanda, and Kassie are not. However, this liminal gender state likely will bring many challenges, but in the engineering classroom, it appears to be beneficial. Thus, her mother's parenting decision to raise Morgan free from gender norms, although holding potential consequence in other realms, allows her the freedom and flexibility to cross into male-dominated arenas with greater ease. If we as a culture wish to challenge stereotypes, then we must begin to transform and change them, beginning as early as the pink and blue gender branding wars at birth.

Gender norms aside, however, Morgan is not immune to the outside worlds' opinion of who she is as a person. She wants to be accepted and liked and to fit in among her

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[208] F_S1_43.

family and peers, yet in a way that still values her unique qualities. Insecure about her boisterous personality, fun-loving silliness, and her body, Morgan strives to connect with other high-achieving peers like her in the engineering classroom.

Morgan describes herself as goofy, but she also believes she can be annoying to others. She works hard to be liked by her classmates, but remains fearful that she will say something wrong or get in the way of the upperclassmen (for example, "that one girl in ROTC who every now and then says she hates freshman.")[209] She tries to be authentic, but her insecurity prevents her from engaging with some students.

> "I talk a lot and sometimes I get distracted, and I just point things out, and I'm like 'I'm talking to someone and oh look! A butterfly.' I feel like more serious people feel discomforted by my scatterbrainedness [sic]. I think it is fun, what I do is just fun. I want to make people happy. And sometimes I talk too much? It's more of a personal insecurity. I don't think anyone has ever come out and been like, 'Morgan, you are annoying.' I am sure I annoy someone. [The insecurity] keeps me from getting into other people's conversations. Like, I like, I can't help listening because people talk really loudly in there. And sometimes I just want to jump in the middle and be like, 'hey!' But I feel that if I jump in too many times, they'll just be like 'Morgan BACK OFF!' And I would respect that,

[209] F_S1_28.

> but I try to avoid even driving people to that point. That is pretty much it. It is an overall social feeling."[210]

It is a tragedy that so many of us waste our youth caring more about what others might think of us than learning to boldly live as our authentic selves. Recalling the theory of scarcity (Mullainathan & Shafir, 2013), or mental bandwith, how much more could we accomplish in life if we were not dedicating so much mental real estate to the opinions and approval of others? Although Morgan does not struggle in the same way that Kassie and Amanda do in negotiating gender displays, she still struggles with "unwritten rules of what it means to be 'feminine' and exhibiting stereotypically 'female' behaviors like being nice, quiet, polite, and liked by all" (Girl Scout Research Institute, 2008). She is afraid to grade her teammates anything less than a 100, and she is afraid that others will think she is annoying when she expresses her voice and opinion in class. Realizing that young women will struggle with unwritten rules of femininity, creating a classroom culture that encourages them to have a voice, to lead their teams, and to offer feedback without the fear of being disliked, educators can help advance young women—particularly in the male-dominated engineering classroom.

4.7.3 Pan-sexuality

Although I did not ask, within the first several minutes of our first interview, Morgan shared that she is pan-sexual and then told me more about her sexual identity. She came out to her mother and brother, casually, in the mini-van on the way to a Super Bowl party during sixth grade. However, she had to sit down to talk to her father about it, and he is

[210] F_S1_27.

less supportive than her mother, accusing her of following a social trend: "He thought I was following a social trend for some reason." This has caused a very strained relationship between Morgan and her dad, and one that her mother realizes is likely very confusing for Morgan. Morgan is insulted and frustrated at her father for not trusting her to think independently. "He encouraged me to think when I was younger. It was kind of insulting when he assumed that I was just going with whatever everyone else thought." Morgan participates in the Gay-Straight Alliance, which has helped her to forge her identity and meet LGBT allies in her school. She does not hide her pan-sexuality, but she does not openly discuss it with her classmates. She doubts that most students even know that about her.

> "I am pan-sexual [said in a definitive, and certain voice]. Pan-sexual means that gender, or identification, like it doesn't matter. Like I am able to fall in love with a transgender, people who don't identify with either gender, female, male...it's like bi-sexual but even a little wider. I thought I was bi in 6th grade, I didn't realize pan-sexual was a real thing, but then I went to GSA to see what was going on...I realized that it wasn't normal to find other women attractive. I was like, oh! I thought that it was regular to look and someone and be like, yea, they are attractive, but then I realized that other women don't do that. I find them attractive. But it wasn't a bad thing for me at all because my family is very accepting."[211]

[211] F_S1_34.

4.7.4 Strained Relationship with Her Father

In contrast to Morgan's mother, who is incredibly supportive, her father is negative, pessimistic, close-minded, deeply conservative, absent, uncommunicative, and somewhat sexist against women in STEM. Morgan's mother suggests that because Morgan has had to learn to work around her father at home, she has learned to navigate around negative people in life, allowing for greater resilience and strength. As Morgan was taking the Implicit Association Test (IAT) one day at home, her father passed by. She told him briefly about the IAT, and his commentary to her was offensive.

> "My dad actually just passed by as I was typing, and after hearing about this IAT, commented that 'stereotypes are there for a reason.' He stated that he saw many women go to college planning to be mathematicians, but graduated with psychology majors instead. I took offense at his implications that women can't follow through, but said nothing. I haven't felt limited by my upraising in any way, but similar conversations do put a strain on my respect for my father's opinions."[212]

Morgan feels as though she cannot speak up to her father, which her mother notices: "She is the kid. She can't say as much; she feels like she has less latitude. As she gets older she will. Then that will be interesting because, maybe that is why she learns to work around people."[213] "I think if he knew how to talk to her, if he felt comfortable talking to

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[212] F_J2_3.
[213] F_P_11.

her, it would be ok. But I think he just doesn't. I think he just avoids her when he is not sure what to say. That is kind of how he deals with her."[214]

In Morgan's family, her mother denies competence in all things STEM related and says that her husband has that covered as the "math person." However, if his relationship with Morgan continues to dwindle over time, Morgan may feel less confident to continue in STEM without that support at home, because parents play a critical role in influencing engineering education experience (Brinkman et al., 2014). Although Morgan gets a lot of support from her mother, the negative voice and poor relationship with her father could potentially increase stereotype threat and decrease her self-efficacy in engineering. As educators, we cannot always see what happens at home, but we can be intentional in the messages that we send to young women that will bolster their self efficacy in STEM, and ultimately engineering.

4.7.5 Classroom Environment

An incredibly thoughtful and deep thinker, Morgan seems very mature for a freshman, even quoting Greek mythology to describe her relationship philosophy. She has deep insights and personal reflections that give her a certainty unlike other teens. However, it is almost as if she loses confidence, because she feels different, or more evolved, than her peers, and cannot relate to them. She wants to associate with other high achievers like herself but lacks confidence to be authentic in the classroom.

The immaturity of her male classmates is distracting to the learning environment, and she finds herself seeking refuge in another corner of the classroom that seats more

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[214] F_P_13.

attentive students. Morgan’s mother realizes she was spoiled throughout grade school, having most always been grouped with the other high-achieving and gifted/talented students. However, engineering is an open and “mixed” class. She recalls an interaction with Morgan over the students in her class:

> “It is funny because she has realized being in an on level course what a different world she has been in all these years. ‘I don’t get it, who are these people? They don’t care about anything.’ I am like ‘that is the rest of the world.’ You are in this little bubble of people who all care very much. She has been kind of spoiled because she hasn’t had to be in a class where people don’t care. [She’s accustomed to] the same group of students you see in most of your classes cause they are all higher performing, more ambitious.”[215]

Morgan’s class is loud and rambunctious, instigated mostly by the freshman and sophomore boys. A couple of the young women engage in the frivolity, but they are not the center of the action. Morgan identifies the boys as the class clowns who garner everyone’s attention because they “love to listen to them.”[216] Morgan says she likes the people in the other corner because they are less easily distracted and care more about education. She regularly spends time sitting or visiting with those students for group work and during free time.

[215] F_P_6.
[216] F_S1_45.

> "I find I dislike my corner a lot more than everywhere else in the room. That is probably because I have been here longer, but I go over to the far corner where that guy is sitting and I have friends there like Catherine, and there is a senior there who is super nice, and Topher is hilarious. I feel that they are a lot nicer and a little more—ok I don't know how to say this—okay they are a little more less easier distracted. They care more about education."[217]

The students distract Morgan's learning. She wears headphones at times to block them out, but she says that it does not work. Throughout the course of the study, Morgan mentioned their behavior in every interview.

> "I do not like some of these guys. They are like children only with dirtier minds."[218]

> "The guys in the center area aisle. They are very loud and stupid. They aren't stupid necessarily; they just don't take anything seriously so they seem stupid to me because I take things a little more seriously. I am goofy, but I know when to be serious. To me that is a bit stupid."[219]

Social class differences in school can be related to ability grouping or tracking that begins at the onset of formal education. Tracking, in essence sorting, is the process

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[217] F_S1_30.
[218] F_S2_62.
[219] F_S3_71.

whereby students are divided into categories so that they can be assigned in groups to various kinds of classes such as fast, average, slow, or students who may self-select or are encouraged toward vocational, general, or academic trajectories (Oakes, 2005). Morgan is a TAG student (tested as Talented and Gifted), a fast learner on an academic trajectory, who had been pulled out of her regular classes since first grade for special lessons with other special kids. Once in middle school, all of those students were grouped together in the same classes. Engineering was one of her first courses in which she was re-integrated with "regular" students and the masculinity expressions of the young men overwhelmed her learning environment. Like several of the students in this study, there was a barrier of academic ability between other engineering students—Cathy, Isabelle, Luna, Madeleine, and Morgan. Many engineering programs are established in K-12 is with a more vocational brand than an academic brand, although this is changing. This opens access to more students, but can deter for academically gifted students who have become accustomed to segregated learning environments. A consequence of re-integration of learners of varying ability is a hierarchy of not only ability, but also favor (such as what was observed in Cathy's case). I am not advocating for tracking or lack of tracking; I am merely stating that the implications of such in this school are evident in the observed engineering classes. Students will naturally create a social order, but it should not be prompted or intensified by inequitable messages from the teacher.

4.7.6 Key Points and Recommendations

- In an engineering context, I believe Morgan is at an advantage because she does not fully subscribe to the same standards and expectations for feminine gender norms of behavior and style. Therefore, there is less negotiating between gendered identities, because she has a fluid border between the two. Thus, her mother's parenting decision to raise Morgan free from gender norms, although it may hold consequence in other realms, allows her the freedom and flexibility to cross into male-dominated arenas with greater ease. If we as a culture wish to challenge stereotypes, we must begin to transform and change them, beginning as early as the pink and blue gender branding wars at birth.

- Although Morgan does not struggle in the same way as Kassie, Amanda, and Madeleine do in negotiating gender displays, she still struggles with "unwritten rules of what it means to be 'feminine' and exhibiting stereotypically 'female' behaviors like being nice, quiet, polite, and liked by all (Girl Scout Research Institute, 2008)." She is afraid to grade her teammates anything less than a 100, and she is afraid that others will think she is annoying by expressing her voice and opinion in class. Realizing that young women will struggle with unwritten rules of femininity, creating a classroom culture that encourages them to have a voice, to lead their teams, and to offer feedback without the fear of being disliked, educators can help advance young women—particularly in the male-dominated engineering classroom.
- In Morgan's family, her mother denies competence in all things STEM related and says that her husband has that covered as the "math person." However, if Morgan's relationship with her father continues to dwindle over time because of her sexuality, then Morgan may feel less confident to continue in STEM without that support at home. So, while Morgan gets a lot of support from her mother, the

negative voice and poor relationship with her father could potentially increase stereotype threat and decrease her self-efficacy in engineering. As educators, we cannot always see what happens at home, but we can be intentional in the messages that we send to young women that will bolster their self-efficacy in STEM, and ultimately engineering.

- Engineering was one of Morgan's first courses in which she was re-integrated with "regular" or non-gifted students, allowing access to more students. However, this practice can be a deterrent for academically gifted students who have become accustomed to segregated learning environments. The implications of tracking were evident in the engineering classes observed in this study, creating social barriers of ability and favor by the teacher. Students will naturally create a social order, but it should not be prompted or intensified by inequitable messages from the teacher.

4.8 Max

Max is a sophomore student in the Introduction to Engineering course, in the same class as Morgan and Charlie. She is in her second year of ROTC and wants to stay in all 4 years and continue into an ROTC program at college so that she can enter the Air Force as an officer. Her career goals include doing something in engineering in the Air Force, and then later becoming a music teacher. Her interest in music stems from her participation in the band since sixth grade, when she began playing cello.

4.8.1 Choosing Engineering

After joining ROTC, Max was exposed to aerospace engineering and became interested enough to sign up for engineering for her sophomore year. She wants to be a famous engineer and believes she has what it takes to reach that goal. Max likes being "ahead of the pack" and believes taking high school engineering will help her achieve this objective by developing new skills and ways of thinking and by learning more about her strengths and weaknesses in these areas. Max believes that taking engineering in high school will be advantageous to her future career path.

Max chose engineering because she needed the credit, but she loves the class, even though she is falling a little bit behind. She describes her teacher as awesome, that she has "actually learned a lot," and that she plans to continue engineering classes even if she is unable to graduate from the Academy. Her favorite activities in the class are the ones in which she puts in "all the blood, sweat, and tears and frustration and everything onto the computer and seeing it come out a final product is pretty awesome." She is referring to the 3D printed objects.

Max's mother, Norma, believes that Max has been interested in engineering since elementary school, and therefore wants to help Max achieve her dreams by providing her with the right opportunities to explore engineering. Originally, Max was interested in NASA and becoming an astronaut, but somehow her interest in science transformed into an interest in engineering. Earlier in Max's life, her parents, on Max's behalf, applied for her to enter into a school focused on engineering. She was accepted, but was not able to attend because of a family move. When Norma and her husband were planning their move to their current location, they specifically chose Unnamed because of its STEM program. Norma describes Max as strong headed, smart, self-teaching, motivated, capable, mature, determined, and disorganized.

Max wanted to participate in the study because she “can’t stand stereotypes.” She finds it difficult to understand why she had to work very hard to overcome perceived stereotypes against women in ROTC and engineering. She describes herself as a strong and independent woman who likes to get things done. She set her eye on engineering and is determined to persist, despite the fact that she does not know any Hispanic engineers. As a Mexican, she believes she has experienced a stereotype that Mexicans are only good for fixing houses, painting, and building fences. She knows she can do more, but it is a “day to day battle between [her] views and what everyone else sees.” She feels as though it is her “against the world,” which is what motivates her to speak out against these overt stereotypes.

4.8.2 Activist and Feminist

One of Max’s rules of life is “You’ll never get what you want if you are not clear about what you want.” For this reason, she is “loud” about things that are important to her. With that, Max is quite the social justice activist; having participated in campaigns for No Place for Hate, Erase the R-word, homosexual rights, racism, and other similar issues, all efforts to challenge stereotypes or inequities. Max is compassionate about these initiatives because she does not “feel people should be judged based on their color or sexuality” or other personal matter.

Max describes herself as a feminist, motivated in part by conversations with her mother about women’s role in society as an elementary student. Her mother explained to her that women are treated differently from men, and that women do whatever men say. As Max matured, she recognized that her mother was in an abusive relationship and that this mindset was likely a bi-product of her situation. Max believes that everything in life is based on social expectations and/or limitations: that women and men are expected to play certain roles in work and at home. She acknowledges that these are stereotypes and imbedded ways of thinking, but is adamant that life does not have to be this way.

4.8.3 Self-Expression

Max uses her wardrobe as a form of expression, both for her style, interests, and mood. Some days, rare by my observation, she "decks out" with accessories. Most days, she buries her body in an oversized hoodie sweatshirt and jeans, which she says is often a sign to leave her alone. During a conversation about her colorful bracelets, Max revealed to me that she is bisexual. She said she wears the bracelets to be "gay and proud." During her freshman year she was active in the Gay-Straight Alliance, and she did "a lot of coming out and saying 'hey, this is who I am, if you don't like it tough.'" This year she does not participate because of scheduling, and she said the student leader last year was "kind of really mean" and Max didn't like her at all.

4.8.4 Bisexuality

Max recalls that she began to recognize her sexuality between fifth and sixth grades and by seventh grade knew for sure that she was not heterosexual. In clarifying whether she is homosexual or bisexual, she says she is definitely bisexual but leans toward liking females more. She says guys are different and more difficult to deal with. Max thinks that love should not have a gender. She explains, "I don't fall in love with the gender, I fall in love with the person." Being bisexual to her means she does not limit herself to one gender, because she believes one "can't really help who or what you fall in love with." Max believes she challenges a misconception about gays by not allowing her sexuality to define her. Max is not attracted to anyone in her engineering classes, but she is attracted to students in other classes. She has concerns about coming on too strong, particularly if they "don't roll that way."

Max has yet to tell her parents, but her sister knows about her sexuality. She came out by announcing her sexuality to her friends and finding others in a similar position. For her, the process of coming out involved identifying a support group with whom she could share comfort. She does not have a plan to tell her parents, but she thinks she will wait until the conversation naturally arises. She fears that they may treat her differently or that they may not suppor her and make home life difficult. She considers home a safe place and fears that coming out to her parents might jeopardize the comfort she derives there.

4.8.5 Home Life

Max's mother, Norma, is a customer service representative in the banking industry. Her husband, Max's stepfather, is a data analyst and programmer. Max has a younger brother, 9, and a sister, 13. Max's mother is Mexican, and her stepfather is white. She says that her house might be split in half racially, but they are still one family, which she really likes.

Max's biological father was very abusive, and her parents' divorce was a difficult. After the divorce, Max and her siblings sustained more physical and emotional abuse during the court-required parental visits with their father. Now, Max and her sister do not want even supervised visits with their father. Norma considers Max to be a very strong young woman because she focuses on moving on instead of the wounds. Diagnosed with posttraumatic stress disorder, Max is dealing with a lot of her history this year, which Norma believes is the cause of her issues in school. As a parent, Norma finds it challenging to be the support system that Max needs as she is healing: knowing what to say and when, while balancing her own feelings of sadness for what transpired and remaining able to properly discipline. Norma feels compelled to compensate at times for the mistakes of Max's biological father but acknowledges that she cannot. She did the best she could by removing her children from that environment.

Max did not tell me herself about her past with her father, other than physical and verbal abuse. However, her mother told me that Max had been molested by her father. There were also incidents when he attempted or threatened to kidnap Max and her sister. Max states that her biological father is not a good influence on her brother and sister and that "we" are in the process of taking away his parental rights. She says, "I don't want him in my life." Max feels protective of her siblings. She said that as long as "Daddy" is far away, she is safe. Max has not spoken to her biological father in months. She finds this bittersweet: pleased that she does not have to deal with the issues, but longing for a relationship with him. She is content, however with just her "mom and step-daddy."

Max attended therapy but did not like the therapist and felt that it drudged up too much pain. Her parents (mom and stepdad) believe she is using her past as a crutch, which is causing problems at school. Although she no longer attends counseling, she has decided that we wants to try it again. Concerns, according to her and her mother, are finding the resources to pay and transportation to the sessions.

Max hears her biological father's voice in her head telling her that she is not good enough. The emotion from this language always weighs on her. Sometimes, she is motivated to prove him wrong, but other times the weight is debilitating. Most days, she says she is okay and can smile and laugh and have a great time. Other days, the weight of her concerns cause her to want to curl up on her bed and cry underneath the covers all day.

As a result, Norma explains that this has been an off year for Max, which they have allowed because of her personal issues. Considering all of the years of school that she has "never done bad," where a C is considered bad, they are giving her a break because she is taking more difficult classes while struggling with her personal issues. But the grace is only offered for this year, Norma expressed in an empathetic but motivating way, as Max sat in the room during the interview.

Max has been struggling in her classes, and earlier in the year, she sent an email to all of her teachers to explain her past with her father and that she is dealing with issues such as depression. In her frustration, she chose this medium to reach out to her teachers so that they could better understand her. She believed that the more they know, the more they might understand, and the more they might choose to help her. She explains that it was not that she would not do the work, it was that she could not. She needed an extra push, a pat on the back, and affirmations of a job well done, which she received from all of her teachers except for her male geometry teacher, who she think does not care.

Not all students will reach out like Max did in a time of need. She could have silently struggled, like many students do. It can be easy to mark students off as low achievers, lazy, or too troublesome, when we have a class full of students to worry about. It is difficult to imagine the weight that Max carries, as she seeks to heal, while struggling to achieve in her classes. She does not like letting herself, her mother and stepfather, or her teachers down. She wants to be better. These students such as Max deserve the opportunity to learn just like any other. Learning ways to identify and address the needs of troubled students is paramount for educators. At a minimum, learning to be more sensitive and empathetic is a start. Sometimes, it is easy to jump to conclusions and label students, but we should be challenged to look below the surface and make an effort to not further damage the child.

4.8.6 Family Influence

Despite her tragic suffering, Max's mother and stepfather continue to be a positive influence. Her stepfather works in IT, and he encourages her to consider a career in technology because of the potential for high wages. She goes to him with all technical questions and concerns, and she has learned a lot from him. Max exclaimed that she learned the life-saving Ctrl-Alt-Delete from him. Whenever there are computer problems at home, she says she is "right there trying to see what he is doing."

Not going to college is not an option for Max, which Norma says she has always stressed. This is important to Norma because a college education is unusual for most Hispanic women, particularly those of her generation. She sees many opportunities for Max's generation, including scholarships, that make a college education achievable. Norma reinforces that all three of her children must attend college, even if she as a parent must take out student loans. She believes that if she and her husband had had support from their parents, their lives might have been different, and their economic stature better.

For this reason, Norma is prepared to assume college debt for her children and to make the sacrifices needed so that her children can have a fresh start when they finish college. Max also believes that college is mandatory, because of her parent's directive and her own choice. Norma pushes Max to succeed because her mom did not push her. Norma believes she could have been so much more and now wants better for her daughter.

4.8.7 Math and Science

Max loves algebra and thinks she is very good at it. However, geometry has been difficult for her this year. She explains that she was very good at math until eighth grade, when did poorly in algebra and had to repeat it in ninth grade. She reports that she did well the second time around.

When Max showed signs of struggling in geometry at the beginning of the year, her mother and stepfather contacted the teacher. When he did not respond, they sent another email and copied the school assistant principal and principal. They wanted to better understand what was happening, whether the issue was with Max or the class. They met with the teacher and the assistant principal to set out strategies for Max's improvement. The teacher has worked with Max all year in tutorials so that she better understands and is passing the material.

Her struggle in geometry affected her extracurricular activities. Because she was not passing geometry at a certain point, she was not eligible for the UIL Ensemble competition. Max used to be a straight A student, but since freshman year "it's getting harder and harder. And it is not easy keeping up." Max likes science and thinks she is good at it, even though chemistry is not one of her strong suits. Helping students to have a growth mindset and strong attribution to effort allows them greater persistence when the work becomes challenging.

Max believes that you have to be good at math and science to succeed in engineering, and the emails she receives from colleges has solidified this association. Halfway through the school year, Max began to reconsider engineering, because she was doing so poorly in geometry and chemistry. Out of fear that she was not going to meet the standards for engineering, she waivered back and forth on her decision to persist in engineering. She has decided to stick with it, but she is concerned that her trouble in these subjects will jeopardize her future in engineering. She believes that she just needs a little more time with certain things, even though in her current engineering course she does not recognize much math or science in the curriculum. In speaking with friends in more advanced engineering courses at the high school, she has heard that the design course has a lot of math and science, but hopes and thinks that she will be fine if she asks the teacher for help. Engineering requires math and science, but it does not require extraordinary skills, A+'s, or just AP or gifted students. When we perpetuate this message, we discourage young people who could be innovative and creative problem solvers, at a time when we need them most. We must change the conversation in grade schools and in our college marketing materials so that engineering welcomes a variety of students, skillsets, and interests (Committee on Public Understanding of Engineering Messages, 2008). Math and science should not be the gatekeepers to engineering.

4.8.8 Money as a Limiting Factor

Even though Max's mother and stepfather are supportive, money is a regular topic of concern. At the beginning of the study, Max told me she would not be able to email me from home because they turned off the Internet and cable connection. She describes money as a constant issue and cannot remember a time when "we have ever been comfortable with our financial stability." The money specter arose for this course: Max was unable to pay the ~$100 lab fee for the engineering course. She describes how embarrassed she was to tell her teacher, but also admits that the conversation it was not as bad as she had imagined. Fortunately, Max was willing to ask for help, but how many students do not take engineering because of this financial burden? Are we excluding students because of lab fees? If equity and access is the goal, then we must remove barriers such as this that could potentially eliminate an entire class of people.

Money limits the expansion of Max's horizons and participation in unique opportunities. She has been invited to many trips, conferences, and programs to develop leadership skills, or explore engineering, but financial constraints have not allowed her to participate. She views this as constraint as motivation to work harder so that she can afford the things she wants later in life. Her parents will not allow her to work when her grades are low, but she wants to work so that she can afford the things she wants and the activities she wants to do. Max does not play a sports; she says "we don't have the money to pay for a city thing" and she does not have room in her schedule at school.

Max says it is nice to have an understanding teacher like Mrs. Jones in high school, but she believes that in the "real world" money will be an issue, simply because it has always been an issue. She will depend on scholarships to go to college, which is a stress factor for her. Max believes that “you are either born to be a stereotypical Hispanic person or you work your butt off to break the barrier and do something.” With great insight, Max understands that often race or ethnicity influence where you live and the money you have. This in turn influences your education, the sort of career you have, and where you go in life. She calls it a domino effect and a pattern that she aims to cast off. Students such as Max benefit from meeting role models who look like them in places they want to go, or even have never imagined. These vicarious experiences increase self-efficacy and help them to persist and achieve their goals.

4.8.9 In the Classroom

In the engineering class, Max is confident in her abilities to use Inventor, a CAD software, when she is given enough time. She believes that she can design “cool stuff,” but it takes her longer than everyone else, which she considers to be this a weakness. As a tactile learner, she believes that engineering would be a good career for her because of its hands-on nature. In addition, she is not afraid to ask questions in class, also a strength in the field.

4.8.10 Working with Ken and Joe

During the observation period, Max spent most of her time working on a project with Ken and Joe, one a freshman and one a sophomore. She believes that Ken and “his little buddies” like to pick on and tease the female students, although not to be mean but because they are “guys.” Sometimes, their behavior makes her mad, but she chalks it up to the fact that they are freshmen who will say stupid things. Ken is the ring leader of the male students, but he is also a very bright student. He is often off task and plays, but he usually pulls it together to accomplish his work. Max on the other hand is very behind on her projects and is not doing very well in the course.

Max considers herself to be the leader of their group “because the other two kind of aren’t.” However, she was not the one to divide up responsibilities, and she was not pleased that she was told to do the drawings and computer work. Her reaction was to appease the group to avoid problems.

Max deems her teammates lazy and only wanting to work when the teacher is watching. She believes she has done everything for the team so that her grade will not suffer. Max says that she has to review and fix the work that they complete and that they assigned her the responsibility of building the prototype. Contrasting here is her desire to be the leader and her perceived responsibility to carry the group’s weight. When she is assigned work or responsibility, she is not pleased, but feels she has to redo all of her teammates’ work. It is as though she likes the responsibility and power but wants to complain about it.

Max give Ken some credit for his efforts, but she completely dismisses Joe. They both plan to give Joe “severely low” marks on the group grading sheets. At the beginning of their teamwork, Joe offered design ideas. Max thought his ideas were outrageous and not usable. Perhaps Joe believed his ideas were unvalued and thus chose not to participate. Max’s response to Joe’s lack of participation was very strong. In her frustration and stress, she yells at him, telling him that she wants to punch him in the face because he has not contributed. Max decided to not share her concerns with the teacher because she did not think anything could be done and she did not want to be “that person” who complains to the teacher.

Max claims that she does her best “babysitting them, making sure they sit down, and do their work,” but that her efforts are futile her efforts when the work is mediocre. “I might as well do the whole thing myself,” she laments. Max does not feel it is her responsibility, but the babysitting has become her role.

Interestingly enough, Joe participated on the one day that Max could not talk. She was participating in a Day of Silence event, so the first day of group work was spent communicating via messages on the computer. Max admitted that she used this medium to help guide her teammates to where she wanted them to go with the project without having to say “No, that is a dumb idea.” But the fact the she was quiet evidently allowed Joe room to participate. Generally, Max was very mean to Joe. She was to Ken as well, but he pushed back. In contrast, Joe retreated and shut down. Mrs. Jones never interceded on his behalf.

The team earned a 70 on the presentation, and Max blatantly blamed that on her teammate Ken. She said she had planned to fix his work but did not have the opportunity. She was disappointed with their mark.

The teacher was overheard telling another female student to “keep the guys [in her group] in check.” Mrs. Jones believes that her female students are more organized and perfectionistic than her male students. Therefore, she understands why they would take responsibility for the deliverables on the class projects, rather than leave it to the males. With this language and encouragement, it is no wonder that the young women feel responsibility to do so, aligning to traditional gender roles for women. Educators must be cautious so as to not unintentionally place expectations on any group of student to be responsible for another.

4.8.11 Life Outside of School Influencing the Cclassroom

Without lengthy psychotherapy sessions, it is impossible to presume the depth of Max's issues resulting from being molested by her father, feeling responsible for protecting her sister, going through her parent's painful divorce, not being able to participate in activities or other tools for school because of family financial limitations, and being a Mexican female in a largely white school. On top of trying to process all of those issues, during her sophomore year, she began to struggle in school, which affected her confidence in her intelligence and her ability. Mrs. Jones empathized with Max's situation and provided concessions on due dates and quality of work without question. However, Max's self-efficacy in STEM was dwindling, which was largely influenced by a perceived lack of support from her geometry teacher. Max doubted whether she would be able to "cut it' in engineering without A's in math and science. In addition, her parents dismissed her pain and suffering as "milking" the issue. I believe that Max craves attention and that she allows that desire to manifest in how she treated others.

Certainly, Max's life outside of school has influenced her experience in the engineering classroom. When comparing Max's experience to Phelan's model of border crossing (Phelan et al., 1991), Max exhibits similarities to Elvira and Trinh, both students whose home worlds vary greatly from their school world. The perception of the boundaries between worlds does not prevent them from managing crossings or adapting to different settings, but adjustments are required and not easy. Max is dealing with deep emotional pain and stress from her home environment, while trying to survive at school. At school, she feels free to express her sexual identity, but she must hide it at home. Max has adopted strategies for operating in both home and school/peer worlds, but in doing so, she must always hide part of who she is. In addition, PTSD has a wealth of effects on a person. Looking at the amount of mental bandwidth (Mullainathan & Shafir, 2013) that Max must commit to processing all of her emotions, and living dual lives, one wonders how much she has left for learning, The consequences are seen on her grades, and the diminished mental capacity is perpetuated by the added stress of failure. As a Mexican bisexual female from a low-socioeconomic family suffering from PTSD, Max has a multitude of inequities to overcome every day in her engineering classroom.

Martin, Simmons, and Yu (Martin et al., 2013) explored the role of social capital in the experiences of Hispanic female engineering majors and found that even single instances or weak ties can be effective in bridging gaps in engineering-related social capital. They suggest that facilitating opportunities for students to develop sustained social capital may have potential to attract and retain underrepresented students in engineering.

4.8.12 Key Points and Recommendations

- Below the surface, young adults can carry loads of grief and stress from their home life. Like Max, the result is manifested in school performance. Educators can create a safe space for students by not relegating them to labels based on uniformed assumptions. Taking time to understand and care for the student can help them to progress in school without adding to their stress.
- Max struggles in geometry and chemistry and thinks she might not be able to be an engineer if her struggles continue. Helping students to have a growth mindset and strong attribution to effort will allow them greater persistence

when the work becomes challenging. In addition, we must change the conversation in grade schools and in our college marketing materials so that engineering welcomes a variety of students, skillsets, and interests. Math and science should not be the gatekeepers to engineering, particularly when the self-efficacy, not ability, of females in STEM is consistently lower than males.

- Engineering lab fees such as those at Max's school can be a tremendous barrier to many students. Although Max asked for assistance, it was embarrassing for her. Many other students would avoid embarrassment by not asking and therefore not participating. If equity and access is the goal, then we must remove barriers such as lab fees that could potentially eliminate an entire class of people.
- Max is aware of social and cultural stereotypes about Hispanic women. Although she is determined to break them, and her mother encourages her to do so, students such as Max benefit from meeting role models who look like them in places they want to go, or even have never imagined. These vicarious experiences increase self-efficacy and will help her to persist and achieve her goals.
- The implicit biases of teachers are exhibited in discourse and behavior in the classroom and can create a set of unspoken rules and expectations. In Max's case, and the others in this study, Mrs. Jones's belief that her female students are more organized and perfectionistic than her male students and that the females should "keep the boys in check" fosters an expectation that the females should babysit the males. Educators must be cautious so as to not

unintentionally place expectations on any group of student to be responsible for another, particularly one that perpetuates gender stereotypes and creates unnecessary power differentials in the classroom.

CHAPTER 5. CROSS CASE ANALYSIS

Chapter 4 presented the stories of nine young women in high school engineering programs of study. Although each experience is unique, commonalities exist regarding family, influence, classroom environment, biases, and beliefs. However, their experiences cannot be summarized into a single story, because these young women vary across race, socioeconomic background, and sexual orientation. This chapter ties the cases together by connecting back to the conceptual framework described in Chapter 2, Figure 2.1: (1) what do the young women bring to the class, (2) what happens in the class, and (3) what do the young women take away from the class.

5.1 Band 1: What Young Women Bring to the Class

Young women bring complex individual experiences into the classroom. The most commonly shared experiences among the participants revolved around access to engineering and included a desire to help others, math and science interest and confidence serving as the gatekeeper to engineering, strong parental STEM influence and family support, and previous experience crossing over gender barriers.

5.1.1 Desire to Help Others

Many young women have a desire to help others (Eagly & Crowley, 1986; Miller, Rosser, Benigno, & Zieseniss, 2000) and are attracted to engineering for the social aspects, such as making a difference in the world and working with others. All nine participants derived enjoyment from helping their classmates and from the idea of engineering as a career to solve the world's problems. The National Academy of Engineering released a report in 2008 (Committee on Public Understanding of Engineering Messages, 2008), challenging us to *Change the Conversation* about engineering to optimistic, inspirational messages that emphasize connections between engineering and ideas and possibilities, rather than engineering as a math and science–based method of solving problems. The messages that most appeal to young women are "Engineering makes a world of difference" and "Engineering is essential to our health, happiness, and safety." The objective of this project is to encourage and motivate students to view engineering as an open and welcoming gate to endless possibilities, rather than to view math and science as the gatekeeper and guard against entry. Messages for recruiting young women to engineering should focus on the positive messages, early and often.

5.1.2 Math and Science Interest and Confidence as the Gatekeeper to Engineering

With this small study population, math and science served as the gatekeepers to high school engineering, as they also function, ultimately, in the engineering workforce. Interest, ability, and self-efficacy played a tremendous role in these and all young women's entry into high school engineering. Seven students received specific encouragement from an adult in the form of "You are good at math and science, therefore you should try engineering." The participants generally believed that engineering IS math and science and that you have to be good at both to do well in engineering. Even though none of the students said she used a lot of math or science in her courses, they all expressed concern that they might not be able to survive college-level math and science, particularly Max and Morgan. Most girls, despite ability and achievement, do not have a high self-efficacy in math and science, assessing their mathematical ability lower than do boys with equivalent past mathematical achievement (Correll, 2001), which limits their participation in engineering. Educators must bolster the self-efficacy of females in math and science ability, particularly because of the perception that one must be extraordinary at math and science to be an engineer, which is not strictly true. Engineering does require math and science, but it should not require a tremendous self-efficacy or even love for math and science. Teaching students about growth mindset, attribution theory, and stereotype threat can help them overcome barriers, improve math and science self-efficacy, and thus persist in engineering.

5.1.3 Strong Parental STEM Influence and Family Support

Parent careers and interests influence their daughters' interest in participating in engineering, as revealed in eight of the case studies. Occupational inheritance is a common entry into engineering, specifically for young women (Mannon & Schreuders, 2007). In this study, seven participants have a parent (specifically fathers or stepfathers) who works as a STEM professional. The other two participants, Charlie and Kassie, were from low-to-middle socioeconomic status families with no parental occupational influence. However, Kassie's father originally majored in engineering (but changed to psychology) and enjoys designing and building things as a hobby. He helped her build prototypes for her class projects. These influences seemed to be instrumental in Kassie's choice to enter into and persist in the high school engineering program (she had nearly completed 4 years of the program at the time of the study). All of the participants, except Charlie, regularly discussed their family's positive role in their education and career selection, which is vital to a female's pursuit of engineering at the high school level. Support, as exhibited in these case studies, involved taking an active interest in their daughter's education and encouraging their daughter to select a college/career path rather than just take required courses (PLTW courses are electives). Parents play a significant role in their daughters' engineering education (Juyeon Yun et al., 2013) via career trajectory influence and via their support of education generally and their children's [?] future career.

Almost all of the participants had strong family influence, high STEM self-efficacy, and a good understanding of what engineering is in a way that aligns with their interests. Unfortunately, students without a strong family influence may not have the same access to role models and opportunities that help them learn about engineering. Students of low socioeconomic status and from rural areas may have limited exposure to engineering, and therefore, less diverse introductions to the various disciplines and careers. For example, Charlie became interested in studying engineering after learning about it in her middle school technology/typing class. Max said that she knows only two engineers, her teacher and me, neither of which, she pointed out, are clearly Hispanic. Providing engineering exposure, including to role models that look like them, to all students early on will help them to make more informed education and career choices. Helping young women to build a strong self-efficacy in science and math will help them believe that engineering is an option for their future.

5.1.4 Previous Experience Crossing Over Gender Barriers

Cathy, Amanda, Madeleine, Max, and Isabelle had previous experience crossing over into male-dominated arenas before entering engineering: Cathy and Amanda in Taekwondo, Madeleine in basketball and baseball, Max in ROTC, and Isabelle in professional acting. Although acting may not necessarily be male dominated, the constant rejection requires incredible perseverance and resilience. The successful experience of navigating one's identity in an environment dominated by another identity could have bolstered the self-efficacy of these young women to persist in engineering. To them, the male domain was less intimidating, and their belief in their success was stronger than that of someone without a similar experience. It becomes more difficult for girls to easily cross into boys' groups and activities by junior high or middle school (Thorne, 1993), so the fact that all of these young women (except Max) had early experiences crossing over into a male-dominated environment was doubly beneficial for them.

Young women bring complex lived experiences to the classroom that influence how they access and experience the engineering classroom. Many of the participants in this study shared a desire to help others, math and science interest and confidence serving as the gatekeeper to engineering, strong parental STEM influence and family support, and previous experience crossing over gender barriers.

5.2 Band 2: What Happens in the Class

Macro social structures are exhibited in the engineering classroom and frame the environment and developed culture, as influenced through the female student, and the overarching social culture. The most common experiences among the nine stories are the masculinity expressions by the young men, and the young women as outsiders trying to belong in a masculine environment.

5.2.1 Masculinity Expressions by Young Men

Seven of the participants regularly mentioned that the behavior of their male classmates was a distraction to the learning environment; Kassie and Charlie were the outliers. Each class period was different, and the number of distracting students varied. However, the young women related generally negative experiences and feelings. They described the male students as “pervy,” creepy, trouble-makers, annoying, stupid, lazy, loud, typical freshman boys, immature, etc. They felt awkward, weird, or not interested in interacting with the male students. Among the young men in these engineering classes, “there is a response to powerlessness, a claim to the gendered position of power, and a pressured exaggeration of masculine conventions” (Connell, 2005, p. 111). On a grand scale, this behavior by young men reflects an effort to claim and sustain a leading position in the classroom, guaranteeing the dominant position of men and the subordination of women. It likely was not the students’ intended goal to distract the class, or to dominate their female peers every day, however, the majority of men, even young men, gain from this hegemony. They benefit from the “patriarchal dividend, the advantage men in general gain from the overall subordination of women” (Connell, 2005, p. 79). When the young men banded together in their antics, particularly in Cathy’s class, they were in charge. Connell refers to this as complicity: “masculinities structured in ways that realize the patriarchal dividend, without the tensions or risks of being the frontline troops of patriarchy” (p. 79). They had power over the teacher, the other students, the instruction, the classroom milieu, and student learning. The result is a seemingly subtle, yet formidable message to women of exclusion and subordination.

5.2.2 Outsiders Trying to Belong

Although humans share a general need to belong, adolescents' perceived sense of belonging in high school is associated with important educational outcomes in motivational, affective, and achievement-related domains (Wallace, Ye, & Chhuon, 2012). Their sense of belonging involves four distinct school-experience factors: generalized connection to teachers; connection to a specific teacher; identification and participation in official school-sanctioned activities; and perception of fitting in with peers (McPherson et al., 2001). The high school engineering environment is unique in that the male/female ratio in the engineering class differs substantially from those for other academic courses (with the exceptions of AP physics or computer science, which can also be dominated by males for similar reasons). Both the institutions of school and engineering are gendered masculine (Connell, 2005). Thus the social organization of the high school engineering classroom is masculine. To feel a sense of belonging in the engineering classroom, the young women must learn to adapt, and attempt to gain access, because the cultural values of the classroom and curriculum are based on male norms. As a result young women are required to manage two conflicting identities, work which is not required of their male peers (Du, 2006). For a student to gain access to groups and activities of the other gender, without notably disrupting or altering what goes on, the student must (1) *want* to participate in activities stereotypically associated with the other gender and (2) *persist* in the attempt (Thorne, 1993). Young women who are successful at crossing into engineering persevere despite the risk of being labeled or teased. Thorne finds that the protection of a higher status sometimes helps, which may include students of the majority race, gifted students, wealthy or popular students, or students favored by the teacher.

Because of the exclusion such that these young women experienced as a result of the masculinity expressions by the male students, they, like many women engineering students, developed different strategies to improve their chances of learning in a male-dominated environment (Du, 2006). Because high school engineering is organized to routinely display and celebrate behaviors and activities that are conventionally linked to males, when females engage in high school engineering, the routine nature of “doing gender” is challenged. West and Zimmerman (West & Zimmerman, 1987) describe gender role and gender display as the behavioral aspects of doing gender: “a complex of socially guided perceptual, interactional, and micropolitical activities that cast particular pursuits as expressions of masculine and feminine ‘natures’” (pp. 200-201). So, while some young women strive to be “one of the boys” to belong to the masculine community of practice, other young women find greater success by expressing prototypical femininity. Madeleine, Amanda, and Kassie negotiated both worlds by testing the continuums—exploration of gender roles and gender displays being among their strategies.

Du (2006) found that women engineering students tend to be better than male engineering students at managing, planning, organizing, coordinating communication, and raising perspectives in group discussion. However, these skills are not expected competencies in and contributions to engineering practice. Technical skills were more highly valued in the minds of male students and teaching staff of the electrical engineering program that Du studied. Kassie found a similar value system in her senior design class. There exists a duality between the social and the technical, the preference for the latter being based on male norms. Du suggests that this engenders the culture of hard-core engineering knowledge as masculine, leaving little room for those skills that are associated with females in western culture (Harding, 1996). "These culturally defined expectations, competencies and values on knowledge in the engineering community make women's contributions less competent and invisible" (Du, 2006) (p. 41).

For example, during the course of the study, Mrs. Jones told a female student to "keep the guys [in her group] in check." Mrs. Jones believed that the female students in her classes were more organized and perfectionistic than the male students, and praised this behavior. She expected the female students to take responsibility for the deliverables on the class projects rather than share equal responsibility with the male students. With this language and encouragement, it is no wonder that the female students, such as Max, Luna, Cathy, Amanda, Morgan, and Madeleine, felt a responsibility to do so, aligning to traditional gender roles for women. Consequently, their time was diverted away from developing the technical skills required to advance in engineering.

As a result of this duality, men appear to be engineers because they look like engineers and they are better prepared by gender socialization to maneuver in the organizational environment of engineering (McIlwee & Robinson, 1992). This socialization begins with Lincoln Logs and Legos. The engineering course curriculum at the study school is based upon using "toys" (Legos and robots) and technology that have long been linked with gender stereotypes. Research indicates that girls engage in science in a variety of ways (Brickhouse, Lowery, & Schultz, 2000). However, many young women may refuse to participate in scientific activities that are incongruent with their gendered identities (Carlone, 1999), seeking nontraditional ways to participate in science that are consistent with their gendered stereotypes (Eisenhart & Finkel, 1998). Both Kassie and Madeleine had a strong aversion to the mechanical aspect of their course that required the use the Fischertechnik and robots. Even the teacher expressed discomfort with the mechanical systems in her classroom, admitting that she does not like them and that is why she studied chemical engineering. In the same way that instructors have been shown to create and exacerbate math anxiety in students (Jackson & Leffingwell, 1999), Mrs. Jones could unintentionally be creating mechanical anxiety for her female students—specifically Kassie and Madeleine who could be subconsciously refusing to participate because the activity does not align with their feminine identity. In contrast, Amanda enjoyed these tools but always took a back seat to her male teammates during hands-on activities—her way of doing gender by submissiveness.

Du argues that, “[T]he masculine culture in engineering communities of practice involves more effort in identity management for women students than their male peers” (Du, 2006, p. 35). Doing gender is unavoidable, but constantly negotiating one’s identity can be exhausting and waste precious mental resources that could be dedicated to learning (Mullainathan & Shafir, 2013). The most common compromise was demonstrations of “essential” femininity, such as dress or note-taking roles. The result is a “role conflict,” where one must manage her “essential” nature, a continuous accomplishment of gender. Such environments can cause young women to believe that they are out of place and that if they were not there, then the trouble of managing and accomplishing gender would not exist (West & Zimmerman, 1987). West and Zimmerman argue, “[t]hus if, in doing gender, men are also doing dominance and women are doing deference, the resultant social order, which supposedly reflects ‘natural differences,’ is a powerful reinforcer and legitimator of hierarchical arrangements” (West & Zimmerman, 1987, pp. 211-212).

5.2.3 Variations

A few variations with unique intersections should be noted about classroom experience, interestingly involving three students from the same class: Max, Charlie, and Morgan. Max’s mode of operation in the classroom was abrasive, loud, and very often mean and emasculating toward her male teammates, potentially a product of abuse from her father, her way of expressing or challenging her Mexican heritage, her lower socioeconomic status, or her closeted sexual orientation. In contrast, Charlie’s mode of operation was sweet, nurturing, and kind and directed at pleasing everyone. After having been bullied and relocated more than a dozen times, Charlie wanted to make friends and not waves. She was hurt by Emelia as a teammate and sought to connect with a Korean student, another outsider, who sat next to her. As a mixed-race female from a low-socioeconomic status family, her experience was very different from that of Max. The third variation can be found with Morgan, a pan-sexual student raised intentionally to feel free of gender norms. Morgan likely held a greater advantage than the other young women because she does not fully subscribe to the same standards and expectations for feminine gender norms of behavior and style. Like the others, she struggled with the “unwritten rules of what it means to be ‘feminine’ and exhibit stereotypically ‘female’ behaviors like being nice, quiet, polite, and liked by all (Girl Scout Research Institute, 2008)," but she appeared to have a greater tolerance and comfort level than the other participants.

Macro social structures are exhibited in the engineering classroom and frame the environment and culture. The most common experiences among the nine stories are the masculinity expressions by the young men, and the young women as outsiders trying to belong in a masculine environment. Ultimately, learning to express one's gender identity as an adolescent, especially in the midst of borderwork and crossing (Thorne, 1993), should not be at the expense of learning and advancing in engineering.

5.3 Band 3: What Young Women Take Away from the Class

Because the study is not longitudinal in nature, it is not possible to extrapolate enough evidence to explain band 3, although I can make some inferences about what the young women take away from the engineering classroom. There is enough evidence in the previous literature to suggest that the experiences in the classroom influence young women's choice to persist, as identity, interests, and self-efficacy are known to influence behaviors. Thus if their overall experiences are more positive than negative, then a female student is more likely to persist in engineering. Otherwise, it is more likely for the student to leave engineering for other options more aligned with her identity and interests.

The stories of these young women suggest that fitting in to an engineering classroom takes work, as evidenced by the negotiating of gendered identities. The question then becomes, is there a point in which female students may decide its not worth the effort to fit in, and a threshold is crossed that directs the young woman out of engineering? In addition, it is not clear that these students received an accurate depiction of engineering based on what the literature suggests K-12 engineering should look like (See Section 1.1.6). If the students leave the classroom with a misconception of what engineering is and what engineers do, have we helped them to make a more informed career decision, or simply turned them away?

Since high school engineering boasts approximately the same percentage of participation of women as universities do, it could be projected that many of the students who take high school engineering are the same students that would have more than likely pursued engineering in university. Thus, if high school engineering does not yield persisting female students, we may potentially see a decline in collegiate participation. Therefore as engineering continues to expand in the K-12 setting, it is critical that we begin to better understand what the young women are taking away from the classroom, and ensure that it is positively contributing to the increased participation of women in engineering.

5.4 Summary of Cross Case Analysis

There were qualities unique to each individual case, and commonalties among them. To understand the experiences of young women in engineering, it was helpful to examine from three perspectives: (1) what do the young women bring to the class, (2) what happens in the class, and (3) what do the young women take away from the class. The most common shared experiences revolved around access to engineering and included a desire to help others, math and science interest and confidence as the gatekeeper to engineering, and strong parental STEM influence and family support. The second most common thread involved the participants' abilities to manage a male-dominated environment. The stories of the nine young women in this study offer just a sample of the experiences found in high school engineerin

CHAPTER 6. CONCLUSION

High school engineering is a nascent and growing market for developers and an emergent opportunity for more students across the US. With the national demand for improved STEM education and an increased workforce capacity, more schools are instituting turn key programs such as Project Lead the Way, or are developing their own curriculum like that at the Plano ISD STEAM Academy. However, the lack of participation of women in engineering at the university level seems to be mirrored in the high school engineering classrooms, where participation for both is about 20%. With a goal to increase the participation of those underrepresented in engineering, to both meet the demand of our country and for the sake of social justice, we can look to the current users. Much useful research has been used to examine problematization of underrepresentation (K Beddoes, 2011), but there is a dearth of literature that helps us understand the experiences of young women in high school engineering. From a basic user-centered design approach, one must understand the user, their experience, and the desired experience, to define and ultimately create an optimal solution.

As described in Chapter 2, the conceptual framework (Figure 2.1) mapped three perspectives that are helpful in examining the experiences of young women in engineering. First, young women bring complex individual experiences into the classroom, as demonstrated by Band 1: What Young Women Bring to the Class. Second, social structures influence the classroom environment, as demonstrated by Band 2: What Happens in the Class. Third, the experiences in the classroom influence young women's choice to persist, as demonstrated by Band 3: What Young Women Take Away from the

Class. What is unique about this conceptual framework is that the theories mapped to the bands of the model have never before been integrated to understand and explain the diverse, and complex experiences of young women in high school engineering, and a contribution to the research community is a synthesis of these theories in the engineering classroom. The results from this study yield conceptual validity to intersectional feminist theory: larger social structures of gender, race, class, and sexuality, influence the high school engineering classroom, and diverse identity dimensions have broader social meaning. Potentially the greatest contribution from this work is related to the experiences of young women crossing gender barriers, negotiating identities, and challenging gender roles to belong in a male environment.

The motivation of this study began with a single story of the female engineer, with the hopes of painting a broader picture of not only those who participate in engineering, but what they may experience in a high school setting. The stories of the nine young women demonstrate that when we examine the experiences with consideration of the intersections of gender, class, race, and sexuality, we see that the struggle of power from the institutions of these identities exist even in the microcosms of a high school engineering class.

From the incredible struggle of the academically favored and ‘Privileged’ in Cathy’s class, to female athlete Madeleine walking a tight rope of gender identity, to Max who fought to overcome cultural expectations for Hispanic women, to social-capital-rich Luna fearing sexual harassment in engineering, to Morgan, a pan-sexual student in a liminal gender state, the stories of these young women are representative, though not conclusive, of the diversity of backgrounds, issues, and struggles that young women face in high school engineering. The nine rich case studies presented in Chapter 4, provide us with new stories that prevent us from narrowing the experiences of women to a single incomplete stereotype. While no story or experience was the same, there were common threads among them, some of which merely give a nod towards the single story many of us preserve.

What I believe was unique about this study are the experiences of the young women when the intersection of their identities cause struggle, because that is where *they* grow and where *we* learn how to address unique needs of special populations. For the women in this study already in engineering, persistence was key. While these nine young women boldly and courageously attempted to defy stereotypes and expectations based on their gender, race, class, and sexuality, my hope is that observations from their experiences in high school engineering will inform educators, parents, engineering curriculum developers, designers of teacher professional development, and future research to improve equity and access for every student in engineering.

6.1 Recommendations

Primarily, the recommendations center on creating equitable learning environments for students, providing greater access to engineering careers for every student, improving student self-efficacy in STEM, challenging stereotypes and identifying biases that negatively influence student behavior, and challenging the status quo to transform engineering education.

Improving public understanding of who gets to be an engineer, and what it takes to be an engineer, will begin to challenge some of the longstanding stereotypes, misconceptions, and perceptions of engineering. If engineering is to be offered at a K-12 level, then we must ensure that students have accurate and positive experiences throughout those years to attract future engineers. For example, reinforcing Isabelle's identification of creativity and design as key parts of engineering will likely be critical to her continued interest. For students such as Charlie, who have strong socially driven career ambitions, it is imperative to not limit their career potential by reinforcing the longstanding stereotypes of engineering within high school curriculum. Students such as Max, who are aware of social and cultural stereotypes about Hispanic women and want to break the mold, would benefit from meeting role models who look like them in places they want to go, or even have never imagined. These vicarious experiences increase self-efficacy and assist in persistence and achievement of goals, not to mention challenge the image of engineers. Not all young women have access to career awareness and support for engineering, which makes it ever more important to provide those opportunities and engagements to every student.

Doing gender is unavoidable. However, creating an even playing field for women, people of color, and sexual minorities in engineering is possible. Amanda constantly negotiated her gender identity in her engineering class, trying to fit into the male environment, yet wanting to still express herself. Young women should not have to act like men and shun femininity to be a part of engineering, nor should they have to perform hegemonic femininity in order to be non-threatening to men, and our discourse should not encourage either. Amanda differs from others because she persisted when others would give up the struggle, and it is difficult to know whether there is a threshold of tolerance for even the boldest of young women. Regularly encouraging young women in engineering and providing opportunities to bolster self-efficacy can likely prolong one's tolerance, and thus persistence, in an engineering environment. Parents and educators can learn to identify when students are becoming preoccupied with fitting into the dominant culture and encourage them to be authentic and true to themselves. Intentionally creating an equitable classroom that does not favor one culture over another will help to alleviate some feelings of scarcity, freeing up student bandwidth to learn and succeed.

Most of the young women in this study believed they are good at math; however their belief was often measured against how others are performing. Helping all students to develop a growth mindset in math and science and to encourage them to attribute success to hard work and effort will begin to influence female student self-efficacy by allowing them to overcome stereotype threat.

School should be a safe space from unwanted attention, but we know it is not always so. Luna had an expectation that, as an outnumbered female in an engineering, she would be hit on and taken advantage of by the men. Although her perspective was of college and the workforce, this same fear of sexual harassment could exist for females considering high school engineering as well. Ensuring that sexual harassment does not occur in the classroom (or lab or work areas) could be critical to improving the female experience in high school engineering. Sexual harassment would include any unwanted touching, such as young men massaging girls' shoulders as reported by Madeleine, or crude talk, as reported by Amanda and Cathy, who felt awkward and out of place as a result of it.

6.1.1 For Parents

The messages that we send to youth about their potential, and what jobs and roles are appropriate for them may be unintentional and subtle, yet very powerful. For example, Amanda's mother was never fully convinced that her daughter was sincere and genuinely interested in engineering, and not just trying to please her father, and her messages permeated the discourse at home. These negative micromessages will accumulate but hopefully not overcome and outweigh the positive messages received from her father. The reality is, we all have biases, and they are deeply rooted in the fabric of our being. However, by understanding what biases we have, we can begin to recognize how they manifest in our interactions with others and begin to change them. As we interact with young women working to find their STEM identity, we must be cognizant of the micromessages we send as a result of our biases.

Parents have a choice in how they raise their children. Morgan's mother made an intentional choice to keep Morgan as free from gender norms as she could. If we as a culture wish to challenge stereotypes, then we must begin to transform and change them, beginning as early as the pink and blue gender branding wars at birth. The study suggests that Morgan's experience helped her cross over into a male domain.

Parents can help their children explore careers through community offerings at libraries, universities, museums, and other informal learning environments. This exposure will increase student awareness of the breadth of opportunities available to them and will enable them to make more informed decisions. Parents should allow their children opportunities to design, build, and create at home, in a way that develops a strong hands-on nature.

6.1.2 For K-12 Counselors and Administrators

Not all students come from families with the time and means to provide career exploration opportunities. Counselors, and both formal and informal educators, must help students who do not have as much cultural capital from which to draw to learn about careers and opportunities in engineering. Introducing them to role models and mentors is one way to do so.

Because of scheduling problems, Madeleine was unable to take the engineering courses she wanted and was consequently relegated to two courses that focused on manufacturing that used Fischertechnik, which ultimately turned her off of engineering. To retain students such as Madeleine, who are motivated by design and creativity, in the pipeline, high schools must offer more courses that do not provide such a myopic view of a large discipline with many opportunities.

Engineering lab fees such as those at Max's school can be a tremendous barrier to many students. Although embarrassed, Max asked for financial assistance. Other students might prefer to avoid embarrassment and not ask for assistance even if that meant not participating. If equity and access is the goal, then we must remove barriers such as lab fees that could potentially eliminate an entire class of people from entering into engineering.

We must change the conversation in grade schools, and in our course marketing materials, so that engineering is welcoming to a variety of students, skillsets, and interests. Math and science should not be the gatekeepers to engineering, particularly when the self-efficacy, not ability, of females in STEM is consistently lower than males. When we change the conversation from an emphasis on math and science, to the value of engineering, we will begin to see more females interested in engineering. Counselors should intentionally recruit girls, in groups, and develop a critical mass within the classrooms to change the dynamic of the learning environment and begin to shift student perception of who belongs.

Engineering as an elective can limit participation by high-achieving students opting for more rigorous coursework. Framing engineering as one of several career electives, where one might be required, or designing an engineering curriculum so that is at an honors or AP level could increase participation and access to students such as Luna.

6.1.3 For Curriculum Developers

The male-dominated engineering class can be a challenging milieu for even the boldest females who have had success at crossing gender boundaries, such as Madeleine, because routinely doing gender becomes an overwhelming task in an environment where one feels out of place. Robots, racecars, and rockets, typical engineering course materials, are highly gendered items that conflict with many young women's gendered identities. The solution is not to have the students design pink castles or use robots with braids and bows. Curriculum developers should adjust engineering curricula to be attractive and interesting to all masculine and feminine identities. If young women feel a gender role conflict in high school engineering, then they should be allowed a safe space to display their gender through their work. This can be facilitated via projects that allow for creativity and personalization.

6.1.4 For Educators

In lists of recommendations such as this, it may seem as though most of the responsibility falls on the teacher's shoulders. This list is not one resulting from existing wrongdoing, but rather based on all of the things being done right. Teachers consistently have more face time with students than counselors, and certainly administrators, and thus the greatest opportunity to influence a child's life and trajectory. Almost 7 out of 10 female STEM college students say that a teacher or K-12 class was the top factor that sparked their interested in STEM (Harris Interactive, 2004). Teachers can make a tremendous difference in the lives of students.

Creating an equitable learning environment for every student means not allowing one group to overpower the classroom. No student, particularly those underrepresented in an engineering context (females, students of color, non-heterosexuals), should be forced to learn in an abrasive environment where the demonstrations of masculinity constantly oppress their existence and identity. For example, Charlie experienced hidden aggression from a female group-mate, but she did not feel empowered to tell the teacher or provide honest evaluation. Educators can work to create a safe space that invites respectful interaction and open communication and discourages passive-aggressive behaviors, particularly among females. Teachers need effective tools for dealing with these types of oppressive behaviors.

The implicit biases of teachers will be exhibited in discourse and behavior in the classroom and can create a set of unspoken rules and expectations. In Max's case, and for others in this study, Mrs. Jones's belief that her female students are more organized and perfectionistic than her male students, and that the females should "keep the boys in check," fosters an expectation that the "girls should babysit the guys." Educators must be careful to not place expectations on any group of student to be responsible for another, particularly one that perpetuates gender stereotypes and creates unnecessary power differentials in the classroom. In conjunction, by recognizing that young women will struggle with unwritten rules of femininity and by creating a classroom culture that encourages them to have a voice, lead their teams, and offer feedback without the fear of being disliked, educators can help advance young women—particularly in the male-dominated engineering classroom. Better facilitation of group roles, such as ensuring equitable hands-on time, and even assigning group roles that challenge stereotypes (woman as leader/hands-on, man as note-taker), can improve group interactions and avoid traditional gender roles of power and deference, and therefore improve the female student's learning experience in engineering. Teachers can be more intentional in their team design to facilitate learning and discourage gender segregation.

Even as adults, we can struggle against stereotypes and norms for our gender, race, class, and sexuality. Some of these struggles may be exhibited by strong dislikes, fears and anxieties, and we must be cautious to not transfer our fears to our students. Such fears could be demonstrated teaching a lesson with a stack of papers in our hands and sweat on our brows or by making sweeping comments such as "I'm not good at math." One way to avoid the effects of these interactions, or transferring anxiety, is to teach educators about a growth mindset, have them teach students about a growth mindset, and then have them hold one another accountable for discourse and behavior that suggests otherwise. Such an exercise challenges the normal power structure in a classroom, in which the teacher is the all-knowing being, and creates instead an environment that encourages and supports lifelong learning. In addition, the attribution of success to learning through the effort required removes some of the pressure from stereotype threat that young women feel.

Labeling—particularly dichotomous labels, such as good/bad, smart/struggling, etc.—should be avoided at all costs in the classroom because they create barriers to an equitable learning environment (such as in Cathy's class). Labels, by students or teachers, lead to bias and inequitable treatment. Students will naturally create a social order, but it should not be prompted or intensified by inequitable messages from the teacher.

Conversely, omission can also be a problem. Mrs. Jones often addressed the males in the class, omitting the females. (See the story shared about attire for the final presentations.) When a teacher addresses just the young men in a male-dominated class, then he or she is compounding a message that the young women do not belong. In an engineering environment, this is the opposite message we want to send to young women. Ensuring that teachers equally address the needs of both genders can help eliminate the effects of omission on the self-efficacy of females in an engineering environment.

While this study focuses on high school aged young women, the recommendations may also apply to professors and other educators in higher education or other settings.

6.1.5 For Professional Development Designers

Educators are not alone. There are tools, professional development, and training that can provide them with the information and motivation needed to help every student consider engineering. Developers of these resources can equip educators with tools to deliver effective messaging, create equitable learning environments that address the needs of every student, recognize implicit bias and resulting micromessages, recruit diverse role models to challenge stereotypes, and broaden student understanding of all of the options and opportunities available in engineering.

6.2 Limitations

The experiences of these nine young women are transferable to others students of similar backgrounds. The intent of this work is not to make generalizations about all young women in engineering. Rather, my hope is that their experiences can be transferable to assist in understanding the stories and voices of others not normally heard.

In addition, I feel a responsibility to note my struggle to find the intersections of race with the other axes of identity. Although I have come a long way from my upbringing in a rural white community know for racism, my white privilege and complete lack of awareness of race relations dulls my ability to determine how the race of seven of the nine participants truly plays a role in their experiences as white students. As members of the dominant race in the class, school, community, and state, the privilege that those seven white students, the teacher, and I carry in our invisible knapsack full of unearned assets (McIntosh, 1988) inevitably plays a significant role that will remain inadequately documented in this study. May it also be noted that my awareness and empathy for gender, race, class, sexuality—and intersectionality of these issues—have been transformed by this experience, and I will truly never be the same.

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APPENDICES

Appendix A Contributors

Author, Meagan Pollock

Meagan Pollock is dedicated to educating and empowering others to succeed. Her personal goal is to improve equity, access, and diversity in education and the workplace. Meagan is a National Science Foundation Graduate Research Fellow and PhD graduate of the School of Engineering Education at Purdue University. Meagan worked as an engineer for Texas Instruments, including three co-op rotations, before returning to school to earn her doctorate. She has earned a B.S. in computer science from Texas Woman's University and an M.S. in electrical engineering from Texas Tech University.

As a consultant, Meagan enjoys working for both the nonprofit and private sectors developing curriculum, programs, and conducting research. Meagan has been designing and facilitating professional development workshops for counselors and educators on topics of engineering, STEM*, and gender equity since 2008, for organizations such as High Tech High Heels and the National Alliance for Partnerships in Equity. In addition, Meagan has developed integrated STEM curriculum for Learning.com, and Scientific Minds, and worked as a research consultant for Texas Instruments Education Technology in exploring the K-12 engineering education market opportunities.

As a researcher, Meagan's work is focused on closing the gender gap in engineering, improving STEM career counseling, equipping STEM professionals to be role models, and providing equity training for educators.

Upon graduation, Meagan begins a new position as the Director of Professional Development for the National Alliance for Partnerships in Equity, responsible for developing products and services.

Motivation & Bias

As a grade school student, I loved math, science, and problem-solving, but never pictured myself pursuing a career based on this foundation. Like many young girls, I lacked the confidence, interest, and awareness necessary to pursue a career in engineering. Academically strong in all subjects, I considered various careers, but never engineering, largely because I knew nothing about the field—a very common problem for students (Cunningham et al., 2005). I finally decided on interior design as my major and registered for college. However, late in my senior year of high school, I learned of an opportunity to pursue a career in engineering, and it came with a full scholarship for undergraduate school, graduate school, and paid internships in industry. With significant financial need, I applied for the program, was accepted, and changed my trajectory, although I was still uninformed and unfamiliar with the field of engineering. Given my experience in grade school, and throughout my life, it is my personal objective to ensure that every student be exposed to engineering, that all girls consider engineering as a potential career choice, and that gender bias in STEM become nonexistent.

I adopted a changing observational role, which is an adaptation of participant to non-participant observer based on the situation (Creswell, 2008). As a participant observer, it was often advantageous to interact to consider experiences from the views of participants. Vice versa, at times it was advantageous to watch and record a phenomenon. In order to dissuade a power structure between researcher and student participants, I encouraged the young women to see themselves as contributors to the research rather than subjects of the research.

Doctoral Committee

The Doctoral Committee for Meagan Pollock consists of five members. Three are faculty members in the School of Engineering Education at Purdue University, and two external members were invited to the committee for their expertise and varying perspective. Monica Cardella is the Committee Chair and Advisor. Listed in alphabetical order: Dr. Richard Gale, Dr. Alice Pawley, Dr. Senay Purzer, and Dr. Susan Walden.

Dr. Monica Cardella, Purdue University

Dr. Monica Cardella has a Ph.D. in industrial engineering from the University of Washington, an M.S. in industrial engineering from the University of Washington, and a B.S. in mathematics from the University of Puget Sound in Tacoma, Washington. Prior to her appointment at Purdue, Dr. Cardella was a CASEE (Center for the Advancement of Scholarship in Engineering Education) postdoctoral engineering education researcher at Stanford University. Her research interests include engineering design thinking, mathematical thinking, visual thinking, P-12 engineering education, and user-centered design.

Dr. Cardella is an Associate Professor of Engineering Education and the Co-Director of Assessment Research for the Institute for P-12 Engineering Research and Learning (INSPIRE) at Purdue University. She has more than a decade of experience conducting research related to engineering education in both formal and informal settings using qualitative and quantitative research methods. Some of her recent work includes an examination of parents' efforts to help their children learn about engineering (Zhang & Cardella, June 2010).

Dr. Richard Gale, Texas Tech University

Dr. Richard Gale is highly engaged in K-12 engineering education outreach through robotics programs, and he has tirelessly worked to increase the participation of females in engineering through these activities. He has worked with BEST (Boosting Engineering, Science, and Technology), GEAR (Get Excited About Robotics), and FIRST (For Inspiration and Recognition of Science and Technology) for almost 10 years. Dr. Gale was invited to the committee for his experience increasing student engagement in engineering education.

Dr. Gale held the position of Distinguished Member, Technical Staff, at Texas Instruments and was responsible for coordinating the work of the New Applications Research and Development Group in the Technology Development section of Digital Imaging at Texas Instrument Incorporated until retirement in April 2001. Currently, he is the Associate Chair of Graduate Studies, Associate Dean of Undergraduate Studies, and Professor of Engineering at Texas Tech University, where he served as Meagan's advisor for her M.S. in electrical engineering from 2006 to 2007.

Dr. Alice Pawley, Purdue University

Dr. Alice Pawley has a Ph.D. in industrial engineering and a minor in women's studies from the University of Wisconsin–Madison, an M.S. in industrial engineering from University of Wisconsin–Madison, and a B.Eng. in chemical engineering from

McGill University. Her research interests include engineering epistemology, history of engineering education, feminist science in technology studies, and gender, race, and class in engineering education.

Dr. Pawley is an Associate Professor of Engineering Education and leads the Feminist Research in Engineering Education (FREE) group at Purdue University. Some of her recent work includes examining women's career pathways into and through academic faculty levels in STEM disciplines and characterizing how gender is represented in engineering education journals.

Dr. Şenay Purzer, Purdue University

Dr. Şenay Purzer has a Ph.D. in science education from Arizona State University, a M.A. in science education from Arizona State University, a B.S.E. in engineering with a concentration in mechanical systems from Arizona State University, and a B.S. in physics education from Hacettepe University in Turkey. Her research interests include the role of group argumentation in design, the relationship between self-efficacy beliefs, team interactions, and student achievement, student interactions in teams that are diverse in terms of gender and ethnicity, and P-12 engineering education.

Dr. Purzer is an Assistant Professor of Engineering Education and the Co-Director of Assessment Research for the Institute for P-12 Engineering Research and Learning (INSPIRE) at Purdue University. Some of her recent work includes examining the relationship between discourse, learning, and self-efficacy.

Dr. Susan Walden, University of Oklahoma

Dr. Susan Walden is a multi-dimensional researcher with 10 years' experience as project director and investigator using ethnographic-based mixed-methods to examine cultures of engineering education, as well as 20 years of experience in K-12 science and engineering education. Dr. Walden was invited to the committee for her expertise in examining the experiences of the underrepresented in engineering using qualitative research methods.

At the University of Oklahoma, Dr. Walden holds four relevant roles: Associate Director of the Sooner Engineering Education Center, Founding Director of the Research Institute for STEM Education, Associate Research Professor of Engineering, and Coordinator of Undergraduate Research.