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The Perceptions of Female High-School Students Regarding Their Engineering Self-Efficacy

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Concordia University–Portland

College of Education

Doctorate of Education Program

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The Perceptions of Female High-School Students
Regarding Their Engineering Self-Efficacy

Joyce Ellen Russo
Concordia University–Portland
College of Education

Dissertation submitted to the Faculty of the College of Education
in partial fulfillment of the requirements for the degree of
Doctor of Education in
Transformational Leadership

Mark Jimenez, Ed. D., Faculty Chair Dissertation Committee
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Concordia University–Portland

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Abstract

The purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. To answer the guiding research questions, female students were asked to complete a survey to gather data on their described perceptions. Ten randomly selected students also participated in a study interview, and student artifacts were viewed to better understand the student experience with the engineering practices of the Next Generation Science Standards. Science teachers at the study-site high school were also interviewed to gather data on teacher perceptions of the learning experiences of this student sample. The data revealed that the engineering self-efficacy of the participating students was self-rated at an average to high level. However, the science self-efficacy of these students was self-rated at a high to very high level. The students were engaged in the classroom engineering tasks because they were challenging, hands-on, involved, and required the students to think about their learning. The students expressed that engineering lessons were not taught with sufficient frequency and they did not understand the role of engineers within the workplace. The teachers participating in this study noted that their female students were engaged in the engineering lessons; however, insufficient time was available throughout the school year to present real-world engineering scenarios.

Keywords: NGSS, engineering practices, self-efficacy, high school

Dedication

This dissertation is dedicated to my father, William McAdam. He passed away during the third year of this doctoral journey. He was my guiding light throughout my life.

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I would like to acknowledge Dr. Mark Jimenez, Faculty Chair, for his guidance throughout this research and study documentation. I also thank Committee Members Dr. John Yoder and Dr. Jennifer Keeley for providing meaningful feedback and guidance. Thank you for helping me make this dream a reality. The collaborative bond created on this journey among myself and Dr. Tammy Jones and Shawna Little was invaluable. Words cannot express the extent of my appreciation for your support and, most importantly, your friendship.

Unending gratitude is extended to my husband, Tony Flagor. I have wanted to earn my doctorate since graduating with a bachelor’s degree in 1988. Thank you for supporting this formidable goal and allowing me to achieve my dreams. I spent countless hours “glued” to my computer. Rather than complaint, you provided only encouragement to keep moving forward. Earning my doctorate would not have been possible without your support. I also thank my children. I have always taught you to do your best in whatever you choose to do. You followed this instruction and I am so very proud of you.

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Chapter 1: Introduction

As early as the 1950s, E. C. Barth reported that women were not entering the field of engineering at a rate expected to support the future U.S. workforce needs (as cited in "Women in Engineering," 1957). Out of 120,000 graduating engineering students in 1956, only 62 were women. Although this number has increased since 1956, the ratio of male to female engineering graduate-school enrollees and working engineers remains below the respective demographic gender distributions (Buse, Hill, & Benson, 2017; National Science Board [NSB], 2018; National Science Foundation [NSF], 2017; U.S. Bureau of Labor Statistics, 2016). Women typically enter the workforce in fields that do not require math or engineering skills (Betz & Hackett, 1981; NSF, 2017). Although researchers have been discussing this phenomenon for decades, the numbers have not equalized (Buse et al., 2017).

The purpose of this current case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. Self-efficacy research has been conducted with samples of secondary-level students (Fouad et al., 2010; Garriott et al., 2014; Lopez, Lent, Brown & Gore, 1997); however, a dearth of study is available on the specific topic of the current research. The findings of this study might increase educator understanding as to why female high-school students do or do not choose to continue with postsecondary education in engineering.

Background

As noted earlier, statistics have shown that women do not choose to enter the field of engineering as often as men (Buse et al., 2017; NSF, 2017; U.S. Bureau of Labor Statistics, 2016). Older female students also tend to choose career paths considered more traditional for their gender (Novakovic & Fouad, 2012). Younger female students (i.e., postsecondary level and upon graduation) have reported a desire toward careers previously considered nontraditional for women, such as those grounded in math, physics, and engineering; yet, the majority continue to choose a traditional path. This shift may be due to decreased self-efficacy among populations of older female students. However, studies have shown that female students have lower confidence in science, technology, engineering, and/or math (STEM; Bystydzienski, Eisenhart, & Bruning, 2015; Hardin, & Longhurst, 2016; Heilbronner, 2013; Inda, Rodriguez, & Pena, 2013; Novakovic & Fouad, 2012).

The low self-efficacy in female students, coupled with their continued selection of traditional careers, is a concern due to the expected increase in STEM-related jobs (Kildee, 2017; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Women will ultimately need to fill these openings alongside men because women comprise nearly one half of the American workforce pool (U.S. Bureau of Labor Statistics, 2016). One causal factor for creation of the Next Generation Science Standards (NGSS) was to inspire a more diverse group of students to enter science and engineering careers (National Research Council [NRC], 2012; NGSS Lead States, 2013). The standards were written to include all races and genders (Januszyk, Miller, & Lee, 2016; Lee, Miller, & Januszyk, 2014; NGSS Lead States, 2013).

The NRC (2012) and the NGSS writing team (NGSS Lead States, 2013) included engineering practices as one of the dimensions of learning targeted for increasing interest and knowledge in the development of engineering skills. This is significant because engineering standards were not included in past K–12 science education (Moore, Tank, Glancy, & Kersten, 2015). Students attending schools in states that have adopted the NGSS will now be presented with opportunities for engineering learning experiences. Such experiences are important to building an understanding of the role of engineers within the workplace (Bybee, 2011; NRC, 2012; NGSS Lead States, 2013; Page, Lewis, Autenrieth, & Butler-Purry, 2013) and increasing the self-confidence of students in their engineering skills.

Bandura (1977, 1986) theorized that positive learning experiences and support from others lead to increased self-efficacy. Lent, Brown, and Hackett (1994) applied this Bandura notion to academic and career choices in conjunction with social cognitive career theory (SCCT). Self-efficacy was found to be a variable leading to interest, goals, and persistence. In studies with college-level samples, the investigators have found self-efficacy to be a factor in determining engineering interest (Flores et al., 2014; Inda et al., 2013; Lent et al., 2005; Lent et al., 2013; Novarro, Flores, Lee, & Gonzalez, 2014) and persistence (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2015). SCCT has also been applied to samples of secondary-level students (Brown, Concannon, Marx, Donaldson, & Black, 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997).

Statement of the Problem

The application of SCCT has indicated that positive engineering learning experiences are important for college-level female students to foster self-efficacy and interest in this field. Engineering practices were incorporated in the NGSS to increase the number of students interested in science and engineering (NRC, 2012; NGSS Lead States, 2013). As noted earlier, research has also been conducted on the self-efficacy of secondary-level students attending STEM classes (Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997); however, curriculum aligned with the NGSS was not utilized. Researchers have examined the attitudes and engagement of students with curriculum designed to parallel the NGSS; however, the students only participated in the program for a brief period (Brown et al., 2016; Kim, 2016). Further study was needed on the engineering self-efficacy of female high-school students learning with curriculum aligned to the NGSS. Gaining a clearer understanding in this area of study held potential for increasing the number of female students choosing to enter the field of engineering.

Purpose of the Study and Research Questions

As introduced earlier, the purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. The findings contribute to a clearer understanding of how these female students perceive their own self-efficacy after engaging in engineering-practice lessons in science. The following research questions guided this study:

1. How do female students attending an Oregon high school perceive their self-efficacy in engineering?
2. What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?
3. How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?
4. Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?

To answer the guiding research questions, a small group of students participated in a survey and a few of these students participated in a study interview. Additionally, a small group of teachers participated in an interview. Students artifacts were collected to also contribute to answering the research questions.

Rationale, Relevance, and Significance of the Study

The topic of the current study was important to examine for several reasons. First, the number of positions within the U.S. workplace involving knowledge and skills in STEM is expected to continuously increase (Kildee, 2017; Langdon et al., 2011). This rise is due to the ongoing demand for increasingly innovative and creative technology (NSB, 2018). Therefore, the number of students in the United States entering college with the intent to study engineering must increase proportionately to fill the expected number of future science and engineering positions. Gaining a clearer understanding of the engineering self-efficacy of female secondary-level students may lead to increasing the ultimate number of women interested in the field of engineering. Secondly, the NRC (2012) recommended changes to science standards and how science is taught within K–12 classrooms and the NGSS were created from these recommendations (NGSS Lead States, 2013). No studies have examined the self-efficacy of secondary-level female students with regard to engineering after their engagement in NGSS-aligned curriculum for an extended period of time. The delay in research could be due to individual states needing to adopt the NGSS as their guiding standards. Additionally, school districts must approve new curriculum and teachers must learn the standards and be trained on their use before students can experience the engineering-practice dimension of the NGSS.

Oregon adopted the NGSS in the spring of 2014 (Oregon Department of Education, n.d.). The school district involved in this case study began training their teachers on use of the standards in 2015. The teachers subsequently aligned the curriculum to the NGSS for the 2016–17 academic year. Oregon students have had two or more years to participate in lessons designed with the three dimensions of learning including engineering practices.

Definition of Terms

Engineering practices. Students attending K–12 classes learn science content involving three dimensions of learning. One dimension includes science and engineering practices. Science practices allow students to engage in science at a deeper level. The engineering practices include defining problems, developing models, planning and conducting investigations, examining related data using math skills, designing solutions, and augmenting and communicating results (NGSS Lead States, 2013).

National Research Council (NRC). The NRC is a department within the National Academy of Sciences and National Academy of Engineering. This council made recommendations for new science standards in K–12 curriculum allowing for a deeper understanding of specific science content and practices (NRC, 2012).

Next Generation Science Standards (NGSS). The NGSS are performance expectations in K–12 science. The standards were created collaboratively by known scientists with the intent of providing foundational goals for all students. The intent was to inspire more students to appreciate science and continue its study beyond high school (NGSS Lead States, 2013).

STEM. STEM is the acronym used in this study for science, technology, engineering, and/or math. STEM learning is the integration of four domains using low and high critical-thinking skills (Louis, & Seifert, 2013).

Self-efficacy. Self-efficacy is the manner in which an individual perceives their own abilities to accomplish a goal as a result of completing specific actions (Bandura, 1977).

Student engagement. This term describes a student who is involved in work on an emotional, behavioral, and cognitive level that produces activation and self-pleasure (Balwant, 2016).

Assumptions, Limitations, and Delimitations

A criterion for student participants in the current study was two or more years' of school attendance within the district selected for its curriculum aligned with the NGSS. There are multiple districts within the chosen area and, depending upon the age level of the students, multiple instructional possibilities for instructors. It was assumed that all teachers taught curriculum aligned with the NGSS with fidelity and modified lessons to help students meet the new performance expectations. It was also assumed that students completed the self-reported survey with integrity.

This study was limited to a specific city, school, and student population. The city wherein the study was conducted did not present a diverse population. Consequently, the population at the study-site high school was not a typical diverse sample of ethnicities and races representative of schools across the country. However, it did represent a typical student sample for Oregon. The case was limited to one high school, and male students were purposely excluded from the study due to the focus on the engineering self-efficacy of female students. The research further focused on self-efficacy resulting from the learning experiences that contributed to the views of the participating students.

Chapter Summary

Self-efficacy is influenced by successful learning experiences (Bandura, 1977, 1986; Hackett & Betz, 1981) and, in turn, career choice is influenced by self-efficacy (Lent et al., 1994). This case study examined the self-perceptions of female students attending an Oregon high school with regard to their engineering self-efficacy. The research is an in-depth analysis of the views and experiences of 10 students and those of their science teachers. The curriculum of the study-site school has been aligned to the performance expectations of the NGSS since the

2016–17 academic year. Examination of the engineering self-efficacy of female high-school students was important due to its potential for increased understanding of why members of this population of students do not tend to ultimately choose further study and/or careers in engineering. An in-depth examination of pertinent related literature is highly germane to this topic.

In Chapter 1, I provided a brief history of the problem under study. The problem statement, purpose statement, research questions, rationale, definition of key terms, and the assumptions, delimitations, and limitations were also presented. Chapter 2 provides an in-depth examination of pertinent literature. A detailed description of the methodology is provided in Chapter 3 and the data analysis and results of the study are presented in Chapter 4. Chapter 5 provides insights gained from the results along with recommendations for future research.

Chapter 2: Literature Review

Overview

The focus of this literature review is to identify and discuss the development of social cognitive career theory (SCCT) to show how different variables of this theory influence the decision to pursue an engineering career and to examine how learning experiences and support influence self-efficacy (Lent et al., 1994). Specifically, this review examines how learning experiences in STEM courses play a role in the self-efficacy and attitudes of female students toward engineering as a career choice. Articles from peer-reviewed journals, dissertations, government reports, and books related to the current study are reviewed in the examination. Publication within the 12 years prior to the onset of the current research was a focus in their selection. However, earlier articles were also considered relevant for historical purposes and to gain an understanding of SCCT and the NGSS.

SCCT has its origins in the Bandura (1977) social learning theory and the Bandura (1986) social cognitive theory. Lent et al. (1994) postulated that students choose an academic program or career based upon their self-efficacy, expected outcome, interest, and goals, as well as the actions required to pursue a given profession. Researchers have since applied SCCT to many career paths. This literature review includes studies that were designed to investigate the variables of SCCT with students studying engineering at the college level (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014), as well as with students studying STEM at the secondary level (Brown et al., 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997). Based upon SCCT, learning experiences in K–12 science courses are expected to influence student self-efficacy and attitude toward engineering.

Study Topic and Context

The topic of this current study is the perceptions of female high school students with regard to their engineering self-efficacy after participating in curriculum aligned to the performance expectations of the NGSS. The results are important to gaining a clearer understanding of why members of this student population do or do not ultimately choose to progress toward an engineering career. This notion is supported by Lent et al. (1994) who postulated that self-efficacy plays a significant role in determining a career path. Researchers have found that female students are less likely than their male counterparts to believe they would complete an engineering program (Inda et al., 2013; Litzler, Samuelson, & Lorah, 2014).

Research conducted by Litzler et al. (2014) and Inda et al. (2013) corroborated the findings of Betz and Hackett (1981) that female students have not traditionally chosen careers grounded in math and engineering skills. To increase the number of female students reaching the field of engineering, the NRC (2012) created recommendations for science standards that include engineering knowledge and skills. The new standards provide all students opportunities to develop engineering skills (Januszyk et al., 2016; Lee et al., 2014; NGSS Lead States, 2013). K–12 science teachers create lessons and experiences for students based upon state and national standards. However, most states have not incorporated engineering standards into K–12 science curriculum (Moore et al., 2015). This motivated the NRC (2012) recommendations for science education within the United States.

The NGSS followed the lead of the NRC (2012) recommendations by including engineering practices in the standards (NGSS Lead States, 2013). Their purpose was to prepare students for a more technologically advanced nation and careers in the sciences (NRC, 2012). On March 6, 2014, the Oregon State Board of Education adopted the NGSS as the official K–12 science standards across the state (Oregon Department of Education, n.d.). Oregon students will be assessed in science based upon the new standards in the 2018–19 academic year. The delay in testing was to give Oregon school districts time to implement new curriculum and train teachers on the NGSS. Teachers participating in this study were involved in "hands-on" engineering learning experiences since the 2015–16 academic year.

Significance and Problem Statement

The significance of this study is the potential gain in understanding surrounding the impact of the NGSS on the self-perceptions of female high-school students with regard to their engineering self-efficacy. The collected data provided information allowing discussion to continue on improving the attitudes of female students toward engineering. It is hoped that these discussions will lead to an increase in the number of female students with an interest in pursuing engineering as a career within the United States.

With the support of teachers, the NRC (2012) published education guidelines to stress the importance of meaningful engineering experiences to increase student understanding of, and interest in, engineering that "mirrors" real-world experiences. The intent of the creation of the NGSS was to give all students a rigorous, well-rounded science education that would prepare them for a career in science or engineering or related higher education (NGSS Lead States, 2013). Use of the word "all" is important. Female students were identified as "underserved by the educational system" with regard to science (p. 1). Data indicate that women do not choose a career in engineering as often as men (Buse et al., 2017; NSB, 2018; NSF, 2017; U.S. Bureau of Labor Statistics, 2016). One NRC (2012) goal was to diversify the pool of potential employees trained and educated in engineering.

Researchers have examined student self-efficacy after engagement in curriculum inspired by the NGSS for a short period of time (Brown et al., 2016; Kim, 2016). Participating students demonstrated higher self-efficacy and stronger attitudes toward engineering upon conclusion of the studies. However, the perceptions of female high-school students with regard to their self-efficacy in engineering after engagement in lessons grounded in the engineering practices of the NGSS for two or more years was unknown. Research was needed in this area of study.

Conceptual Framework

The United States is more complex and technological in nature than it was in the 20th century. A multidisciplinary approach to STEM may be necessary to solve the resulting complexity (Roehrig, Moore, Wang, & Park, 2012). By 2024, STEM-related jobs across the country are anticipated to increase by 17% (Kildee, 2017). It will take the entire workforce pool to cover this increase. Based upon these numbers, women will need to enter careers they have not traditionally chosen to eliminate the shortage.

Women comprised 44.3% of all U.S. wage earners in 2016 (U.S. Bureau of Labor Statistics, 2016). However, this statistic grossly distorts the quantity of women working within the field of engineering. The U.S. Bureau of Labor Statistics (2016) reported that only 14% of these 2016 wage earners were women employed in architecture and engineering. Although the number of females entering the field of engineering has increased, the numbers continue to reflect that women are not choosing engineering careers as often as men (Buse et al., 2017; NSB, 2018; NSF, 2017; U.S. Bureau of Labor Statistics, 2016).

The U.S. economy depends upon increasing the number of students entering STEM careers (White House, Office of the Press Secretary, 2017). Therefore, the country is faced with the task of increasing female interest in the pursuit of an engineering career. The number of women graduating from college has risen; hence, increasing the number who graduate with a STEM degree should be less challenging (Milgram, 2011). This can be accomplished by ensuring quality K–12 education that includes learning experiences in engineering. Recognizing the importance of increasing student interest in STEM-related careers and offering quality K–12 education supportive of this aim, President Trump is committed to ensuring STEM education (White House, Office of the Press Secretary, 2017).

The NRC (2012) addressed engineering education and the NGSS writing team responded by including engineering practices in the standards (NGSS Lead States, 2013). To increase the number of female students interested in engineering, educators must continuously examine the quality of K–12 education, ensuring it is inclusive of engineering exposure. Such evaluation can be effectively performed and successfully instituted by including engineering concepts and practices in lessons and by investigating why female high-school students are not developing an interest in future engineering careers.

Theoretical Framework

Several theoretical frameworks exist for evaluating, predicting, and assessing career and educational choices. SCCT (Lent et al., 1994), social cognitive theory (Bandura, 1986), and social learning theory (Bandura, 1977) are three constructs researchers apply to evaluate such choices for both males and females. Substantial evidence exists to confirm that the application of these models correlates to career choice. SCCT addresses the variables associated with learning experiences and support systems. The conceptual framework of this current research aligns with SCCT because these variables were previously tested and confirmed with engineering and STEM students.

SCCT was conceived from social learning theory (Bandura, 1977) and social cognitive theory (Bandura, 1986). Bandura (1986) explained there are three parts to the personality of an individual that influence each other—traits, behavior, and environment. These three areas interact with each other to create personality. Bandura referred to this interaction as *triadic reciprocity.* For example, intelligence and thoughts are influenced by culture and the environment. The manner in which individuals interpret an experience shapes their environment, behavior, and perception of themselves, which in turn, influences their next experience. The result is self-efficacy in the ability to complete an action (Bandura, 1977, 1986). Lent et al. (1994) and Lent, Brown, and Hackett (2000) hypothesized that these variables also interact to influence behavior and career choice.

The confidence to successfully complete a task is known as self-efficacy (Bandura, 1977). Bandura (1977) identified four components that govern self-efficacy—successful performance of a given task, observing others successfully performing the task, verbal persuasion, and the support or barriers received from others. These four areas work to increase or decrease the overall self-belief in future success. Bandura postulated that low self-efficacy does not begin or remain with a particular difficult task. A task is only begun when success is expected. Bandura referred to this decision process as *outcome expectation.* After additional research, he referred to this finding as social cognitive theory (Bandura, 1986).

Betz and Hackett (Betz & Hackett, 1981; Hackett & Betz, 1981) applied the Bandura (1977) model to career choice and development. These researchers found that the self-efficacy of women was lower in male-dominated occupations, such as engineering and other fields grounded in math, while the self-efficacy of men was lower in traditionally female-dominated professions. Lent et al. (1994) used this information to create a model for career choice. They incorporated the Bandura (1977) self-efficacy theory and the Bandura (1986) triadic reciprocal model of behavior, personal traits, and environmental variables with goals, interest, self-efficacy, and outcome expectations. The results were, in turn, applied to academic and career choices to develop SCCT.

Lent et al. (1994) postulated that learning experiences, personal background information, and support and barriers have an impact on self-efficacy. Self-efficacy and outcome expectations then influence interest and goals, which subsequently impact academic and career pursits. Consequently, the Betz and Hackett (1981) research on career choice, the Bandura (1977) social learning theory, and the Bandura (1986) social cognitive theory collectively led to the development of SCCT (Lent et al., 1994).

Application of Social Cognitive Career Theory

Research has shown self-efficacy to be a powerfully influential variable in career choice (Fouad et al., 2010; Lent et al., 1994). Fouad et al. (2010) advanced that students who believe they are capable and believe they will succeed in a specific task due to their actions become more interested in that particular area of study. Lent et al. (1994) postulated that student self-efficacy and outcome expectations have a direct impact on interest, goals, and academic and career choice. Thus, the level of self-efficacy is an excellent way to predict career choice.

Betz and Hackett (1981) determined that females have lower self-efficacy in nontraditional occupations such as engineering and math. Applying SCCT, female students would not choose to study engineering or math due to low belief in their ability to succeed. This notion correlates with the results of studies that include self-efficacy as a determining factor for persistence in engineering education (Lent et al., 2003; Lent et al., 2013; Navarro et al., 2014). Students must believe they can succeed in a training program and related job duties when making and pursuing a career choice.

Math and science are essential disciplines for engineering students because engineers apply these two subjects daily to design and solve problems. With a sample of adolescent girls, Novakovic and Fouad (2012) found that self-efficacy was a predictor for studying math and science. The girls with high math and science self-efficacy demonstrated a higher probability of choosing a career related to math and science compared to girls with lower self-efficacy. This notion aligns with the findings reported by Betz and Hackett (1981) that females prefer career positions historically filled by females, as well as those reported by Betz (2004) indicating that high self-efficacy correlates with success in math and science.

By applying SCCT, researchers can examine whether external variables, such as support and barriers and academic experiences, impact career choice. Self-efficacy and social support systems have had a positive effect on the persistence of engineering students at the college level (Lent et al., 2016). Teachers, parents, and peers can either be a positive support or a barrier to career development. Maltese and Cooper (2017) determined that teachers have an impact on stimulating the interest of female students in fields grounded in STEM.

The science and engineering practices of the NGSS incorporate opportunities to gain learning experience in engineering and other science disciplines (NGSS Lead States, 2013). Research on SCCT shows that students with positive learning experiences have greater confidence in their abilities and believe they can succeed (Fouad & Santana, 2017). The NGSS include science and engineering practices along with concepts and core disciplinary ideas that help students understand and apply their learning to daily life (NGSS Lead States, 2013). Learning based upon the NGSS is more rigorous, which helps prepare students for college or entry into science-related careers (Lee et al., 2014, p. 224).

Student engagement is necessary for meaningful learning. The intent of the NGSS is for every student to be more involved within the classroom and their own content learning (NGSS Lead States, 2013). Brown et al. (2016) found that middle-school students are less engaged with peers, assignments, and activities, which leads to lower self-efficacy and moderate interest in STEM. College students studying science, engineering, and math demonstrate higher test scores when engaged in active learning (Freeman et al., 2014). The NGSS advocates for positive learning experiences for all students, which could increase the self-efficacy of female students with regard to STEM.

With application of SCCT, researchers can investigate and include several factors that influence students to choose engineering as a career. Lent et al. (1994) contend the existence of a link between self-efficacy, learning experience, and support systems. Therefore, utilizing SCCT in the exploration of engineering self-efficacy in female students engaged in a NGSS-aligned curriculum is an appropriate theoretical framework.

Review of Related Research

Middle school and high school is the time students begin to consider academic and/or career pursuits. A career choice is partially dependent upon self-belief in ability and notions of the nature of a specific occupation of interest (Betz & Hackett, 1981; Lent et al., 1994). SCCT specifies that self-efficacy, background variables, interest in an area of study, outcome expectations, and goals all play a role in student choice toward a particular academic or career path (Lent et al., 1994). Researchers have successfully applied SCCT to samples of college-level engineering students (Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014) and secondary-level STEM students (Brown et al., 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997). It is important to examine how SCCT variables affect these student populations in order to help educators and researchers understand what motivates students toward learning engineering practices and what maintains their interest in related courses, activities, and programs.

Factors Influencing Career Choice

Several factors contribute to the decision process when making a career choice involving STEM. These factors include the rigor of courses in high school, math ability, and gender. They can also impact whether college is even pursued and the field of study chosen. High-school students with high SAT math scores are more likely to enter into physical-science study at the postsecondary level, with the exception of the life sciences (Porter & Umback, 2006). Tai, Lui, Maltese, and Fan (2006) found that math scores did not predict whether a student pursues a life-science degree; however, math aptitude was found to predict if students chose to pursue physical-science and engineering degrees. The Porter and Umback (2006) results agreed with those reported by Tai et al. Female students were found to prefer the study of life or social sciences over math and engineering (Miller, Blessing, & Schwarts, 2006; Porter & Umback, 2006). When students believe they can succeed in math, they are more likely to study fields involving STEM (“For Girls in STEM,” 2015; Wang, 2013).

Differences exist in how female and male students perceive their ability to succeed in particular occupations. This variance may be due to the lower self-confidence of females in nontraditional job roles (Betz & Hackett, 1981). Men have shown the same level of self-efficacy in traditional and nontraditional roles, whereas females have lower self-efficacy in nontraditional careers involving math, such as engineering and drafting, than they do in traditional roles. This may be why women do not choose to enter STEM-related careers. According to the U.S. Bureau of Labor Statistics (2016), more men work in jobs involving math skills than do women.

Additionally, males have traditionally outperformed females in math on the SAT (CollegeBoard, 2011). In 2017, the average SAT score in math for male participants was 538 with 53% meeting the benchmark, compared to 516 and 44% of female students meeting this criterion. Wai, Cacchio, Putallaz, and Makel (2010) analyzed 1,173,350 SAT-M test scores drawn from seventh-grade students located within the southern and midwestern regions of the United States. These researchers found that the majority of scores with a significant difference between males and females were primarily in the top 5%. Wai et al. suggested that additional research is needed to understand causal factors for this variance.

SAT outcomes and gender scoring differences could be a factor in understanding the gender variance in STEM-related careers. Researchers have found a relationship between success in math and science and self-efficacy in these subject areas within samples of secondary-level male and female high-school students of color (Garriott et al., 2014). It is possible that, from a very young age, female students have not had successful experiences in STEM-related areas in order to build a positive belief in their abilities.

Social Cognitive Career Theory

Lent et al. (1994) postulated that self-efficacy has a strong influence on career choice. Novakovic and Fouad (2012) found this to be true in adolescent female students. Heilbronner (2011) concluded that self-efficacy is a factor in whether students persist with STEM, and Wang (2013) found that math self-efficacy influences student choice in terms of pursuing STEM careers. This information is especially relevant for female students. Researchers have found that more female than male students do not believe they can succeed in STEM courses nor achieve a STEM-related degree (Bystydzienski et al., 2015; Hardin & Longhurst, 2016).

The relationship between self-efficacy and other SCCT variables has been studied extensively with samples of engineering students. Researchers have found that self-efficacy beliefs contribute to deterring student interest in engineering (Flores et al., 2014; Inda et al., 2013; Lent et al., 2005; Lent et al., 2013; Novarro et al., 2014). Student persistence in continuing engineering study was shown to be connected to student belief in their own abilities (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2015). In turn, self-efficacy was found to predict both the level of student interest in engineering and whether students believe they can complete an engineering program (Flores et al., 2014; Lent et al., 2003; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014).

Students tend to pursue and remain in an engineering program when they believe they can succeed in the related courses and field. Those with this confidence are more likely to develop a stronger interest in activities associated with engineering because their high level of confidence transfers to their engineering skills (Lent et al., 2003). A lower interest in engineering correlates with women who do not believe they have the ability to attain the skills necessary to complete an engineering program (Litzler et al., 2014). In turn, women with fewer interests in engineering activities outside the classroom are more likely to have a lower interest in engineering classes and engineering as a career (Inda et al., 2013, p. 353).

High self-efficacy demonstrated in STEM courses does not guarantee a student will choose a STEM-related career. Lent et al. (2013) found that students must be interested and experience satisfaction in engineering. However, a prediction of interest can be made through examining self-efficacy (Lent et al., 2013; Lent et al., 2016). Students must believe they can learn the necessary engineering skills in order to build interest in an engineering career. Confidence leads to an interest in engineering. Hardin and Longhurst (2016) found that women demonstrate lower interest in obtaining a STEM-related degree, which correlates with the fact that fewer women currently work within the field of engineering (U.S. Bureau of Labor Statistics, 2016).

Research has shown that students interested in engineering also experience satisfaction participating in engineering activities closely related to real-world engineering tasks conducted on job sites. Increasing self-efficacy increases interest, which in turn, increases the desire to succeed (Navarro et al., 2014, p. 24). However, student belief in their own abilities, belief in a successful outcome, and interest in engineering are not the sole factors involved in choosing engineering as a career. Receiving support from mentors, teachers, peers, and/or family is also an essential factor affecting self-efficacy (Inda et al., 2013; Lent et al., 2003; Lent et al., 2015; Lent et al., 2013).

Lack of support from teachers and parents may play a role in women choosing not to pursue nontraditional work roles (Betz & Hackett, 1981). A clear support system is important because support and barriers influence self-belief in engineering abilities (Inda et al., 2013; Lent et al., 2015; Lent et al., 2013). Social support and barriers can be derived from multiple sources such as parents (Zhang & Barnett, 2015), teachers, and peers (Amelink & Creamer, 2010; Inda et al., 2013). Peers were found to impact the beliefs of individual students in their own abilities (Amelink & Creamer, 2010) and it is evident that conversations with peers persuade choices in women (Litzler et al., 2014). The results of these studies were significant. Engineering programs require students to spend a considerable amount of time interacting with peers through group projects and laboratory testing. A negative or positive peer relationship can significantly influence how students view their engineering abilities and whether they will complete an engineering program.

Educators spend long hours with students. Bystydzienski et al. (2015) found that low-income females who do not feel supported by their professors and peers in an engineering program are more likely to choose majors outside engineering. Nugent et al. (2015) found that teachers play a significant role in whether students choose a STEM-related career. This influence is stronger than peers and family. Educators can either excite or dissuade students from the field of engineering.

In 2014, more than three quarters of technology and engineering teachers within 21 states were male (Moye, Jones, & Dugger, 2015, p. 35). The high number of male K–12 teachers was significant, given that Betz and Hackett (1981) believe that the low self-efficacy of female students could be from an absence of role models, positive experiences, and teacher support. Novakovic and Fouad (2012) found that older students seek traditional roles or careers, compared to younger students who tend to express a desire for nontraditional roles. These researchers postulated that this might be due to the awareness of barriers as students age. Secondary-level students may be more aware of their lack of support as they contemplate their education and career paths.

SCCT can be applied with study samples composed of both male and female students (Lent et al., 1994). Researchers have investigated the impact of support and barriers on both males and females and a difference is evident between genders in how levels of support are perceived. Hardin and Longhurst (2016) reported that male students perceive increasingly greater support as they progress through a school semester, while female students perceive no change in the level of support they receive. The difference in these perceptions could be why female students do not pursue STEM-related careers. Hardin and Longhurst suggested that secondary-level educators intervene before female students enter college to help equalize the percentage of male and female students choosing engineering as an academic and career path. Such intervention at the secondary level may be key to increasing engineering self-efficacy in female students, which in turn, may ultimately increase the number of future female engineers.

Learning Experiences and Next Generation Science Standards

Positive and negative learning experiences have a direct impact on self-efficacy (Bandura, 1977), which subsequently impacts career choice (Hackett & Betz, 1981; Lent et al., 1994). When educators provide students with opportunities for success, it leads to an increase in self-efficacy and a desire to continue. Learning experiences become elements of past performance. Positive past experiences lead to higher self-efficacy (Lopez et al., 1997). In high school, a course schedule plays a role in acquiring learning experiences in engineering-related fields of study.

The type of courses and experiences to which students are exposed in high school affects their future decisions. Knowledge in the disciplines of math, science, and physics are necessary for a career in engineering. Course load and schedule can impact experiences with the potential to move students toward engineering. Long, Conger, and Iatarola (2012) found that students who enrolled in challenging and rigorous high-school courses were more likely to attend college. Kang, Windschitl, Stroupe, and Thompson (2016) reported that students are more engaged in learning when involved in quality, rigorous lessons. STEM programs tend to be chosen by students when college courses are challenging and hands-on, as well as when career choices are made accessible (Heilbronner, 2011). Students need to feel challenged, but not at a level beyond their ability to succeed. When instructors consistently deliver lessons and activities that are challenging, students are observed to cognitively engage the use of scientific skills (Kang et al., 2016), which is necessary for engineers.

Phan (2016) found that enactive learning was an effective vehicle for students to learn and master tasks; it also impacts self-efficacy through learning experiences. Further, student self-efficacy increases, which then motivates students to persist. Enactive and problem-based learning is essential for students to conceptualize and solve real-world problems as engineers (Asunda & Mativo, 2016). When applied in the classroom, Brown et al. (2016) found that students begin to understand the value of STEM as they engage in problem-based learning and thereby strengthen their desire to continue to increase learning in these areas.

According to Bybee (2011), science lessons must involve learning in a manner that runs parallel to the real-world tasks performed by seasoned scientists. Inquiry and science practices improve the attitudes of students, render learning fun, and result in proficient science learners. Kim. Kim (2016) found that the attitudes of female students toward science and related content knowledge improves when science is “fun and exciting” (p. 182). Kim supported an inquiry-based curriculum. Hugerat (2016) also found that students are more positive when they are actively engaged in science, which results in a more favorable climate for both students and teachers. The *doing* of science promotes learning (Bybee, 2011).

History has shown that science teaching within the K–12 academic levels has not included all areas of science (Bybee, 2011). Prior to the introduction of the NGSS, most science curriculums across the nation did not include engineering concepts or even expose students to engineering (Moore et al., 2015). Teachers had little experience and knowledge of engineering tasks within the workplace (Page et al., 2013).

The science- and engineering-practices dimension of learning within the NGSS involve eight practices identified as essential skills for every student (NGSS Lead States, 2013). By including engineering practices and real-world, problem-based learning in the standards, students will improve their knowledge of engineering concepts and their perceptions of the role of engineers within the workplace (Bybee, 2011; NRC, 2012; NGSS Lead States, 2013; Page et al., 2013). They will engage in rigorous science education (Januszyk et al., 2016; Lee et al., 2014), and the learning experience will equip them with the ability to successfully analyze and design solutions to problems faced by the nation (Miller, Januszyk, & Lee, 2015). These experiences hold the potential to build self-efficacy through positive learning experiences and the positive support of peers and teachers.

The NGSS apply to all students (Januszyk et al., 2016). The writing team was tasked with ensuring diversity and standards written in a manner that identified, included, and challenged every student (Lee et al., 2014). The standards recognized females, all races, and students with disabilities (Januszyk et al., 2016; NGSS Lead States, 2013). Their diversity may encourage more female students to develop an interest in nontraditional careers.

According to Lent et al. (1994), self-efficacy and support systems are two variables that significantly influence career choice. As noted earlier, women have demonstrated lower self-efficacy in nontraditional careers (Betz & Hackett, 1981; Novakovic & Fouad, 2012). This could be due to fewer opportunities to learn nontraditional skills (Betz & Hackett, 1981). With the creation and adoption of NGSS, all students engaged in NGSS-aligned curriculum are learning and experiencing engineering practices. This led to the topic of this current study. The focus of this research is to analyze student self-perceptions of self-efficacy in engineering with a small group of female students engaged in NGSS-aligned curriculum at a high school located within Oregon. Whether the engineering practices of the NGSS are changing the self-perceptions of females participating in engineering lessons, as to their self-efficacy in this area of study, is yet to be determined. However, it is known that female students are not choosing engineering as a career (U.S. Bureau of Labor Statistics, 2016) and that learning experiences and support influence self-efficacy (Bandura, 1977, 1986).

Methodological Issues

The methodology applied to research provides structure and function; however, one type may work for one study but not for another. Several factors are relevant to the process of choosing a design for a research project—the problem under study, the past experiences of the researcher(s), and the intended audience (Creswell, 2014). The methodology is essential to improving understanding surrounding a given phenomenon.

The majority of studies included in this review are quantitative in nature; however, a few qualitative and mixed-method studies are presented. Researchers who examined the variables of SCCT with samples of engineering students applied a quantitative research design (Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014). Those who evaluated student learning experiences and perceptions of science lessons were qualitative in design (Bystydzienski et al., 2015; Kang et al., 2016; Roehrig et al., 2012; Zhang & Barnett, 2015). Finally, a few of the studies exemplify a combination of methodologies, which is known as a mixed-method approach (Kim, 2016; Miller et al., 2006; Page et al., 2013). Each study was analyzed and reviewed to determine the best design approach for investigating the engineering self-efficacy of female high-school students while engaged in NGSS-aligned curriculum.

A quantitative approach is appropriate if the researcher desires to test variables and the relationship between variables within a given theory (Creswell, 2014). The variables of SCCT have been examined to confirm the relationship among all components. Robert Lent (Lent et al., 1994; Lent et al., 2000; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013;

Lent et al., 2016); Gail Hackett (Betz & Hackett, 1981); and Nancy Betz (Betz, 2004; Betz & Hackett, 1981) conducted much of the initial research. Since 2005, Robert Lent; Lisa Flores (Flores et al., 2014); Hang-Shim Lee (Lee et al., 2014); Nadya Fouad (Fouad et al, 2010; Fouad & Santana, 2017; Fouad, Smith, & Enochs, 1997); and Rachel Navarro (Navarro et al., 2014) have actively published research on the variables involved in SCCT to improve the understanding of career choices.

A quantitative approach has been useful in confirming the impact of the following factors on student career choice: self-efficacy (Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014); support and barriers (Inda et al., 2013; Lent et al., 2015; Lent et al., 2013; Litzler et al., 2014); and interest (Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014). The sample populations recruited for the related studies were composed of engineering students at the university level. Although the data collected provided valuable information on career choice, the quantitative data were not able to identify how or why the variables influenced student choices. These students may have possessed higher self-efficacy, which may have been why they were already participating in STEM courses or an engineering program.

When questions lead researchers to an understanding of a phenomenon or occurrence, a qualitative method was applied. Both reader and researcher gain insight into participant views and the meaning behind a problem through a qualitative approach (Creswell, 2014). The individual voices in qualitative research are as impactful as the numbers in quantitative study. Each word contributes meaning, clarity, and understanding to a phenomenon, and the words of the participants are data. Very few qualitative research studies are included in this literature review. A significant portion of the reviewed studies include examination of the variables of

SCCT as they relate to engineering. Quantitative studies are also presented to show that SCCT is valid for research involving engineering students.

The writing team completed the NGSS in 2013 (NGSS Lead States, 2013), which explains the limited teacher and student experience with the engineering practices of the standards at the onset of the current study. Researchers have had insufficient time to collect qualitative data on learning experiences from teachers and students. Depending upon the state and school district, some students have now had two or more years' experience with the engineering practices of the NGSS.

Although limited in number, the qualitative studies reviewed offered valuable information for the current research. Studies on student engagement (Bystydzienski et al., 2015; Kang et al., 2016) and a STEM-related career choice (Zhang & Barnett, 2015) allowed for deeper understanding due to the rich and descriptive details of participant viewpoints. For example, the Zhang and Barnett (2015) interviews provided an understanding of how parents and peers influence student career choice. Students offered descriptive details of how others deliver support for their career decisions. The students who chose to pursue careers in the sciences received a greater amount of information related to different types of science careers, compared to those who did not choose STEM-related careers. The Zhang and Barnett data revealed that students are more confident with regard to their career choices if made during parental communication. Unfortunately, the study sample was composed of only five participants, which is small in comparison to studies applying a quantitative design. However, the findings hold potential for researchers to come to a clearer understanding of trends or patterns among the broader population of students.

A few investigators of studies reviewed for this current research were led to select a mixed-method design. They collected both quantitative and qualitative data using surveys, questionnaires, and interviews. Miller et al. (2006) conducted research on male and female science-course preferences and uncovered a degree of differences between genders through the use of closed-ended questions. Participating students also responded to five open-ended questions to provide their opinions on the difference between male and female science students. The qualitative data revealed that the indifference or lack of desire to pursue certain sciences noted in female students is not due to the degree of difficulty, but rather, to lack of interest. The qualitative data helped to explain the quantitative data; thus, the two sets of data led to a better understanding of course preferences. Although informative, applying both design methods led to smaller sample sizes compared to a purely quantitative design method. However, it would have been time consuming and unrealistic to interview and analyze hundreds of open-ended questions. Creswell (2014) suggested that a mixed-method design can be challenging due to the need to collect two sets of data.

Depending upon the research questions and research site, each methodology type presents advantages and disadvantages. Investigators must consider their research goals prior to the onset of a study. A quantitative design may be more appropriate compared to a qualitative method in some circumstances, while qualitative study may be more appropriate in other research situations. The advantages and disadvantages of each design approach must be examined on the front end of any research. Ultimately, the investigator chooses the design method that best fits his or her aim, the type of data to be collected, and where the study will be conducted.

Now that the majority of teachers in this region of Oregon have been teaching science with the NGSS inclusive of engineering practices for two years and students have had time to build learning experiences in engineering content and practices, it was useful to examine whether these experiences influenced the perceptions of female students with regard to the field of engineering. It was also useful to draw teacher perceptions of student engagement in the engineering-practice lessons and to learn how students view their engineering abilities. Case study allowed this type of data to be thoughtfully collected.

Synthesis of the Research Findings

Social Cognitive Career Theory

Choosing an academic program supporting a career path is a significant decision for students. Applying SCCT, social scientists have investigated multiple variables to determine which factors influence male and female students to study engineering and take on math-related majors. Researchers have conducted these studies at the college level (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014), as well as the secondary level (Brown et al., 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997). Each confirms high self-efficacy as a factor in determining goal achievement (Flores et al., 2014; Lent et al., 2003; Lent et al., 2005) and sustained interest (Flores et al., 2014; Lent et al., 2003; Lent et al., 2005; Lent et al., 2013).

The SCCT model has been useful in research with samples of both male and female students pursuing careers in engineering or other math-related fields (Betz & Hackett, 1981; Hardin & Longhurst, 2016; Heilbronner, 2013; Inda et al., 2013, Novakovic & Fouad, 2012). A few of the studies found a difference in self-efficacy between genders. Inda et al. (2013) reported that female engineering students believe they are less capable of completing an engineering program. Hardin and Longhurst (2016) also found lower self-efficacy in female STEM students compared to male. These results are similar to the Betz and Hackett (1981) and

Novakovic and Fouad (2012) findings of women with lower self-efficacy in career choices typically considered less traditional for women such as math, engineering, and accounting. Even female students recognized for excellence in science display lower confidence in their abilities. Heilbronner (2013) found that female students rewarded for their success in science through Science Talent Search reported lower self-efficacy than finalists among their male counterparts. This lower confidence of female students in their abilities may be a causal factor for their lack of interest in engineering.

A student with high self-efficacy in math or science does not necessarily pursue a career in engineering; they must also have an interest in the field. Students with both high self-efficacy and interest are more likely to continue in an engineering program (Lent et al., 2013; Navarro et al., 2014). Motivating female students toward engineering is the challenge within the United States. Female high-school students display little interest in physical science and math but do show interest in life and social sciences (Miller et al., 2006). Interest was the most important criterion for choosing a profession among the finalists of Science Talent Search (Heilbronner, 2013). However, as noted earlier, the female finalists had lower confidence compared to the males, which may have contributed to their lower interest in the field of engineering.

According to SCCT, student support and barriers also affect self-efficacy. Secondary-level students spend approximately 20 hours per month with each of their teachers. Teachers have many opportunities to engage in conversation with their students during that time frame and the interaction can either be positive or negative. When the conversation is supportive, studies have shown that teachers improve the self-efficacy of female students (Inda et al., 2013) and can motivate their interest in pursuing a STEM-related career (Maltese & Cooper, 2017). Bystydzienski et al. (2015) investigated female students of STEM from lower socioeconomic backgrounds. The students perceived they were not receiving support from their professors and peers within the engineering program and chose not to pursue engineering as a career.

Males and females may perceive support and barriers differently. Novakovic and Fouad (2012) suggested that, as adolescent girls age, they become aware of individuals who do not support nontraditional careers for women. Hardin and Longhurst (2016) found a “disconnect” in the perceptions of support at the end of a semester between male and female students. The difference in perceptions could be an attributing factor in career choice.

Learning Experiences and Next Generation Science Standards

An individual will not attempt to pursue a career in engineering with low self-efficacy, even if they understand it will lead to a successful career. Learning experience impacts self-efficacy, which in turn, affects career choice (Lent et al., 1994). Giving female students more chances to improve their science skills can improve self-efficacy. According to Hackett and Betz (1981), success with a task or skill is the most potent predictor of self-efficacy. If students believe they are skilled and successful in engineering learning tasks, they will be more likely to pursue engineering as a career.

The quality and rigor of learning experiences in science are essential to develop a deeper understanding of the content (Kange et al., 2016). Students must feel successful; however, lessons need to challenge them from start to finish. Heilbronner (2011) found that students choose STEM programs when courses are challenging at their current academic levels. If the lessons are too easy, the students will not attribute their ability to success. Bandura (1977) advanced that self-efficacy improves when individuals believe they can accomplish a task because of their ability and not the ease of a task.

The NGSS were created to engage and challenge students in K–12 science education in order to increase their interest level and prepare them for a science-related career (NRC, 2012). Although every student who participates in NGSS-aligned curriculum will not choose a science career, it is the hope that the standards will garner greater interest in STEM-related jobs and, ultimately, greater diversity among related fields of work. The engineering practices included in the NGSS involve skills that engineers use in their daily work activities, allowing students to visualize their real-world activities (NGSS Lead States, 2013). The inclusion of engineering practices signifies a change in the manner in which educators are asked to teach science (Bybee, 2014; Lee et al., 2014; Moore et al., 2015). Prior to the NGSS, 12 states explicitly included engineering concepts in their science standards and 14 states did not include any engineering concepts (Moore et al., 2015). The rigor and inclusion of science and engineering practices prepare all students for a career in science or engineering (Bybee, 2014; Januszyk et al., 2016; Lee et al., 2014; NRC, 2012).

The engineering practices within the NGSS include inquiry and adds other essential elements to understanding science and engineering such as technology and exposure to the routine activities of engineers (Bybee, 2011). Kim (2016) found that attitudes and understanding of science concepts were improved within a group of female middle-school students by utilizing a hands-on technology-based curriculum. Student interest and desire to pursue a career in the sciences also increased. Exposure to engineering helps female students understand that engineers do more than build bridges. Bystydzienski et al. (2015) exposed 131 female high-school students to engineering careers with a program known as Female Recruits Explore Engineering. The percentage of female students interested in engineering improved by 33%. Thus, the exposure to inquiry and science and engineering practices might result in a positive change in the perceptions of female students regarding engineering and increase the number of women interested in its study at the college level.

Critique of Previous Research

As noted earlier, a significant increase in STEM-related positions is expected across the United States (Kildee, 2017). The demand for workers educated in STEM "from all demographics sectors [*sic*] of U.S. society" will increase proportionately (Olson & Riorden-Gerardi, 2012, p. 2). Educators must understand why women do not pursue careers as engineers. Through the application of SCCT, it has been found that student belief in their own abilities, expected outcome, personal ambition, and a support system influence the decision to enter or remain in engineering study at the college level (Inda et al., 2013; Lent et al., 2003; Lent et al., 2005; Lent et al., 2015; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014), as well as STEM students at the secondary level (Brown et al., 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997). This data provides useful insight into why women do or do not choose to study engineering.

Bandura (1977) posited that positive experiences increase self-efficacy. As noted earlier, the NGSS include engineering practices that provide students with knowledge related to the real-world activities of engineers (NGSS, Lead State, 2013). Kim (2016) investigated the attitude change of female students following participation in an inquiry science program inspired by Bybee (2014) who was on the NGSS writing team (NGSS, Lead State, 2013). The attitudes of these students toward science significantly improved after their program participation (Kim, 2016). However, the study was conducted within a modern university with access to the most up-to-date equipment and supplies. Students experienced the lives of modern scientists. It is indeed important to increase student excitement toward learning science; however, it is unclear whether the results of the Kim study can be attributed to the inquiry-driven program or the excitement of the learning environment. Many public schools within the United States are not equipped with modern science facilities; consequently, the results may not be replicable in a more typical education setting.

Students participating in the Kim (2016) study were not representative of a typical K–12 classroom of students. They were hand selected based upon teacher recommendations. Kim did not need to differentiate instruction or manage behavioral issues. The opportunity to engage with like-minded students might have had an impact on the results. Teacher input on how the participants were chosen would have provided insight into the type of students in the study sample. Furthermore, teacher perceptions of the attitudes of the female students would have been helpful in order to understand the change before and after program completion. It is unknown as to whether the teachers perceived the attitude change as due to the facilities or participants in the program. Lastly, the conclusion would have been more apparent if the study had taken place within a K–12 education site.

Brown et al. (2016) investigated whether teaching STEM with an explicit approach had an impact on self-efficacy among a group of secondary-level students. The participants were enrolled in an Earth-science course, and the study took place during the second semester of school. The students completed an attitude and belief survey prior to participating in a project-based, NGSS space-science education unit. The students completed a postsurvey on their attitudes toward STEM and group work following completion of the unit. The female students perceived STEM to be useful in the future, more so than the male respondents. Students with a lower level of participation in the group activities also displayed lower self-efficacy.

The data collected in the Brown et al. (2016) study were useful for understanding group-work dynamics within a science classroom. However, the teachers and participating students were not interviewed during the research. As a result, it was not clear why the students were less engaged in the curriculum or why they chose a particular role within their work group. Student and teacher views on the unit and activities would have garnered valuable insight into the attitude change and reasons for selecting specific roles. The participating students studied plate tectonics prior to the space-science unit. The previous science units may have been boring to the students in comparison to the space unit. Again, teacher perceptions and student interviews would have provided insight into the first seven months of the science lessons. An additional questionnaire at the beginning of the year would also have provided valuable insight into the views of the students surrounding science before any additional learning.

Miller et al. (2006) conducted a mixed-method study that indicated why students were not planning on studying science in college. Female participants preferred courses in high school that were not related to science such as English. Students not planning on majoring in science reported they were not interested in science, disliked it, or found it boring. If they were planning on enrolling in science courses, it was to earn a degree supporting their desire to help others from within the health-care industry. Although a valuable study, the students were not representative of a typical K–12 school in Oregon. The high school was connected to a local university and most of the students planned on attending college. Consequently, the results may not reflect the attitudes of other high-school students. Secondly, the type of science program or curriculum implemented within the school district was not noted. Given the connection to a university, the students may have had a greater number of opportunities for positive learning experiences and a reliable support system. Third, teacher perceptions or input on the attitudes of the students toward science and student participation in the study were also not included in the research documentation.

Paige et al. (2013) interviewed teachers who participated in a training program teaching them how to incorporate engineering concepts into their student instruction. The teachers perceived the program as improving their knowledge of engineering and they were excited to pass that on to their students. However, the results did not include data indicating an improvement either through participant interviews or surveys; hence, it is unknown as to whether the program improved learning experiences for students.

Every study presented within this literature review had limitations. According to Boswell and Cannon (2009), it is common to analyze the weaknesses of an investigation because no study is perfect or without faults. However, this body of research contributed to understanding why female students do not choose advanced education or careers in engineering and how self-efficacy (i.e., positive learning experiences), as well as support and barriers, impact career choice. In light of this review, additional study was needed surrounding the engineering self-efficacy of female high-school students after engaging in NGSS-aligned curriculum, as well as teacher perceptions of student engagement within science classrooms.

Chapter Summary

The literature review for this current study included articles from peer-reviewed journals, dissertations, government reports, and books focused on the topic area under study. A growth in STEM-related jobs within the United States is evident, and that trend is expected to continue (Langdon et al., 2011). According to Langdon et al. (2011), these positions are necessary to spur our economy with creative ideas and technological advances. Creative ideas produce new discoveries, which give rise to new products and knowledge (NSB, 2018). Women comprise nearly 45% of the U.S. workforce but less than 20% of the workforce in STEM-related industries (U.S. Bureau of Labor Statistics, 2016). Therefore, the United States must increase the number of women choosing STEM-related careers. According to the White House, Office of the Press Secretary (2017), the future of the U.S. economy depends upon increasing and maintaining the workforce employed within these areas.

Traditionally, women have not chosen careers requiring math or engineering skills (Betz & Hackett, 1981). In 2016, 14% of all engineering and architecture workers were women (U.S. Bureau of Labor Statistics, 2016). Women are critically needed within the engineering field to cover the growth of this industry that comprises 44.3% of the total workforce. The number of female engineers is comparable to the number of female students interested in math and engineering at the collegiate level. According to the NSB (2018), the number of females graduating with a bachelor's in engineering has been approximately 20% since 2000. Miller et al. (2006), as well as Porter and Umback (2006), found that female students have a lower interest in math and physical science compared to male students, and greater interest in the life and social sciences. Statistics published by the NSB (2018) and the U.S. Bureau of Labor Statistics (2016) support this finding.

The low interest female students have in STEM-related careers may originate from a low self-efficacy or confidence in the ability to succeed in such professions. Lent et al. (1994) postulated that interest in a career is derived from self-efficacy, which subsequently leads to goals and action. The role self-efficacy plays in career choice appears to be significant. Self-efficacy has determined interest in engineering (Flores et al., 2014; Inda et al., 2013; Lent et al., 2005; Lent et al., 2013; Novarro et al., 2014) and persistence in this field of study (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2015). Students have selected STEM-related careers more often when they believe they can succeed in the field ("For Girls in STEM," 2015; Wang, 2013). Both Litzler et al. (2014) and Inda et al. (2013) found that women have less confidence in their ability to complete an engineering program than men.

The low self-efficacy of female students with regard to engineering might also be due to a lack of positive related learning experiences. Bandura (1977) postulated that successful learning experiences and verbal persuasion have an impact on general self-efficacy. Learning experiences and a strong support system influence career choices, which Lent et al. (1994) reported after applying SCCT in their related study. Opportunities for students to engage in science and engineering practices may increase the number of students pursuing a career within the engineering field.

Hackett and Betz (1981) advanced that success in developing a particular behavior has the most substantial influence on self-efficacy. The engineering practices of the NGSS were written to provide students with opportunities to explore, understand, and master skills in engineering (NGSS Lead States, 2013). The new engineering knowledge and skills will, in turn, help students understand the real-world activities of engineers within the workplace and their contribution to the U.S. economy. Kim (2016) found that student attitudes improve with a NGSS-inspired, inquiry-based technology program. Bystydzienski et al. (2015) found that the interest of female high-school students in engineering increased after participating in a program exposing them to engineering practices.

A dearth of studies exist that were focused on examining the self-efficacy of female high-school students who participated in science education with a curriculum aligned to NGSS. The fact that the NGSS were completed in 2013 could be a causal factor (NGSS Lead States, 2013). The standards were not adopted within the state of Oregon until March 6, 2014 (Oregon

Department of Education, n.d.). Oregon school districts were given until the 2018–19 academic year to begin testing to the new standards. Few of the districts implemented the standards immediately.

Exposure to the science and engineering practices through the NGSS might spur a positive change in the engineering self-efficacy among female high-school students, as well as increase the number of women studying engineering at the college level. Therefore, it was relevant to study a group of female students attending a sourthern Oregon high school and their perceptions of their own engineering self-efficacy. Reasons for the low level of self-efficacy among the this student population were unknown prior to this research. Teacher perceptions of the engagement of female students in engineering lessons was also unknown by the school site.

Chapter 3: Methodology

The purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. Researchers have examined student self-efficacy following their engagement in NGSS-inspired curriculum; however, the students participating in these studies were exposed to the curriculum for only a brief period of time (Brown et al., 2016; Kim, 2016). Collectively, the students demonstrated higher self-efficacy and a more positive attitude toward engineering after engaging with NGSS-inspired curriculum. As noted earlier, the self-perceptions of engineering self-efficacy among a population of female students attending an Oregon high school after participating in a curriculum aligned to the NGSS were unknown prior to this research. Consequently, the further study was needed.

It has been found that student self-efficacy in engineering plays a role in student interest in this field of study (Flores et al., 2014; Inda et al., 2013; Lent et al., 2005; Lent et al., 2013; Novarro et al., 2014). Bandura (1986) indicated that positive experiences improve self-efficacy. Therefore, positive experiences in engineering practice via NGSS-related lessons may lead to positive improvement in the engineering self-efficacy of female high-school students.

Research Questions

The self-perceptions of a small population of female students attending an Oregon high school, with regard to their engineering self-efficacy after participating in NGSS-aligned curriculum for two or more years, was unknown by the high school participating in this study prior to this research. Further study was clearly indicated. This case study contributed to existing related literature by providing increased understanding of the learning experiences of the described students. A small number of these students participated in a study survey and interview. Science teachers from the same Oregon high school also participated in interviews. The following research questions guided the study:

1. How do female students attending an Oregon high school perceive their self-efficacy in engineering?
2. What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?
3. How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?
4. Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?

Purpose and Design of the Study

The purpose of this study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. The high school integrated NGSS into the curriculum in 2016 in order to adhere to the Oregon Science Standards. Oregon adopted the NGSS on March 6, 2014 (Oregon Department of Education, n.d.). School districts were not required to fully implement the new standards until the 2018–19 academic year. Students will participate in a NGSS-aligned state test during the spring of 2019.

The school district within which this study was conducted began training teachers on the NGSS during 2015. The teachers aligned the curriculum to the standards in 2016 and the plan was implemented in the 2016–17 academic year. The ninth-grade students had attended a middle school that adopted NGSS-aligned curriculum in 2016, implementing it during the 2016–17 academic year. After the students participated in lessons inclusive of engineering practices, it was important to gain insight into the engineering self-efficacy of the female enrollees. This case study led to a clearer understanding via a thorough analysis of their related experiences.

A case-study approach was selected for this research due to its advantages over other methodologies when investigating a “how” or “why” question involving past and present behavior that cannot be manipulated (Baxter & Jack, 2008; Yin, 2016). Case study is also useful when exploring a phenomenon using several data sources (Baxter & Jack, 2008). Data were collected in this current study via a student survey, student interviews, and student artifacts. Interviews were also conducted with the science teachers who taught the engineering-practice lessons at the study site.

Valid reasons motivated the selection of case study for this research over a quantitative approach. Several studies reviewed for this invstigation were conducted with a quantitative design. Creswell (2014) noted that a quantitative approach is appropriate when studying the relationship between variables of a particular theory. Several researchers have confirmed that the variables of social cognitive career theory (SCCT) hold true for study samples of both male and female secondary-level students (Brown et al., 2016; Fouad et al., 2010; Garriott et al., 2014; Lopez et al., 1997). Case study allowed for an in-depth understanding of the self-percpetions of a group of female high-school students with regard to their engineering self-efficacy.

Case study was also more appropriate for this research when compared to qualitative grounded theory and ethnography. The intent was to gain insight into the attributes contributing to the engineering self-efficacy of female high-school students. Specifically, how the engineering practices of the NGSS (i.e., learning experiences) impact the engineering self-efficacy of this student population. New theory was not formed to explain an action or process (Creswell, 2013). Interviews served as one form of data collection but were not necessarily the primary focus. Similar to ethnography, this study began with theory; however, the data were not analyzed to understand any particular cultural behavior, language, or belief system.

A phenomenology design was also considered for this study; however, as noted earlier, the research involved several data sources (i.e., a survey and student and teacher interviews). The views of a small group of students and teachers within an Oregon high school were collected to gain a deeper understanding of the self-efficacy and interest of female students in engineering. Phenomenology allows researchers to gather an in-depth understanding of individual experiences to reach a "universal essence" (Creswell, 2013, p. 76). This current study was designed to investigate a defined case; therefore, case study was best suited to answer the research questions and achieve the goals of the study.

Identifying a case is one of the first steps in case study (Creswell, 2013; Stake, 1995; Yin, 2016). A high school in Oregon that adopted NGSS-aligned curriculum for science courses was the case selected in the current research. This allowed for an in-depth investigation of the engineering experiences of a small group of female students. The study was relevant to further discussion and knowledge surrounding female students choosing or not choosing to enter the field of engineering. The engineering self-efficacy of this student population and their perceptions leading to this self-belief were unknown at this Oregon high school prior to the research. Teacher perceptions of lesson engagement by the students was also unknown. This study might assist educators within Oregon to gain insight with regard to the experiences of female high-school students that tend to dictate engineering self-efficacy following participation in NGSS-algined curriculum.

The female students who attended the study-site high school at the time of this research had been engaged in NGSS-aligned curriculum for two or more years and were currently enrolled in a science course. The teachers were trained on NGSS over a 3-year period. To further facilitate educator understanding of how to teach science to the new standards, which includes the incorporation of engineering practices, the teachers attended a week-long seminar during the summer of 2015. Two of the teachers attended another summer seminar during 2016. All of the educators also participated in professional-development training sessions spread over the 2015–16, 2016–17, and 2017–18 academic years.

The principal of the Oregon high school selected as the potential study site received an e-mail asking for permission to conduct a case study at the school. Both the principal and the school district granted permission prior to approval by the Institutional Review Board (IRB). Following approval from the Board, I sent a second e-mail to the school principal to schedule a meeting to discuss the study protocol. Upon meeting with the principal, I asked permission to officially begin the study by e-mailing invitations to participate to eligible teachers. The principal informed me that six science teachers currently met the eligibility criteria to participate and granted permission to present information on the study to the teachers and students and conduct the study interviews on campus. Permission was also given to use a conference room, faculty room, or alcove in the school hall to conduct the interviews; however, the principal did not want students pulled from math, science, English, or social-studies classes.

Study Population

The study sample in this research is composed of a small group of female students and a small number of science teachers from an Oregon high school. The total student population at the high school ranged from 14 to 18 years of age. To participate in the study, the students were required to be female, enrolled in a science course, have attended a school with NGSS-aligned curriculum for the two years preceding the study, and have teachers trained in the NGSS. Among the student body, 517 students met these criteria.

The participating high school has science and technology departments. Six science teachers were eligible to participate in the study. Students enrolled in the technology courses were eligible to receive engineering college credit through the local community college. The engineering instructor was not included in the study sample of teachers. Students enrolled in a design or drafting class were eligible to participate if they were also taking a science course. None of the participating science students were also taking a design or drafting class at the time of the study.

There were several science courses available to the students of the study-site high school. Ninth-grade students are required to complete an introductory integrated science course; four teachers at the school teach this course. Following completion of the ninth grade, students can choose their science course each year through the 12th grade. Other science courses offered by the high school are General Biology, Chemistry, Honors Chemistry, AP Biology, Honors Biology, Anatomy/Physiology, Medical Biology, Physics, Conceptual Physics, Forensics, Environmental Science, and Astronomy.

Sampling Method

This case study used two levels of sampling. The first level identified the case for the study and typical sampling was employed. The Oregon high school that participated in this research is a typical case because it “highlights what was normal or average” (Creswell, 2013, p. 158) in terms of implementation of the NGSS in science classrooms. This school was purposely selected because the teachers participated in an extensive professional-development program on

NGSS, which began in 2015, and the students had attended a middle school or high school aligned to the NGSS beginning in 2016. The curriculum adopted by the school district was aligned with NGSS, and the engineering practices were incorporated into the science-course lessons. The process and timeline for implementation of the NGSS were typical of schools within the state of Oregon. The amount of time the female students participating in this study had to participate in NGSS-aligned lessons was typical of this student population within other Oregon high schools.

The second level of sampling was used to identify the student and teacher participants. Criteria sampling and purposeful random sampling were incorporated. The study warranted a purposeful selection of participants based upon specific criteria. According to Creswell (2013), "purposefully selecting participants or sites" is warranted to answer guiding questions (p. 189). All student participants were female and currently attending the Oregon study-site high school. They had two or more years' experience with NGSS-aligned curriculum and were currently taking a science course taught by an educator trained to teach science with NGSS as the guiding standards. The teachers selected were trained on NGSS and the curriculum; additionally, they had five or more years' experience teaching science.

To begin the process of selecting participants, I sent an e-mail to the six science teachers who met the study criteria. Four of the six responded and a presentation of the study purpose and protocol was delivered to these teachers on campus during a teacher-planning day prior to the start of the school year. The teachers were given a description of the study; shown a copy of the survey; and provided with a letter to parents, consent form, and list of student interview questions (Stake, 1995). All four teachers were willing to participate and signed the consent form at the meeting (see Appendix A). The teachers requested that their interviews be scheduled after they had two or more weeks with their incoming students. Their interviews were scheduled following the presentation of the study to their students. The teachers agreed on a day during the second week of school for me to present the study to each of their classes during a regularly scheduled school day. The morning prior to the student presentation, I met with a fifth teacher to present the study and he agreed to participate and signed the consent form. He also allowed me to present the study to his students on that same day.

Each teacher taught six classes per day. Ten minutes were designated for my student presentation in the classes of the five teachers during each period of the day. I created a presentation schedule so every teacher was informed in advance as to when I would be in their classrooms. I explained the study to 30 groups (i.e., classes) of students. Each group had both male and female students. I distributed 311 student and parent consent forms to female students (see Appendix A). The reason for the consent forms were explained to the students. Special precautions were taken to ensure against any harm to the students as minors (Yin, 2016).

All five teachers allowed me to place a file folder within their classrooms for students to return the consent forms. The folder was picked up two weeks after I presented the study to the students. Out of the 311 consent forms distributed, 33 were signed by both parents and the respective students; 23 of those students provided an e-mail address and each was assigned a code to be used as an identifier. Names were not included within any study documentation. Only the researcher and each participant knew his or her individual student code. Student names and assigned numbers were kept with the consent forms.

An e-mail invitation was sent to the 23 students who provided e-mail addresses, inviting their participation in a study survey. The e-mail included the survey and directions on its completion. Thirteen students responded to the first invitation. A reminder e-mail was subsequently sent five days later and three additional students responded. Another reminder was sent after another five days and one more student responded. A final reminder was sent 3 weeks after the initial invitation.

Students were not eligible to participate in the survey unless they completed the instrument online. Ten students who completed the survey were randomly selected for an interview. Because purposeful random sampling adds credibility to a study (Creswell, 2013; Patton, 1990), the identification number of each student who completed the survey was placed in a container and 10 were randomly drawn as potential interviews. An 11th was ultimately needed and drawn because the 10th student never arrived for the scheduled interview. Every student who completed the survey was not interviewed because the number of survey respondents would have been too large to gain the an in-depth understanding sought (Patton, 1990). The 10 students randomly drawn were asked to participate in the interview. This sample size allowed for themes to emerge from the interview data.

My notes from each interview were saved and filed under each corresponding student identification number. I had sole access to these files. Each teacher was assigned a number for data entry and confidentiality. All student and teacher identification data were securely stored within my home.

Instrumentation

The students participating in this study rated their engineering self-efficacy via the survey and subsequently provided additional details during the study interviews. The intent of the interviews was to gain a deeper understanding of how and why the female students assessed their self-efficacy at a given level and how and why they did or did not participate in engineering lessons. Teacher perceptions of their engagement in lessons were collected to add to the body of evidence. The teachers reflected upon whether the engagement of female students increased with engineering practices incorporated into the lessons.

Three different instruments were used to collect data for this case study. The first instrument was a student survey focused on self-efficacy. A Likert-type scale was provided. The data were used to obtain the average self-efficacy for each participating student and the average for the student sample as a whole. Interview protocols were written for both the student and teacher study interviews to facilitate consistent data collection. All interviews were conducted by me.

As noted earlier, all students who returned a consent form were asked to participate in the survey. This instrument was a combination of surveys previously deemed reliable and valid in separate studies. With permission from the researchers, the following surveys were modified: the original Middle School Career Self-Efficacy Scale (Fouad et al., 1997); the General Engineering Self-Efficacy Scale; and the Engineering Skills Self-Efficacy Scale (Mamaril, Usher, Li, Economy, & Kennedy, 2016).

The Middle School Career Self-Efficacy Scale was created to examine the self-efficacy of middle-school students in math, science, and making career choices (Fouad et al., 1997). The original Scale included two parts—Part I measured student self-efficacy in career decisions and Part II measured self-efficacy, outcome expectations, and goals in math and science. Respondents rated themselves using a 5-point Likert-type scale. Reliability for all parts of the Scale was acceptable with a process-consistency coefficient of 0.79 and a content-consistency coefficient of 0.84.

The General Engineering Self-Efficacy Scale and the Engineering Skills Self-Efficacy Scale were created to measure engineering self-efficacy in undergraduate engineering students

(Mamaril et al., 2016). The General Engineering Self-Efficacy Scale contains six items. The Engineering Skills Self-Efficacy Scale consists of 19 items—five items for experimentation, nine for tinkering, and five items for design skills. The General Engineering Self-Efficacy Scale and the Engineering Skills Self-Efficacy Scale "showed acceptable psychometric properties across two rounds of factor analytic testing" (p. 381).

With approval from the respective researchers, the three surveys were modified to fit high-school students studying engineering concepts and practices within a science curriculum. The Middle School Career Self-Efficacy Scale included items related to career choice but these were modified to focus specifically on engineering. The self-efficacy items for math and science were included, with the exception of the specific questions related to math. All items within the General Engineering Self-Efficacy Scale were included in the final survey. All of the items within the original Engineering Skills Self-Efficacy Scale were included, with the exception of Skills 8, 9, and 10. These items were eliminated because the high-school science courses did not include projects with students "work[ing] with" or "build[ing] machines" (Mamaril et al., 2016). The engineering self-efficacy survey created for this study is provided in Appendix B.

Upon completion of the survey, students were randomly selected to participate in a study interview. The interview consisted of short-answer questions seeking clarity and a more in-depth understanding of how the students view their ability to accomplish an engineering task and how it made them feel when they performed the task. The interview questions were adapted from those documented by Gates (2015). Gates originally used the questions to determine the mathematics self-efficacy as perceived by middle-school students.

The interview protocol for the student interviews was designed to gather information regarding why and how students felt a particular way with various facets of the engineering lessons. Students were asked to expand upon their answers to glean a full description of their learning experience. With permission from Gates (2015), the questions for the interviews were modified. An example of a final question is “How does participating in engineering practices make you feel about being able to learn engineering and why does it make you feel that way?” The interview protocol is provided in Appendix C. The questions provided additional data toward understanding the engineering self-efficacy of the participating female students and their engineering-practice experiences.

Teachers were included in this study to provide an additional source of data due to their daily contact with students. They observe the level of engagement by female students during engineering lessons; hear what they are saying; and watch their reactions to labs, assignments, and activities. The teachers provided their perspectives on the level of student engagement in the engineering-practice lessons. With permission from Gates (2015), the interview questions for the teachers were also adapted. The questions needed to evoke descriptive details or explanations, rather than simple “yes” or “no” answers (Stake, 1995). For example, “Describe the type of student that is engaged in the engineering learning activities” and “Describe what your students say about the lesson or learning during or after an activity.” The interview protocol for the teacher sessions is also provided in Appendix C.

Data Collection

Once data collection began, students who returned a consent form and e-mail address were given directions for, and access to, the self-efficacy survey. Instructions on how to complete a Likert-type survey were also provided (1 = *very high ability*, 2 = *high ability*, 3 = *average ability,* 4 = *low ability,* 5 = *very low ability*). Respondents indicated their belief in their ability in specific areas of science and engineering practices. A response option of *uncertain* was also offered with no point value.

Following an explanation of the survey, the students were reassured of the anonymity and security of their answers. Qualtrics—an online data-collection tool—was used to collect and process the data. The data were exported to a spreadsheet in order to accurately calculate the average score for each statement. The primary aim with the survey was to obtain the average self-efficacy score for the female students participating in the study. Knowing their self-efficacy was necessary to understand their perceptions.

The study interviews were conducted at the school site at a time chosen by each student. According to Yin (2016), it is important to "cater to the interviewees [*sic*] schedule" (p. 98). The students were given a copy of the interview protocol prior to the interview and given a choice to opt out if they desired. With permission from the students and their parents, the interviews were audio recorded to ensure accuracy of the transcription. The interview is a crucial source of evidence in case-study research because the interviewee can provide the "how" and "why" of the problem under study. I transcribed the interviews upon their completion. The transcription was read twice while listening to the recordings to ensure accuracy. The only identifier on the transcription notes was the number assigned to each corresponding participant. All notes will be destroyed at the time approved by the IRB.

The science teachers that consented to the study interview were also given the interview protocol prior to their sessions. The interviews took place at times convenient for their schedules and times suggested by the school principal. The interviews were audio recorded and later transcribed. Teacher names do not appear on any documentation. These interviews were critical for the study because it was essential to obtain the perspectives of the teachers on student engagement to understand the different levels of engagement and why and how students engage in engineering-practice experiences.

Three students provided artifacts or evidence of their level of participation in engineering lessons. Suggested artifacts were class notes, projects, lab reports, assignments, or any other evidence of participation. I asked the students for such evidence to support their interview contribution. The artifacts allowed for a “broader perspective” of their application of engineering practice (Yin, 2016, p. 125). I asked the students to choose artifacts they found relevant to their level of engagement, enjoyment, or interest in engineering as a result of the engineering practices of the NGSS.

Identification of Attributes

In this research study, I sought to provide a clearer understanding of the self-perceptions of female high-school students regarding their self-efficacy in engineering after participating in a curriculum aligned to the NGSS. The participating students had been actively engaged in NGSS-aligned lessons incorporating engineering practices for the two years preceding the study. Identified attributes of the study are self-efficacy expectations, engineering self-efficacy, engagement, and the engineering practices of the NGSS. I also included support systems because students had the opportunity to discuss why or how they acquired a particular level of engineering self-efficacy.

Self-Efficacy

Self-efficacy expectations refer to the belief an individual possesses in his or her ability (i.e., intellectually, emotionally, or physically) to accomplish a specific task (Bandura, 1977). This study examined the engineering self-efficacy of female high-school students and why they perceive positive or negative self-efficacy. According to Bandura, four main components influence self-efficacy—the experience of performing a task, watching others complete a task, the feeling that is sensed with completion of a task, and the support or lack of support received while performing a task. According to Hackett and Betz (1981), the experience of performing a specific task has the most influence on self-efficacy.

This study specifically examined engineering self-efficacy as the self-belief in the ability to accomplish engineering tasks delivered within the high-school classroom environment. Betz and Hackett (1981) applied social learning theory to career choice with a sample of college students and found that women have a high level of self-efficacy in traditional female careers and a low level of self-efficacy in male-dominated professions. Engineering has historically been a male-dominated industry (U.S. Bureau of Labor Statistics, 2016). Less than 20% of full-time engineers are female. Studies have shown that women have lower confidence than men in their ability to complete an engineering program (Litzler et al., 2014) and less confidence in completing a STEM-related course (Hardin, & Longhurst, 2016; Bystydzienski et al., 2015). A major goal in this study was to determine if and why female high-school students have confidence in their engineering abilities.

Engagement, Support, and Practice

Engagement can be behavioral, cognitive, and/or emotional (Fredricks, Blumenfeld, & Paris, 2004). Each type of engagement involves several components such as the desire to complete tasks, involvement in the task, and feelings toward the task (Martinez & Guzman, 2013). According to Fredricks, Blumenfeld, and Paris (2004), “Engagement positively influences achievement” (p. 71). Engagement-influencing achievement supports the Bandura (1977) notion that positive learning experiences influence self-efficacy. In this current study, information was collected on the learning experiences of students within the classroom. Teachers provided their perceptions of the overall engagement of students in engineering lessons. During their interviews, the students described their perceptions of their engineering-practice experiences.

Bandura (1977) postulated that support influences self-efficacy, and Lent et al. (1994) proposed that support and barriers directly impact career choice. Students can receive support from peers; family (Amelink & Creamer, 2010; Inda et al., 2013); and teachers (Zhang & Barnett, 2015). It is noteworthy that teachers strongly influence students 10 through 14 years of age in their interest in STEM-related study and future careers (Nugent et al., 2015). Teachers were asked if they perceived female students as receiving support in the engineering-practice portion of the NGSS. Students also had the opportunity to share their experiences or ideas related to their support systems in the open-ended interviews.

The NRC (2012) recommended the inclusion of engineering practices in science practices. The term *practices* refers to both skills and content knowledge. Different skills and content knowledge are expected of students at different grade levels (NRC, 2012; NGSS Lead States, 2013). The engineering practices of the NGSS include the eight science practices; students also define problems in Step 1 and design solutions in Step 8 (NGSS Lead States, 2013). The goal is to increase awareness and interest in the field of engineering, especially for those students who have not considered engineering in the past (Lee et al., 2014; NGSS Lead States, 2013). The students participating in this current study had experience with the engineering practices of NGSS. The primary research focus was to determine whether they perceived the engineering practices they learned as having an influence on their engineering self-efficacy.

Data-Analysis Procedures

The analysis of study data is dependent upon the analytical skills of the researcher, the quality of the evidence, and interpretative possibilities, rather than on following an exact protocol (Yin, 2016). In the current study, strategies were applied that facilitated the analytical process and gaining insight into the meaning of the data. The data needed to be carefully organized so themes could be uncovered and subsequently represented in various formats (Creswell, 2013). The data were organized into four groups—student interviews, student surveys, student artifacts, and teacher interviews. However, the primary focus of the analysis was to document emerging themes. Each data source provides a piece of the answer to the research questions (Baxter & Jack, 2008).

The Qualtrics computer-software program facilitated collection of the student survey data. Such computer programs can assist with the organization and representation, but the deeper analysis uncovering meaning can only be conducted by the researcher (Yin, 2016). The survey intended to measure the general engineering self-efficacy of female students via a Likert-type scale (1 = *very high ability,* 2 = *high ability,* 3 = *average ability,* 4 = *low ability,* 5 = *very low ability*). There was also a sixth response of *uncertain* with no points assigned. Thus, a rating of 5 indicated a student self-perception of very low ability in that skill.

The computer program used in this study provided the self-efficacy ratings of each participating student for each survey item, the average score for each instrument item and each student, and the overall average rating for the survey. The original average score included the response of *uncertain* in the calculated averages. The data were exported to the spreadsheet, the average response scores recalculated without the *uncertain* responses, and the new average scores were reinput to the computer program. This was necessary to uncover the meaning of the scores in relation to the 10 student interviews.

After analyzing the self-efficacy ratings of the individual students for each survey item, I divided the items into three categories—science self-efficacy, engineering self-efficacy, and overall science and engineering self-efficacy. This enabled me to capture the average scores for each student and a collective average score for the study group. The computer program calculated the percentage of students who responded to each ability level for every survey item, which allowed for a deeper understanding of the scores. When a large percentage of students responded with *high ability*, the average score for one of the factors of self-efficacy (i.e., science, engineering, or the combined science and engineering) was closer to the higher ability range.

The study interviews allowed for a deeper understanding surrounding how and why the participating students believed they possessed high or low ability in engineering. The interviews were audiotaped to allow for transcription and accuracy in the retrieval of information. Data coding began once the interviews were transcribed, which allowed patterns, themes, and categories to emerge (Saldaña, 2016). The coding methods implemented included Holistic Coding, Values Coding, In Vivo Coding, and Focused Coding. The process began with Holistic Coding.

According to Saldaña (2016), Holistic Coding is a first step to placing the data into "broad topics" (p. 166). The next step allowed exploration of the personal beliefs of the female students participating in this current study using their voices through Values Coding and In Vivo Coding. Values Coding identifies beliefs and attitudes and In Vivo Coding captures participant voices. The teacher interviews were also recorded and transcribed. The transcription was read multiple times prior to coding. Holistic Coding and Values Coding were the primary methods implemented with the teacher interviews. The Holistic Coding allowed the primary ideas to be categorized and the Values Coding allowed the attitudes and beliefs of the teachers to be revealed.

The artifacts were analyzed in conjunction with the interview data. According to Saldaña (2016), “The best approach to analyz[ing] an artifact using a holistic, interpretive lens [is by] guided . . . intuitive inquiry” and asking questions (p. 57). There is a reason why an artifact was given to a researcher. Examining the artifact by asking questions, such as “What does this mean?” or “What does this tell me about the participant?” can lead to uncovering that reason. I examined the artifacts from students for clues of participation, engagement, and enjoyment in the engineering lessons. These clues included completion and overall appearance of the project. The artifacts supported the data obtained from the students and teachers during the study interviews.

After the first round of coding and artifact examination, the second cycle of coding began, which included organizing the data and analyzing it for emerging themes (Saldaña, 2016). Focused Coding was implemented for this second round. The codes were placed in categories, which were narrowed down to the primary themes. The process of categorizing was analytical in nature and required making connections between the data drawn from all sources (Baxter & Jack, 2008; Yin, 2016). A colleague coded one of the transcripts to confirm agreement on the primary codes, secondary codes, and emerging themes.

Once the transcripts were coded and evaluated for themes, I chose two participants to review their interview transcripts and the coding as an accuracy check. Known as *member checking*, this is a method of ensuring accuracy of the data collected (Baxter & Jack, 2008;

Creswell, 2013; Yin, 2016). The two participants confirmed accuracy with no additional comments.

Limitations and Delimitations of the Research Design

The acknowledgment of limitations is essential to establish the credibility of any research study. In the current study, participating students completed a Web-based survey. Some research has shown a higher rate of response when conducting face-to-face compared to Web-based surveys (Christensen, Ekholm, Glumer, & Juel, 2014; Heerwegh & Loosveldt, 2008). However, Lui and Wang (2015) found that face-to-face survey answers are not as accurate and showed no difference in response rates. Lui (2017) found that females vocalized their opinions regardless of the type of survey. There is also a possibility that students rush and do not accurately complete a written survey.

If the students participating in this current study submitted a survey either omitting an e-mail address or other request for information, they were not included in the random selection of study interviewees. Consequently, the students were self-selected based upon their survey participation. It is possible that participants who responded to the survey were more likely interested in engineering. According to El-Masri (2017), a researcher can minimize selection bias by ensuring participants are representative of the target population. I minimized such bias by confirming the participants in the current study were not drawn from any one area of science.

The target population for this research study is female students from diverse backgrounds. Although the study indeed included solely female students, the sample was still not representative of the diverse population across the United States. According to the U.S. Census Bureau (2016), the total U.S. citizenry is composed of European Americans (61.3%), African Americans (13.3%), Hispanics (17.8%), and American Indians (1.3%). However, the population where this study was conducted would not be considered a vastly diverse population with 88.2% European Americans, 5.5% Hispanics, 0.7% African Americans, 1.4% Asians, 3.8% of mixed ethnicity, and 0.8% American Indians. The student population of the study-site high school was 77.4% European Americans, 0.5% African Americans, 1.8% Asians, 1.6% American Indians, 11.4% Hispanics, and 6.8% of mixed ethnicity.

Researcher bias must be discussed as a limitation. Ethical researchers disclose any possible limitations in their studies (Yin, 2016). I have been a science teacher within the state of Oregon since 2002. I have taught to the 2001 and 2009 Oregon State Standards, as well as the NGSS. To avoid researcher bias, Yin (2016) suggested review of the findings of a study by colleagues of the respective investigator. Creswell (2013) suggested researcher reflection on the interpretations of the peer review. I had a trusted colleague read one of the interviews conducted for the current study, as well as my analysis of the data collected, and provide feedback. I also chose to have a peer review one set of data. This colleague was one of the peers who reviewed and critiqued the design of the study prior to data collection. The objective of the critique was to confirm reliability of the coding and the category of themes, and my codes and themes were similar with those of my reviewing peers. Creswell (2014) recommended peer debriefing and cross checking in qualitative research. This process was followed and allowed reflection on the emerging interpretations and themes. I also included more than one data source in the process to further reduce bias and provide greater validity of the results. According to Yin (2016), multiple sources of data supporting the findings add validity to a study.

Clear boundaries were established at the outset of this research to ensure the data collected addressed the phenomenon under study (Yin, 2016). Data collection was limited to one study-site high school. While acceptable for case study, this limits the size of the sample.

Because the research focused specifically on female students, male students were purposely excluded from participation. A study delimitation was my choice to have two participants involved in member checking rather than all interviewees. In member checking, participants are given their respective interview transcripts to check for accuracy (Creswell, 2013). The two students read their transcripts and reviewed the coding and themes that emerged from the analysis; both viewed the data as accurate. Neither student provided feedback on the themes, other than to comment on their accuracy and interesting nature.

Validation

Credibility

The strategies employed to ensure rigor are vital to a good qualitative study. Validity was established in this current research via several methods. The research questions were thoughtfully formulated and the methodology transparent, allowing readers to determine whether the study followed a logical and impartial progression (Meyrick, 2006; Yin, 2016). The research questions were tested to ensure their clarity and effectiveness in gaining an understanding of student self-efficacy in mathematics (Gates, 2015). The data-collection protocol and participant-selection processes were explicit and also transparent to the participants. The interview protocol was provided to all participants at the initial presentation of the study and again prior to the interviews. The study followed a systematic and logical process that allowed ample time for data collection and efficient organization throughout the study. Time and organization were essential due to the multiple data sources.

Data triangulation established further credibility of the findings by confirming the evidence (Baxter & Jack, 2008; Creswell, 2013; Yin, 2016). This was possible due to the multiple data sources. The students completed a survey and participated in an interview;

teachers also participated in an interview. The students were asked for artifacts from their notes, labs, and/or activities. Three students presented pictures from previous engineering projects. The process of triangulation involved matching pieces of evidence from two or more sources. The artifacts and transcripts from the teacher interviews were thoroughly analyzed for "corroborating evidence from different sources" (Creswell, 2013, p. 251). The data were ultimately merged to support the study conclusions (Yin, 2016). The process of triangulation demonstrated the validity of the final analysis by indicating consistent data across sources.

As noted earlier, following the study interviews and coding of the transcripts, I randomly chose two participants to review their respective transcripts and the emerging themes for their feedback as to accuracy (Baxter & Jack, 2008; Creswell, 2013; Yin, 2016). Both student reviewers confirmed accuracy of the documentation and coding with no additions or changes. As also noted earlier, two peers reviewed the methods employed in this study and one also reviewed my data analysis. There were several benefits to having colleagues read the study as it was written. According to Creswell (2013), peer reviewers are able to "ask hard questions about methods, meanings, and interpretations" (p. 251). Following completion of the methodology documentation, and prior to the onset of data collection, I asked two colleagues to independently review the study design with a "critical eye." They provided feedback through a phone conversation and I reflected on their input and adjusted the design based upon their suggestions. One colleague read through the interview transcripts and my interpretations to confirm agreement on the primary themes. This process supported the validity of the data, as well as the findings of the study (Creswell, 2013; Yin, 2016).

Dependability

Dependability of the study findings was established through various strategies. A detailed interview protocol was created, which increased reliability (Yin, 2016), and the interviews were audiotaped and transcribed. Creswell (2013) suggested that reliability is enhanced through the audiotaping and transcription of the study interviews. The transcription captured “pauses and overlaps” in participant answers, which were considered in the coding (p. 253).

Baxter and Jack (2008) suggested a process of “double coding” (p. 556). Study interviews are coded and subsequently coded again to verify the initial findings. Following the student and teacher interviews in this study, the recordings were transcribed and coded. The information was set aside for two days before a copy of the same set of data was coded for a second time. The two sets were then compared to ensure accuracy and reliability.

Yin (2016) recommended the creation of a case-study database (p. 130). Based upon this suggestion, the data collected in this study, as well as the data analysis, were maintained in separate files within a computer system to allow others to independently view the data. The database consisted of the survey results, the student and teacher interview transcripts, artifacts, and any notes of my own taken during the data-collection process. The goal of the database was to allow easy access to the data by external readers.

Expected Findings

Oregon adopted the NGSS as the official state science standards in 2014 (Oregon Department of Education, n.d.). The school district participating in this study adopted the standards and aligned the curriculum with them for the 2016–17 academic year. All students attending high school within the district had two years of engineering practices incorporated into their science lessons. Additionally, the teachers integrated aspects of the engineering practices of the NGSS into their related lessons for the 2015–16 academic year prior to the full implementation during the 2016–17 academic year. The NGSS include identifying a design problem and subsequently addressing it by redesigning and testing a solution devised by applying a known model (NRC, 2012). Teachers of the school district participating in this study exposed students to engineering practices by introducing science-practice terminology and simple practice-design problems. Once the students were familiar with the terminology, the teachers introduced the eight practices of engineers, as specified by the NGSS (NGSS Lead States, 2013) and the NRC (2012) education guidelines.

The female students participating in this study were expected to demonstrate high engineering self-efficacy. The learning experiences introduced by the integrated engineering practices were designed to allow students to feel confident in their engineering abilities (i.e., identifying a problem, designing a solution, and implementing tools to solve the problem). The students were expected to perceive themselves as fully engaged in the engineering lessons. The teachers were expected to perceive the students as participating in the engineering-practice lessons. The students were also expected to report feeling included in the curriculum and supported by peers and teachers. As a result of the positive learning experiences, a very high level of engineering self-efficacy was expected among the study sample, leading to an interest in an engineering career.

The described expected outcomes were based upon the Lent et al. (1994) SCCT. The Bandura (1997) social learning theory, as well as the Bandura (1986) social cognitive theory, posit that positive learning experiences and positive support systems facilitate an increase in self-efficacy. Lent et al. postulated that interest in a particular career is partially due to self-efficacy.

Several researchers have shown that engineering self-efficacy determines an interest in the field of engineering (Flores et al., 2014; Inda et al., 2013; Lent et al., 2005; Lent et al., 2013; Novarro et al., 2014). Inda et al. (2013) found that positive support by teachers is related to a particular career interest.

Lopez et al. (1997) found that positive experiences in high-school math lead to high self-efficacy. Kim (2016) noted an improvement in the attitudes of middle-school female students toward science as they gained experience. The science program Kim used in her study was influenced by Bybee (2014) who was the lead on the writing team for the NGSS (NGSS Lead States, 2013).

Ethical Issues

This case study involved the collection of data from both adults and youth. Creswell (2013), Stake (1995), and Yin (2016) all agreed that researchers must employ special considerations and take cautionary measures when dealing with human subjects. This was especially important for this current study due to the involvement of youth. A plan was needed to consider in advance possible problematic issues that could arise (Creswell, 2013). These included topics such as consent, the protection of participants, disclosing researcher conflict of interest, and ensuring researcher transparency (American Psychological Association, 2016; Yin, 2016).

The purpose of this study, the consent forms, the timeline, and a detailed description of the study procedures were submitted to the IRB prior to the onset of the research. Based upon cautionary measures taken to protect the participants, the IRB reviewed the information and granted approval of the study. I adhered to the plan submitted and provided updates to the university regarding my progress.

I was previously employed with the Oregon school district that participated in this research. However, I did not work at the specific study-site school where the data were collected. I previously worked with two of the teachers who participated in this study and with. I did not work for or with the principal of the study-site high school. I have not been an employee of the participating school district for multiple years, nor was I paid to conduct the research or produce specific results in the study. The participants were not paid for their involvement in this study nor for providing any particular responses. However, there were indeed benefits to participation. For example, the findings may facilitate educator understanding of how engineering practices influence the engineering self-efficacy of a small group of female students. The results might also further understanding as to why female students lack interest in entering the field of engineering.

I wrote the procedures for this case study, interviewed all participants, analyzed the survey data, and coded the interview transcripts. Consequently, it was impossible to remove myself from the research. Creswell (2013) suggested several strategies to contribute to the validity and reliability of a study. I employed several of these techniques to bring any potential bias to the forefront such as peer review, member checking, and data triangulation. Meyrick (2006) and Yin (2016) stressed the importance of transparency to avoid researcher bias. The establishment of thoughtful protocol was a facet of this transparency in the current study. Transparency was also present in the instrumentation, which had been tested in prior research, confirming reliability. A detailed plan for data analysis had also been constructed.

Special ethical consideration was given to the student participants in this research because this study group was composed of youth. According to Yin (2016), researchers must protect study participants by conducting their investigations “with special care and sensitivity”

(p. 88). All parties involved in the current research were fully aware of the study purpose and procedures. Approvals from the school district and school site were received at the onset. The parents or guardians of the participating students signed consent forms that fully disclosed the purpose and risk of study participation (see Appendix A). The participating teachers and students also signed a consent form prior to any data collection (see Appendix A). They were allowed to review the interview protocol before the sessions began. They could examine their respective transcripts and coding to ensure their accuracy. Special care was taken to confirm the participants were clear on their role in the study and understood they could withdraw at any point without repercussion.

Information obtained from the participants in this study will always be held strictly confidential. Their names do not appear within the data nor any study documentation. Creswell (2013) and Yin (2016) stressed the importance of protecting the participants by not revealing any information that may cause harm, which includes their identification.

Chapter Summary

The purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. The study sample of female students participated in science courses since the 2016–17 academic year that incorporated the NGSS as their guiding standards. A major aim was to analyze how and why this group of students rated their engineering self-efficacy at particular levels. Specifically, I asked students to describe their experiences with the lessons incorporating engineering practices. The intent was to gain a clearer understanding of the engineering self-efficacy of this group of female students and why female students lack an interest in entering the field of engineering. The students were expected to demonstrate high self-efficacy because they had participated in NGSS-aligned curriculum since 2016. Consequently, they were provided with opportunities for positive learning experiences in the lessons incorporating engineering practices.

Following my receipt of student and guardian consent, the study sample of female students participated in an engineering self-efficacy survey. A few of these students were chosen to participate in a subsequent interview with open-ended questions. The science teachers were also interviewed after signing a consent form. The transcripts from the student interviews were coded to facilitate recognition of primary themes in order to gain an understanding of why female students did or did not have confidence in their engineering skills. The teacher interviews were also coded to gain an understanding of student engagement in the lessons.

Every precaution was taken to ensure minimal risk to the students and teachers participating in this study. The data collected will always be kept strictly confidential. The participants were made clearly aware that they could withdraw from the study at any time with no repercussion. The study procedures were thoughtfully created to avoid ethical issues. Such precautions were especially important because this study involved youth. The study findings were expected to facilitate a clearer understanding of the engineering self-efficacy of female high-school students enrolled in this area of study.

Chapter 4: Data Analysis and Results

Overview

The purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. More specifically, the aim was to understand the engineering self-efficacy of this group of female students after their participation in science courses aligned with the NGSS. The theoretical framework was SCCT (Lent et al., 1994), which guided the research questions and methodology of the study. Bandura (1977) advanced that positive learning experiences have a direct positive impact on self-efficacy. Lent et al. (1994) formulated social cognitive career theory (SCCT) on the premise that self-efficacy influences interest, goals, and career choice. A number of researchers have shown that self-efficacy predicts student interest in engineering and whether they could successfully complete an engineering program (Flores et al., 2014; Lent et al., 2003; Lent et al., 2013; Lent et al., 2016; Navarro et al., 2014).

The NGSS were written to create increased interest and understanding in science and engineering through the provision of opportunities to experience positive learning within this realm of study (NRC, 2012). Embedded within the NGSS are science and engineering practices (NGSS Lead States, 2013). Students involved in NGSS-aligned curriculum learn engineering skills and concepts and gain an understanding of the role of engineers within the real-world workplace (Bybee, 2011; NRC, 2012; NGSS Lead States, 2013; Page et al., 2013). It is hoped that positive learning experiences will lead to a more diverse pool of female students interested in the field of engineering. The NGSS were intentionally written to include all students (Januszyk et al., 2016; Lee et al., 2014). This is important because, historically, female students have not chosen advanced engineering study or careers (Buse et al., 2017; NSB, 2018; NSF, 2017; U.S. Bureau of Labor Statistics, 2016) and the shortage in trained engineers is expected to have an extreme adverse effect on the future U.S. economy (Kildee, 2017; Langdon et al., 2011).

The following research questions guided this study:

1. How do female students attending an Oregon high school perceive their self-efficacy in engineering?
2. What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?
3. How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?
4. Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?

To answer these questions, a group of female students participated in a self-efficacy survey. Additionally, I interviewed students and teachers and collected artifacts demonstrating student involvement in the curriculum.

The study-site high school in Oregon aligned its science curriculum to the NGSS in 2016. The teachers participating in this study were trained in use of the standards and taught science at the high school. It was important the student voices were heard through the interview process and understood; consequently, excerpts from the student interviews are provided. My role in this study was that of the investigator. Although I have served as a science teacher since 2002 within the state of Oregon, I entered into this research with an open mind and placed specific protocols in place to avoid bias. I allowed the participant voices to guide the findings, which are based upon data collected through the student surveys and interviews, teacher interviews, and artifacts.

Description of the Participants

The high school that served as the study site in this research was selected because the school represents a typical Oregon high school in terms of implementation of the NGSS in science courses. The time frame within which district schools were required to integrate the NGSS into the curriculum was similar with districts across the state. The NGSS were written by a team composed of individuals from 26 states that led the initiative for national standards (NGSS Lead States, 2013). A total of 40 people comprised the team, and each member was considered an expert within their field of study. The standards were released to the public in April of 2013 and Oregon adopted them on March 6, 2014 (Oregon Department of Education, n.d.).

The NGSS were not implemented immediately for several reasons. Teachers needed to review the curriculum and align it with the new standards. They also needed training on reading, understanding, and executing them due to their complexity. In Oregon, the first state test with the new standards was scheduled to be administered in the spring of 2019. According to the principal of the study-site high school, the teachers began training on use of the NGSS in 2015, which is a typical time frame for Oregon high schools.

The teachers who participated in this study were required to meet specific criteria. They needed to be trained on the NGSS and have five or more years' teaching experience (see Table 1). Eight science teachers were employed at the high school; six met the criteria. Five out of the six teachers consented to participate in the study. One dropped from the study prior to the interview; two of the four teachers who participated taught ninth-grade integrated science. One out of the four taught a general and honors physics course and one out of the four taught general-biology and advanced-biology courses. The teacher who dropped from the study taught ninth-grade integrated science and two other science courses; however, he allowed me to present the study in each of her classes.

Table 1

Experience of Participating Teachers Within the Field of Education

Teacher	Number of years teaching science	Number of years in education
1	6	18
2	17	17
3	9	21
4	5	5
5	14	Not given

The students who participated in this study also met specific criteria. They needed to be currently attending a science class, have attended a school with a curriculum aligned to the NGSS during the preceding year, and female. The students who met these criteria numbered 517; 311 requested and received consent forms. Thirty-three of the 311 students returned the signed parent and student consent forms; 23 out of the 33 students provided an e-mail address for survey delivery. Out of the 23 students who responded, 17 participated in the survey. They were enrolled in the courses indicated in Table 2.

Out of the 17 students who returned study surveys, I randomly selected 10 to participate in the study interviews. All 10 students selected agreed to continue with the study. The interviews were scheduled at different times and one student did not attend the interview so another was randomly selected from the remaining seven students who participated in the survey. A student was selected from each course, with the exception of astronomy. The 11 students randomly chosen for the interviews were enrolled in the courses indicated in Table 3.

Table 2

Science-Course Enrollment Among the Student Study Sample

Course	Number of students
Integrated science	7
Physics	2
Honors physics	2
Biology	1
Advanced biology	2
Forensics	2
Astronomy	1

Table 3

Science-Course and Academic Grade Level of Study Interviewees

Course	Number of students	Academic grade level
Integrated science	3	9th
Physics	1	11th
Honors physics	2	12th
Advanced biology	2	12th
Forensics	2	12th

Note. One 10th-grade biology student did not arrive for the study interview.

Research Methodology and Analysis

Successful task experiences, watching others perform a task, input from others, and verbal persuasion all influence the self-perception of ability to carry out a task in a successful manner (Bandura, 1977). Lent et al. (1994) applied these factors in a study grounded in SCCT as the theoretical framework and found that these factors also have a direct influence on interest in a specific career path and the goals set. Similarly, research has shown that self-efficacy has a direct impact on persistence in the study of engineering (Flores et al., 2014; Inda et al., 2013; Lent et al., 2003; Lent et al., 2015).

Female students are not choosing to enter the field of engineering based upon employment data (U.S. Bureau of Labor Statistics, 2016) and secondary-education graduation statistics (NSB, 2018). This segment of the student population has less confidence in their ability to complete an engineering program (Inda et al., 2013) and lower self-efficacy in nontraditional careers (Betz & Hackett, 1981; Novakovic & Fouad, 2012). The NGSS were written to include all students in order to increase the interest and number of students entering science and engineering careers by introducing them to real-world, hands-on learning experiences and related critical-thinking skills (NRC, 2012). This study was conducted to gain a clearer understanding of the engineering self-efficacy of a small group of female students, their engagement in learning, and their attitudes toward engineering after attending a high school with curriculum aligned to the NGSS since the 2016–17 academic year.

Data analysis in this study was conducted in several steps.

1. Analysis of the survey results.
2. Transcription of each interview and review of the transcripts.
3. Holistic Coding of the transcripts.
4. Values Coding and In Vivo Coding of the transcripts.

5. Focused Coding of the transcripts to narrow emerging themes.
6. Double coding applied to the transcripts.
7. Review of student artifacts.

The teacher data were analyzed using the same steps; however, the teachers did not participate in the survey.

Survey

To begin data collection, I met with the principal of the study-site high school to ask permission to officially begin the study and send e-mail invitations to the eligible teachers. During this meeting, the principal informed me that six science teachers currently met the eligibility requirements to participate in the study. Consequently, permission was granted to be on campus to present the study to the teachers and students and conduct the interviews on the campus. Permission was given to use a conference room, faculty room, or alcove in the school hall to conduct the interviews. The principal did not want students pulled from math, science, English, or social-studies classes.

I sent an e-mail to the six eligible science teachers. Four of the six responded and agreed to meet with me. I presented the study to these teachers during a teacher-planning day prior to the start of the school year. All four teachers signed the consent form at the meeting and agreed to participate in a study interview. The teachers requested that the interviews be scheduled after they had two or more weeks with their incoming students. The interviews were scheduled after my presentation of the study to all students was completed. The teachers agreed on a day during the second week of school for me to present the study to each of their classes during a regularly scheduled school day. During the morning prior to the presentations, I met with a fifth teacher.

He agreed to participate in the study, signed the consent form, and allowed me to present the study to his students on that same day.

Each teacher participating in this study taught six classes per day. I was given 10 minutes in the classes of the five teachers each period of the day. I created a presentation schedule so they all knew in advance when I would be present within their classrooms and explained the study to 30 groups (i.e., classes) of students. Each class was composed of both males and females. I distributed 311 student and parent consent forms to the female students. All five teachers allowed me to place a file folder within their classrooms for students to return the consent forms. I picked up the file folders two weeks after I presented the study to the students.

Out of the 311 consent forms distributed, 33 forms were returned signed by both the parents and students. Of those, 23 of those students provided an e-mail address and each was assigned an identifying code. I sent an e-mail to these students inviting them to participate in the study survey (i.e., the Student Engineer Self-Efficacy Survey; see Appendix B). Directions were included in this communication as to the completion of the survey. Thirteen students responded to this first invitation and a reminder e-mail was distributed five days later; three additional students responded. Another reminder was sent five days after the initial invitation and one more student responded. A final reminder was e-mailed three weeks after the initial invitation with no response.

The students who completed the survey responded to each item of the instrument by indicating their belief in their ability in specific areas of science and engineering practices (1 = *very high ability,* 2 = *high ability,* 3 = *average ability,* 4 = *low ability,* 5 = *very low ability*). An *uncertain* response option was also provided, which was not calculated into the average scores. The data from the survey were exported to the spreadsheet to eliminate the point value assigned by the computer software when the *uncertain* option was selected. Data analysis revealed engineering self-efficacy, science self-efficacy, and science and engineering self-efficacy of the respondents. I created the following three groups: (a) all participants, (b) the 10 interviewees, and (c) the seven students who were not interviewed. Individual science, individual engineering, and overall self-efficacy were analyzed.

The study survey is a combination of instruments that were deemed reliable and valid in separate research studies. With permission from the investigators, the original Middle School Career Self-Efficacy Scale (Fouad et al., 1997), the General Engineering Self-Efficacy Scale, and the Engineering Skills Self-Efficacy Scale (Mamaril et al., 2016) were modified and combined. A Likert-type response scale was used to obtain the average self-efficacy in engineering for all the responding students and the engineering self-efficacy for individual responding students. The survey data revealed that the study instrument could be separated into two sections—engineering self-efficacy and science self-efficacy. The engineering practices of the NGSS are intertwined with the science practices. There are eight practices identified in the science and engineering dimension of the standards (NGSS Lead States, 2013). The survey was sufficiently specific to facilitate the collection of data related to the strengths and struggles of the students in specific areas of science and engineering practices.

To effectively analyze the survey data, I separated the items presented by the instrument that were associated with science skills from those associated with engineering skills in order to obtain two separate self-efficacy scores. Therefore, Items 1, 3, 4, 6, 7, 13, 14, 15, and 16 were denoted as science skills and Items 2, 5, 8, 9, 10, 11, 12, 17, 19, 20, 21, 22, 23, and 24 as engineering skills. Item 18 was included for the analysis of overall self-efficacy but did not warrant an independent category. Differences were evident after looking at the survey items as a whole and subsequently in two separate categories. I initially intended to analyze the data as a whole for overall self-efficacy; however, an important trend emerged that needed to be revealed and discussed. Table 4 reflects the separation of the survey items.

Interviews

I distributed individual e-mail to the 10 students randomly selected to participate in the study interviews. The e-mail informed them of their selection and advised the students of the day I would be at the school to schedule the interviews. I spoke to each student to confirm they desired to continue with the study and schedule the session; all 10 desired to continue their participation. However, as noted earlier, the student who agreed to the 10th interview did not arrive at the scheduled place or time. Another student was randomly selected and subsequently scheduled for the following week.

Prior to each study interview, I read the interview protocol to each interviewee and asked for her permission to record the session. The students were also given a copy of the protocol and each granted permission to record the interview. After each session, I uploaded the recording onto to my computer and transcribed the interview on that same day. Upon completion of the transcription, I listened to the recording twice as I read the transcription to check for accuracy.

I began coding the interviews when finished with the transcription process; however, I separated the interview questions according to the research questions they addressed prior to the coding. Analysis of the interview data involved more than one type of coding method. Interview Questions 3, 5, 7, 8, and 9 addressed Research Question 1, which asked, “How do female students attending an Oregon high school perceive their self-efficacy in engineering?” Interview Questions 1, 4, 5, and 6 addressed Research Question 2, which asked

Table 4

Survey Items and Corresponding Skill Identification

Survey item number	Item statement	Skill area
1	Earn an A in science.	Science
2	Earn an A on an engineering project.	Engineering
3	Get an A in science throughout high school.	Science
4	Design and describe a science experiment.	Science
5	Design and describe an engineering project.	Engineering
6	Construct and interpret a graph.	Science
7	Develop a hypothesis.	Science
8	I can master the content in the engineering-related projects in science.	Engineering
9	I can master the content in even the most challenging engineering assignments.	Engineering
10	I can do a good job on almost all my engineering assignments.	Engineering
11	I can do an excellent job on engineering-related problems and tasks assigned.	Engineering
12	I can earn a good grade on my engineering related assignments in science.	Engineering
13	I can perform experiments independently.	Science
14	I can analyze data resulting from experiments in class.	Science
15	I can communicate results to the experiments.	Science
16	I can work with tools in the lab.	Science

Table 4 Continued

Survey item number	Item statement	Skill area
17	I can manipulate components and devices.	Engineering
18	I can assemble things.	Science/Engineering
19	I can apply difficult concepts in engineering.	Engineering
20	I can design an experiment.	Engineering
21	I can identify a problem in a design.	Engineering
22	I can develop design solutions.	Engineering
23	I can evaluate a design.	Engineering
24	I can recognize changes needed for a design solution.	Engineering

"What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?" Interview Questions 2, 4, and 5 addressed Research Question 4, which asked, "Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?" In breaking down the interview questions by the research questions, the first stage of coding incorporated Holistic Coding, Values Coding, and In Vivo Coding with Holistic Coding used first. My aim was to "capture the sense of the overall content and the possible categories that may develop" from the entire interview and each individual question (Saldaña, 2016, p. 163). The interview responses were divided into two categories based upon the Holistic Coding—(a) wants to be an engineer and (b) does not want to be an engineer.

A finer “lens” was subsequently applied to each sentence in every interview response to gain an understanding of the beliefs and attitudes of the sample through the student voices. Values coding then brought the attitudes of the students toward engineering and science to the surface. This coding also allowed a clearer understanding of student beliefs surrounding learning engineering and a future career within the field. This was accomplished by finding one or two words within the interviewee responses that represented the meaning for the students. These words or topics were placed into categories and themes developed from the final analysis. The In Vivo Coding facilitated the capture of the student voices. Saldaña (2016) noted the usefulness of this coding for adolescents because their “voices are often marginalized . . . coding with their actual words enhances and deepens an adult’s understanding of their culture and worldviews” (p. 106). The categories created for the interview responses were accompanied by quotes exemplifying the idea expressed.

In the second phase of coding, I narrowed the categories into primary themes by comparing those categories created for each individual student. Through Focused Coding, matching codes emerged across the student sample, which further narrowed the categories and allowed me to construct student meaning. The primary themes for each interview question were supported and could be heard throughout the student voices.

Three of the teacher interviews were conducted while waiting for the students to respond to the survey. An e-mail was distributed to each teacher to ask when they would like to schedule the study interview. Three of the five teachers scheduled the interviews during the week following this contact, which was four weeks into the new school year. One session was scheduled five weeks into the school year, and the fifth teacher requested scheduling during the second quarter of the school year because he wanted additional experience with observing his female students during engineering tasks. Upon completion of the first quarter, he decided not to participate in the interview because he did not feel he could provide useful feedback.

The same protocol and analysis procedures were followed with the teacher interviews as were implemented with the student interviews. The teachers were provided with the interview protocol prior to the onset of their interviews and they were asked for their permission to record their sessions prior to beginning their interviews. All four teachers granted permission to tape the sessions and, after resolving recording difficulties with the second and third interviews, the interviews were recorded, uploaded to my computer, and transcribed. As with the student sessions, I listened to the recordings as the transcripton was read twice to ensure accuracy.

Interview Question 3 was designed to answer Research Question 3, which asked, "How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?" This interview question also helped to answer Research Question 4, which asked, "Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?" I applied the same coding technique for the teacher interviews as was implemented for the student interviews. I began with Holistic Coding by analyzing the entire interview and individual questions to gain a sense of the overall data, as well as to create broad categories. I subsequently reviewed the interview transcripts line by line using Values Coding to glean the attitudes and beliefs of the teachers on student learning experiences. Each interview response was categorized and these categories were narrowed via Focused Coding into primary themes.

Yin (2016) and Creswell (2013) advanced that having a trusted colleague provide feedback supports the validity of the data and the study findings. Therefore, after I transcribed and coded the student and teacher interviews, a colleague read the transcription from one interview, categorized the primary themes, read my coding and analysis, and provided feedback on my interpretations. I did not disclose the name of the interviewee to the reviewing colleague because the peer only reviewed the data and provided an analysis, which was similar to my own. Following completion of the coding process, I randomly chose two student participants to read their respective transcriptions, the codes assigned to check for accuracy, and the emerging themes. The participants found no errors or inaccuracies during this process.

The students participating in this study had not saved any past engineering assignments, and it was too early in the school year to have current assignments. However, three of the students showed me pictures on their phones of engineering projects from the prior year. Two students built a bridge that could withstand a major disaster such as an earthquake. The third student had saved a picture of a bird’s nest built to protect newborn eggs. The artifacts were analyzed with a holistic approach (Saldaña, 2016). I looked at the pictures as a whole to uncover the meaning of the students having the pictures of the finished products. Why did the students save the pictures on their phones? What meaning did the pictures have to the students? What did the finished products tell me about their engagement, participation, and enjoyment of the lesson? Project completion and its overall appearance were also analyzed.

Summary of Findings

Themes emerged as I read through and coded the student and teacher interview transcripts and analyzed the survey data. Themes from the teacher interviews were (a) problem-solving skills, (b) high engagement, (c) activity and teaching difficulty, and (d) real-world correlation. Themes from the student interviews were (a) self-discovery, (b) challenging assignments, (c) insufficient task frequency, (d) hands-on engagement, (e) self-assessment,

(f) knowledge of engineering tasks, and (g) career in science. Themes from the artifacts were (a) pride and (b) engagement. The survey data revealed student belief in their abilities in science and engineering practices.

Teacher Interviews

Problem-solving skills. Students who are engaged and enjoy engineering assignments are generally those with problem-solving skills. It is not necessary for them to be the most gifted or brightest in the classroom, but they must be able to solve problems and "think outside the box." This was supported by one teacher interviewee who commented, "They may not be the best and brightest, but they are meeting benchmarks and can problem solve." These are the type of students who are successful at math; however, they do not have to be students of a higher level math class. This teacher went on to say,

> They need to have the academic background. It's not so much that they need a higher level math ability; it's problem solving. They learn problem solving in math classes. When they come in extremely low in that area—their problem solving and how they process—then they just aren't successful with the engineering projects.

Another teacher stressed that many of the students do not view themselves as gifted in science or engineering, but they use their creativity to problem solve and come to a solution for a design problem. He stated,

> They are the students that grab the task. They want to tear it apart . . . and see the components to figure out a solution and problem solve. It's all about problem solving and being willing to put yourself "out there."

Another educator suggested, "Giving them more of an open-ended task that I think [is] at a higher cognitive level challenges them more. It tests their problem-solving abilities."

All four teachers participating in the study interviews stressed that no difference exists between male and female students in problem-solving skills and lesson engagement. One stated, “The engineering activities are a good equalizer between male and female students. It really is about problem solving.” Another compared the tasks to when he was in high school in the following interview excerpt:

> When I was in high school it was one sided. The boys thought they had more skills and the girls let them take over. Now both boys and girls are equally engaged in the activities. Everybody is on it; everybody is problem-solving. It’s an “even playing field.”

A determining factor for success, according to the teachers, is the ability to problem solve through the initial design, analysis of the design, and the redesigning of the project. The nature of the problem-solving task led to highly engaged students.

High engagement. All four teachers participating in this study believe students are highly engaged when completing engineering assignments. This engagement appears to come from the opportunities to design, problem solve, test, and redesign. One teacher stated,

> They are engaging activities. It is more hands on; it’s not just book work. They are manipulating things. Whether it is an egg drop or catapult, they have time to think about it [and] redesign [the project]. It enhances their learning because there is such high engagement and “buy-in.”

This was supported by the following interview comments from another teacher:

> There is high engagement in the activities. The assignments require students to reflect and make changes. It requires students to be engaged and they want to be highly engaged. They get opportunities to fix their design and then test it again. The ability to

> fix mistakes . . . leads to more students involved because they know they can make it right.

The participating teachers believe that students are engaged in the lessons due to the manner in which the lessons are designed. Every student was encouraged to participate; the lessons were designed for all students. As one interviewee comment exemplified, the teachers observed "more [student] engagement in these types of activities compared to anything else we do in science." They were referring to "almost every student in the classroom." Another educator stated,

> The vast majority enjoy the assignments. It is the reengineering component; it is the freedom to fail. They know they can do it [when they can] take the data and reapply it to improve the design. It makes it so all the students are highly engaged.

Another teacher interviewee spoke of the students becoming so involved in the activities that "they are still thinking about improvements even after the project is done."

Activity and teaching difficulty. The theme that emerged from each teacher interview was the amount of time necessary to teach and perform engineering activities within the classroom. The teachers recognized that students enjoyed the assignments and were engaged, but again, viewed the projects or activities as time consuming. They cannot spend a week on one activity when they have other standards to meet and science work samples that must be completed within a specific time frame. One teacher commented, "The engineering tasks are difficult to teach; they are long [and] take a lot of time. The redesigning component is very time consuming. It is not easy to do on a frequent basis." Another teacher interviewee stated, "We don't do as many as I like; they are too time consuming. They are very involved and difficult," and a third stated, “To do worthwhile science-engineering projects, is impossible due to time constraints. It’s just kind of hard and too bad.”

Real-world correlation. The last theme that emerged in the teacher interviews was that these educators believe they do not actually know what engineers do within the workplace and the engineering tasks assigned to students are not representative of the duties of engineers. This surfaced after they were asked whether they thought the engineering assignments helped female students understand what engineers do during their workday. The participating educators were clearly unsure, as illustrated with statements such as “I am not an engineer” or “[I have not] shadowed an engineer.” One educator viewed the classroom engineering assignments as similar to what an engineer actually does within the workplace. He conjectured that engineering tasks might include “coming up with a design, researching it, prototyping things, reengineering when needed, and sharing [probable] components needed in any engineering firm, but again, I have not done that job, so I am not sure.” Two teachers expressed that that the engineering tasks do not resemble real-world scenarios. One responded,

> The field of engineering is so diverse. Engineers do different things. A couple of projects in my classroom can’t give the students background of what an aerospace engineer or environmental engineer is actually doing. It’s just too broad of a field to go over everything in just a couple of projects. The standards give students an opportunity to learn engineering in all science classes, but we are pushed to do more science practices, you know, inquiry. Getting students up to the engineering expo at Oregon State University is . . . more value because then they see all of these huge projects that they do in various areas of engineering. Where, you know, the one that I am doing here is a solar heater, but you know, there is the whole field that exploded recently with

> alternative energy. It is so huge and diverse that building a little solar heater. . . . I don't think their mind extrapolates out to what that field really is about and what the engineers are actually doing. It's just hard to see what is out there. Depending on the company they go to, it could be one thing or another.

Concern existed among the teacher sample that student assignments could not replicate real life because of budget or environmental constraints. Another educator opined,

> The engineering assignments now do not attach real-world "stuff." They [the students] need to understand that there might be a budget for materials or specifications from the community. They just can't build a bridge with no constraints. A budget makes it relevant.

Upon the conclusion of one teacher interview, she commented,

> Teachers need to be provided with examples and clear activities that they can use that are not huge productions. Teachers need assistance in teaching the lessons. They are not trained engineers and have not actually seen what engineers do in the workplace.

Student Interviews

Self-discovery. A common theme throughout the student interviews was an awareness of their involvement in the lesson. Level of involvement for the students meant the need to think out the resolution to a problem, rather than their teachers telling them what was needed to accomplish the task. One student commented,

> I feel that [we] are more involved. Instead of following someone else's process, we have to think of it on our own. We kind of like [coming] up with our own thing and [doing] our own thing. I really need to think. So, they [the lessons] are more fun because they

> are more involved and you kind of put more of yourself into it, not just like kind of, I mean, you really have to think. I don't know how to describe it.

Another student reported,

> When we have those assignments, I engage with them. Being able to create your own project, instead of being handed a materials list and shown a lab set up, is one of the more fun aspects of engineering. I believe it is what science is like in actuality versus school science. You actually have to think about what you are doing.

Another interviewee added, "I really like being able to make the assignment my own instead of having to follow specific instructions. I get to think about it. I get more involved in the project when it's like that."

Two of the students participating in this study equated the engineering assignments to a puzzle they need to put together. One explained,

> It's like pieces of a puzzle I can put together. You know, I have to think about trying to put all the parts together, except I get to make the puzzle. I feel like I get really involved in what I am doing; the class goes by fast.

The other student stated,

> So, I like engineering assignments. If they don't work out, you try to rethink what went wrong. I mainly just like trying to solve problems and reason things out. It's like a puzzle; I keep trying to fit the parts until it works. I like to think like that, you know. It gets me really excited, and I can tell I am really focusing on the parts.

Challenging assignments. The students participating in this study viewed the engineering assignments as more challenging compared to the general science assignments.

However, most of them were pushed to try harder because of the challenge of the tasks. One student reported,

> I have always gotten straight As in science. So, I think having a challenge, like an engineering assignment, that's really cool. It makes me want to work harder because I know I need to work harder to get an A in that class.

Another student commented,

> If it's something that I am interested in and I like the topic—like the engineering assignments—then I am, like, "yes, let's do this." I want to learn more about it, or if it's hard [or] engaging, then I like the challenge and I try harder. I like those kinds of problems.

One student interviewee confided,

> I kind of struggle. I am used to following specific instructions, like "You have to do it this way." So, I have to try harder. I struggle a little bit because it is not something I normally do, but I like the challenge. A challenge is a good thing; it's not a bad thing.

Another student was referring to the math in engineering assignments when she stated,

> I get excited to learn engineering, but nervous too, because engineering has a lot of math involved that we don't necessarily learn or see in our math classes. So, it's hard. I push myself to do it, but I want to do it because it's a challenge and we don't always get that type of challenge.

Insufficient task frequency. All of the student interviewees expressed that engineering tasks were not assigned with sufficient frequency. The theme *insufficient task frequency* emerged among the responses to Interview Question 1, which asked, "Do you enjoy the engineering assignments in science? Why or why not?" One student commented,

> So, yes, we haven't, or we don't really, I would say, do them often enough. I wish we did. I have liked those type of assignments since grade school. It makes me feel more interested to learn about engineering, although we never spend a whole lot of time on engineering, so I have fallen away from it. So, when we do get an engineering assignment, it's like, "Oh yay." It's like, the once in a lifetime thing.

Another student responded, "I'd say so. I really don't think we do a lot of them, but the few that we do, they are fun. We mostly learn science and do those labs." Another student interviewee stated, "We don't really do, like, a ton of them, but when we do, yes, I really enjoy them." Another respondent expressed, "I wish we did them more often. Honestly, we haven't done a ton of engineering type activities. We usually do science labs."

Hands-on engagement. When the participating students were asked why they enjoyed engineering assignments, the overwhelming response was that they liked being actively engaged in the activities. It was the hands-on aspect of the projects. One student commented, "I enjoy the engineering tasks because it [*sic*] is more hands-on and I am more of a, like, physical person. When I can see it or touch it, I can do things better." Another interviewee expressed, "I definitely like the doing of engineering. I love the hands-on stuff." According to another student,

> It's fun to be able to build something with your hands and figure out how something works. I think it makes it more fun. It's just more interesting to do things with my hands. It's more interactive compared to the things we do in science normally.

One interviewee referred back to an engineering assignment from the third grade, stating,

> I like being able to build things; that's the part I like the most. Like, in the third grade, I made a little model helicopter out of plastic silverware and tape. It still sits on my desk.

> I was so proud of it. So, I just like the satisfaction of being able to build stuff, whether it's made out of wood or fabric, like sewing. I love learning it by doing it or making it. It's more interesting and fun that way.

Self-assessment. During the study interviews, the students were asked if they perceived themselves as proficient at the engineering assignments. Two students answered the question with a solid "yes." The other eight responded with "I am good enough," "For the most part," or "I think so." One student stated, "For the most part. I get good enough grades to keep my A." Another answered, "Sure; I am good enough. I don't go home and study engineering every day. I do my best [and] I never give up." One interviewee commented,

> I would not say I was great at them, but I am not bad. I am average because I don't do anything impressive, but it's not like my teachers are disappointed in what I am doing. I am not one of the smartest students in class. It's not a bad thing. It gives me something to work for to get to the next level.

Two students responded in the same manner. One stated, "I think so. It's good enough to get a high grade." The other commented, "I mean, I am relatively good enough. I try my best."

Knowledge of engineering tasks. Question eight of the interview protocol asked students if they knew what engineers do during their routine workday. Eight out of 10 of the sample did not know what engineers do at work. One student conjectured,

> They are always calculating math. Like a rocket engineer is always trying to figure out, like, solve why the rocket won't work. Car engineers are trying to figure out what pieces work together. I don't know what they do every day.

Another succinctly stated, "Not really," and another responded, "A little bit, but I am not too sure." A third simply stated, "No."

One student interviewee mentioned the different types of courses available at the high school, such as Career Technology Education or drafting, which she thought would lead to a better understanding of what engineers do within the workplace. Because she had not taken those courses, she did not know the tasks engineers perform at work. Later in the interview, she stated, “If I knew more about engineering, then maybe I would do it. It’s hard to go into a career that I don’t know much about.” On this same topic, another interviewee revealed she did know the tasks engineers perform within the workplace and added,

> I really want to. What I know, engineering is very math based, and I really like math. It also has practical applications, which are fun, I guess. Just because I don’t know what happens day to day, does not mean the rest of it doesn’t exist. I found this out by just looking at career options and colleges. If I would be interested in different engineering, there is civil engineering [or] nuclear engineering. Those would be hard. There are lots of different types.

Another student also wished she would have learned what engineers do, commenting,

> I know there is a lot of math involved. I guess it depends on the type of engineering you go into, like electrical or engineers that work on bridges, and I know math is in it. You probably have to look at the environment in certain areas that you are working on. It depends on what you are doing. I think being an architectural engineer would be good because I watched TV shows on how to do that and, last year, I took a drafting class and that was fun, and I got to do the architectural part and that was my favorite part. So, I wish, like, I had learned earlier more about that. When I was in the third grade, I wanted to be an engineer, and that has changed since then because I wasn’t learning about it. I

> now have other interests; I learned more about other fields. So, if I would have learned more about engineering, then I would probably still be interested in it.

Two out of the 10 students of the sample had some knowledge of what engineers do within the workplace every day. Two acquired the information outside the classroom. One of them provided the following information:

> Actually, my best friend's mom is an engineer. She makes blueprints and lays them out for people that build things. So, you could be the person that comes up with the numbers. You could be the person that designs it, or build[s] it, or does trials. There is [*sic*] just so many different types of engineering. It depends on which category obviously. Well, actually, I went to a summer camp that was here. It was chemical engineering. . . . It got me interested in engineering because I never really knew what was considered engineering. It made it seem a lot easier. Because you think "Engineering, oh, you have to build rocket science or something crazy." It makes it a lot easier because there is [*sic*] all types of engineering, not just the hard stuff. Because you just really have to learn about all the different categories of engineering and it's not all the same. It's not as hard as I thought, especially if you are interested in it. It was the first time I got to mess with chemicals, and it was the first time I made something that you see. I think we made a kind of gas that goes into a car. I was, like, "I am 12 years old, and I can make this," and it was not that hard, and I was just loving it.

When the second student was in the sixth grade, she participated in a field trip to Oregon State University, visiting different engineering departments. She reported,

> I have an idea of what engineers do every day, but not really—mainly just from, like, I don't think we have ever had anyone talk about it at school. When I was in the sixth

> grade, we took a trip to the engineering department. Ever since then, that's what I wanted to do.

Career in science. All of the students interviewed in this study plan on continuing their education beyond high school. They are interested in careers within the sciences and mentioned the following 9 fields: x-ray technician, dermatologist, orthodontist, psychologist, marine biologist, zoologist, physicist, astronomer, and two of the students are interested in pursuing some type of engineering. They expressed different reasons for choosing a particular career path. The four health-care students and the zoologist sought to "help people." Two of the eight students who had no engineering interest believe they have the ability to pursue an engineering career. One stated, "Personally, no, I do not want to be an engineer. I prefer working with people more than anything else, but I think I could if I wanted to. I enjoy people more than objects. I like interacting more." The student interested in physics noted, "If I wanted to, I could be an engineer."

Artifacts

Proud. The students participating in this study were very proud of their work. They wanted to tell me about their projects, what they accomplished, and the grade they received. One interviewee offered the following description:

> We built a building last year in science. The building was a little difficult because it had to withstand an earthquake and ours was the only one that withstood a minor and a major earthquake. We had it go from a bigger base to a smaller base, and we used more supplies on the outside to make it, like, thicker. The building actually twisted, so it was kinda weird. There was a weight that you had to have on top of the building, so we had a popsicle stick on top of the building that you could place the weight on, and it would just

> stay because it was, like, in the center the whole time. We worked in a group of three. We chose our group partners. I did better than 100%. It was pretty cool.

Engagement. With their photos of completed projects, the students were able to fully explain their work. They understood why their designs were successful compared to other designs. When their own did not initially meet the standard, they persevered through the redesigning process. One student commented,

> When they give you a situation, when you have to beat it or, like, you have to meet the requirements, like, building the bridge, we had to put this lead weight on it. We had to ask how can you make it support the lead weight, or how can you make this fall so fast with just these materials. It was a challenge.

Survey Data

The students in this study responded to each survey item by indicating their belief in their ability in specific areas of science and engineering practices (1 = *very high ability,* 2 = *high ability,* 3 = *average ability,* 4 = *low ability,* 5 = *very low ability*). As noted earlier, an *uncertain* response was also an option. The data were exported to the spreadsheet from the initial computer software implemented so the response of *uncertain* could be eliminated from the average-score calculations. Survey Items 1, 3, 4, 6, 7, 13, 14, 15, and 16 were categorized as science skills and Items 2, 5, 8, 9, 10, 11, 12, 17, 19, 20, 21, 22, 23, and 24 as engineering skills. Item 18 was included to calculate the average scores for overall self-efficacy but not placed in any specific category. The scores were averages drawn solely from the students participating in the current study, rather than inclusive of the scores of student participants in other research.

Table 5 provides the average overall science and engineering self-efficacy, engineering self-efficacy, and science self-efficacy of the student study sample. The scores were divided into three categories—interviewed, not interviewed, and all students who completed the survey. An average score between 1 and 2 indicates a high to very high ability level in the respective skill; whereas an average score between 2 and 3 indicates an average to high ability in the corresponding skill. The scores indicate that the students rated themselves between high and very high ability in science and average to high ability in engineering. Those interviewed had a slightly higher self-efficacy in all skill areas compared to the students who were not interviewed.

Table 5

Survey-Participant Self-Efficacy Averages

	Self-efficacy		
Student participants	Overall	Engineering	Science
Not interviewed	2.15	2.34	1.89
Interviewed	1.66	2.27	1.59
All respondents	2.06	2.30	1.71

Individual student scores were also analyzed. Table 6 reflects the overall science and engineering self-efficacy, engineering self-efficacy, and science self-efficacy of each student. Student 10 of the table was the only student who self-rated with a higher ability in engineering compared to science. All of the other students rated themselves with higher ability in science compared to engineering. All of the students, with the exception of one, rated their ability levels higher in science skills than in engineering skills.

The data collected for each survey item were also analyzed. The computer software calculated the percentage of students who responded to each ability level for every item after the *uncertain* value was removed and the data imported back into the software. The average student

Table 6

Self-Efficacy of Participating Students

	Self-efficacy of participating students		
Student	Overall	Engineering	Science
1	2.042	2.429	1.444
2	2.667	3.214	1.889
3	2.125	2.071	2.222
4	2.682	2.846	2.375
5	1.783	2.000	1.556
6	1.292	1.429	1.111
7	2.000	2.071	1.889
8	1.417	1.714	1.000
9	1.375	1.571	1.111
10	2.833	2.500	3.333
11	1.500	1.571	1.333
12	2.083	2.214	1.889
13	2.958	3.429	2.222
14	2.083	2.286	1.778
15	2.250	2.643	1.667
16	1.864	2.333	1.333
17	2.042	2.786	1.000

belief in their own skill level in science, engineering, and combined science and engineering were calculated from the individual responses. When a large percentage of students responded with *high ability*, the average score was closer to the higher ability range (see Table 7).

The data presented in Table 7 indicate that the percentage of students who assessed themselves with a very high ability to earn an A in science was 64.71%; however, the percentage who self-assessed a very high ability to earn an A on an engineering project was only 18.75%. Those viewing themselves with a low ability to design and describe an engineering project numbered 17.65% of the sample and 35.29% rated themselves with average ability. None of the students perceived themselves with a low ability to design and describe a science experiment. All of the survey items commonly associated with science received student ratings of higher ability, compared to the items commonly associated with engineering, which received more students reporting an average rating.

Presentation of the Data and Results

Research Question 1

Research Question 1 asked, "How do female students attending an Oregon high school perceive their self-efficacy in engineering?" According to the survey results, the students participating in this study perceived their ability to be successful with engineering tasks within the average to high range. The students viewed themselves as better at tasks that are typically associated with scientific inquiry. Total self-efficacy, with all survey items combined, resulted in a score of high ability. Once the scores were separated by science and engineering ability, it became evident that the students perceived themselves with lower ability in engineering practices compared to science practices.

Table 7

Student Survey Responses

Survey item	Very high ability (%)	High ability (%)	Average ability (%)	Low ability (%)	Very low ability (%)
Earn an A in science	64.71	17.65	17.65	0.00	0.00
Earn an A on an engineering project	18.75	43.75	31.25	6.25	0.00
Get an A in science throughout high school	47.06	35.29	17.65	0.00	0.00
Design and describe a science experiment	29.41	58.82	11.76	0.00	0.00
Design and describe an engineering project	17.65	29.41	35.29	17.65	0.00
Construct and interpret a graph	29.41	64.71	0.00	5.88	0.00
Develop a hypothesis	47.06	35.29	11.76	5.88	0.00
I can master the content in engineering-related projects in science	23.53	23.53	52.94	0.00	0.00
I can master the content in even the most challenging engineering assignments	6.25	37.50	50.00	6.25	0.00
I can do a good job on almost all engineering assignments	11.76	47.06	41.18	0.00	0.00
I can do an excellent job on engineering-related problems and tasks assigned	0.00	64.71	29.41	5.88	0.00
I can earn a good grade on my engineering related assignments in science	12.50	56.25	31.25	0.00	0.00

Table 7 Continued

Survey item	Very high ability (%)	High ability (%)	Average ability (%)	Low ability (%)	Very low ability (%)
I can perform experiments independently	52.94	29.41	11.76	5.88	0.00
I can analyze data resulting from experiments in class	41.18	47.06	5.88	5.88	0.00
I can communicate results of the experiments	50.00	31.25	18.75	0.00	0.00
I can work with tools in the lab	52.94	41.18	5.88	0.00	0.00
I can manipulate components and devices	23.53	35.29	29.41	11.76	0.00
I can assemble things	35.29	47.06	17.65	0.00	0.00
I can apply difficult concepts in engineering	6.25	43.75	37.50	12.50	0.00
I can design an experiment	29.41	52.94	17.65	0.00	0.00
I can identify a problem in a design	5.88	52.94	41.18	0.00	0.00
I can develop design solutions	11.76	52.94	23.53	11.76	0.00
I can evaluate a design	11.76	58.82	17.65	11.76	0.00
I can recognize changes needed for a design solution	17.65	58.82	11.76	11.76	0.00

The students participating in this study expressed that they are “good enough” in the engineering tasks to maintain their grade point average in science. They did not perceive themselves as the best or the brightest in the classroom. When one interviewee was asked if she believed she was good at the engineering assignments, she replied,

> Yes, well, I do; I mean, I am good enough. I usually tend to get really good grades in my science classes. The engineering assignments are a little different because they are harder, but I can still keep my good grade.

This student rated herself with the highest overall engineering self-efficacy score and tied with another student on the second-highest science self-efficacy score.

Question 9 of the interview protocol asked, “Would you want to be an engineer? Why or why not?” Eight out of the 10 interviewees expressed they would not want to be an engineer. Two students desired to attend college to be an engineer, which equates to 20%. One student was ambivalent between astronomy and engineering, leaning more toward astronomy. Two of the eight who had no interest in an engineering career expressed having engineering ability. One interviewee stated, “I am set on something else. I like looking at the universe. If I wanted to, I could be an engineer.” Another responded, “Personally, no, I do not want to be an engineer. I prefer working with people more than anything else, but I think I could if I wanted to.”

Even the students who had earned very high marks on their engineering projects of the preceding year did not perceive themselves as exceptional or having very high abilities in engineering. One student scored over 100% on her building project but still rated herself as average in the ability to design and describe an engineering project, master the content of challenging engineering assignments, and evaluate designs. However, she did believe she could earn an A on engineering assignments and was very proud of her building project in that the structure could withstand a natural disaster. She rated herself with the highest self-belief rating in science and the fourth-highest self-belief rating in engineering ability.

Research Question 2

Research Question 2 asked, "What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?" The students participating in this study perceived their experiences with the engineering practices of the NGSS as challenging, which pushed them to try harder. One student commented,

> I like the engineering assignments because I like challenging myself and changing things. I have always really liked science. So, yeah, the challenge pushes me. . . . I have always gotten straight As in science, so I think having a challenge like an engineering assignment, that's really cool. It makes me want to work harder because I know I need to work harder to get an A in that class.

Some of the students perceived the engineering assignments as more challenging because of the math involved and others viewed the challenge as sourced in attempting to design a solution without established steps. One student interviewee stated,

> Well, it's like the part of science I struggle with because of the math involved. I get good grades, usually. The remodeling is confusing and challenging because we don't have instructions. I have to think about it. It makes me feel that I can be more intelligent than the average or we are all the same. Because I try harder, then I can explain it to the other kids.

Another student expressed,

> Writing it all out, figuring it out, where it all goes is fun. I like to make little changes to see how it affected it. We get to do that on our own. We have to think about each

> change. The teacher doesn't give us a set plan; we are planning. Sometimes it's hard. I like it. It makes me want to make the changes to see how it turns out.

Whether the students thought the challenge came from the math or from not having specific instructions, they were pushed to think about their learning and motivated to try harder.

All of the students opined that they were not experiencing engineering tasks with sufficient frequency. Although the engineering tasks were "challenging" and "harder," they viewed their ability in the tasks as "good enough." All of the participating students expressed the desire to have a greater number of engineering experiences. One student commented,

> There isn't anything boring about the engineering assignments. I really enjoy learning it. I really enjoy learning. It is, like, my favorite thing to do. I don't know why we don't do more. As I said before, we don't do a ton of them, but I wish we did.

Research Question 3

Research Question 3 asked, "How do the teachers of female high-school students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?" The teachers participating in this study perceived female students as highly engaged in assigned tasks involving engineering practices. The teachers opined that the students enjoy the engineering tasks because they are tailored for student engagement. The assignments are hands-on, challenge the students, and provide students with opportunities to fix original design errors. Devising solutions for such errors provides students the freedom to enjoy the assignments without the fear of failure. The teachers observed greater student engagement in engineering tasks than in any other type of assignment. As one teacher described,

> They enjoy the engineering tasks. I think it is because they can get out of their seats; it's hands on. They are thinking in the "left field," creatively, and manipulating materials. They view it as a nice change of pace from the normal. They [*sic*] engagement is higher because it is different. All the student's [*sic*] engagement is higher, which improves learning.

Another teacher stated, "Giving the students more of an open-ended task that I think is at a higher cognitive level challenges them, which they enjoy more." The teachers have heard their students describe the tasks as "fun," "challenging," and "excit[ing] to do." The students continue talking about the projects long after they are completed.

The teachers perceived no difference in lesson engagement between female and male students. As one teacher stated, "There is really no difference between boys and girls right now in terms of involvement in the tasks." Teacher comments were received regarding the girls being more hesitant in years past; however, "now they jump right into the tasks." Another teacher opined, "The engineering activities are a good equalizer between male and female students. [The successful female students] "grab the task and tear it apart and play with it to see the components work."

Research Question 4

Researcher Question 4 asked, "Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?" The 10 student interviewees described being engaged in the engineering lessons. They also expressed being aware of their learning and thinking because the lessons were challenging, hands-on, and involved many parts. The students perceive the lessons as requiring more thought and allowing for more creativity. They noted that the teachers did not provide specific steps or processes to complete the project, which forced the students to “come up with their own things.” At times, their original design was unsuccessful, which resulted in frustration; however, they viewed the process of repeatedly designing as leading to greater engagement and a better understanding of the lesson. One student stated,

> You don’t really know what is going to go wrong; you just kind of have a vision in your head. You just put it on paper. When you have to change it, it’s stressful, but I don’t want to give up. I like the challenge. It gets me really into the assignment. I can see everyone is working and experiencing the same thing. It’s fun.

The teacher data collected in this study corroborated the student data. For example, a teacher commented, “The assignments require students to reflect and make changes. It requires students to be engaged and they want to be highly engaged.”

Although two students viewed aspects of the engineering lessons as “boring,” they still perceived other areas as engaging and fun. One of these students explained “The engineering stuff is boring when we have to record and write everything down, but doing the project is really fun because you, like, are learning and you are learning actively.” The other student stated, “When I find the assignments boring, it’s just the pace of the class. We are not getting the full time. It’s too slow then.” Eight out of the 10 participating student interviewees did not find any part of the engineering assignments boring, which is a sign of engagement (Skinner, Furrer, Marchand, & Kindermann, 2008).

Both the students and teachers who participated in this study described greater engagement in the engineering lessons than in those science related because the projects were hands-on activities. The students enjoyed the active participation. As one student stated, “I love the hands-on stuff,” and another commented, “It’s fun to be able to build something with your hands and figure out how something works." The teachers supported the student feedback, one stating, "They are engaging activities; It's more hands-on." The teachers did also note that the engineering assignments are more engaging compared to other science activities performed within the classroom. The level of engagement was evident when the students spoke of assignments and showed pictures of their past completed projects. The projects were well done, and the students were able to explain how and why they built the buildings in a particular manner. This was exemplified in the following student-interview excerpt:

> When they give you a situation, when you have to beat it or, like, you have to meet the requirements, like building the bridge. We had to put this lead weight on it. We had to ask "How can you make it support the lead weight?" or "How can you make this fall so fast with just these materials?" It was a challenge. I liked having the power to do things like that in high school.

The students participating in this study were clearly engaged in and enjoying the engineering activities, so much so, they expressed the frustration of not doing them "often enough." Every student interviewed commented on wishing the engineering tasks were more often or that they were "not often enough." They wanted engineering type lessons more often because they enjoyed them. The teachers also commented that the students likely desire to experience engineering lessons more often due to the high engagement; however, the assignments are time consuming and other standards must be taught during the school year.

The participating teachers described the type of students who tend to be engaged in engineering lessons and those typically not engaged. Students who are engaged have "good problem-solving skills." These students are "meeting benchmarks and can solve problems." Students do not need to be talented nor gifted to be engaged and successful with engineering projects. One teacher explained, “They need to be able to solve problems. If not, they get frustrated easily if the design is not perfect. They don’t want to redesign when that happens. They have a fixed mind-set instead of a growth mind-set.”

Chapter Summary

My approach to analyzing the study data collected via the student surveys, interviews, and artifacts, as well as from the teacher interviews has been described. The data from all of these sources has been presented. The survey collected student ratings of their self-perceptions related to their ability in engineering and science skills. Averages were calculated from the individual student responses. The results from the coding process implemented with the student interviews revealed the following seven major themes: (a) self-discovery, (b) challenging assignments, (c) insufficient task frequency, (d) hands-on engagement, (e) self-assessment, (f) knowledge of engineering tasks, and (g) career in science. The data collected from the teacher interviews revealed the following four major themes: (a) problem-solving skills, (b) high engagement, (c) activity and teaching difficulty, and (d) real-world correlation. The artifacts presented two major themes—(a) pride and (b) engagement.

The results and themes drawn from the interviews provided data on student self-efficacy that facilitated a clearer understanding of the self-perceptions of students, as they relate to their engineering self-efficacy and learning experiences with engineering practices. The student participants perceived themselves with an average to high ability in engineering. They rated themselves higher in their science self-efficacy compared to their engineering self-efficacy. Students expressed that they are “good enough” on the engineering assignments to maintain their grade point average in science. However, two students opined that they could be an engineer if that was their chosen career path; two others desired future engineering careers.

The student interviews also provided data pertaining to why students are or are not engaged in engineering lessons. They enjoy these lessons because they are hands-on and they like manipulating materials. This enjoyment and engagement could be observed in a building assignment they described from the year prior to this study and when the students expressed that the engineering lessons were not “often enough.” They enjoyed the challenge because the lessons were usually more difficult. The teacher interviews supported these beliefs expressed by the students. The teachers also perceived that the students are more engaged in engineering because the activities are hands-on. However, students without strong problem-solving skills were not successful with the engineering assignments.

Insight gained from the results of this study will be thoroughly discussed. Three themes emerged that did not directly answer the research questions. One from the student interviews was knowledge of engineering tasks. Two from the teacher interviews were activity and teaching difficulty and real-world correlation. These themes will also be discussed in terms of their connection with the SCCT in future research.

Chapter 5: Discussion and Conclusion

Overview

Significantly fewer women than men work within every discipline of engineering in the United States (Buse et al., 2017; NSF, 2017; U.S. Bureau of Labor Statistics, 2016). This lack of female engineers is an issue because the number of STEM jobs is expected to dramatically increase (Kildee, 2017; Langdon et al., 2011). Women comprise nearly half of all wage earners within this country (U.S. Bureau of Labor Statistics, 2016). More are needed to enter the field of engineering to fulfill the projected job openings (NSB, 2018).

The NRC (2012) recognized a need for changes in K–12 science education to improve the level of interest, diversity, and literacy in STEM-related careers. The U.S. K–12 public-education system has failed to incorporate engineering concepts and skills into the science standards (Moore et al., 2015). Consequently, students are not getting experience in engineering or learning engineering concepts. The NRC (2012), aware of the current and future STEM job market and quality of K–12 science education, published science content knowledge and skill recommendations. The NGSS are performance expectations based upon the NRC recommendations (NGSS Lead States, 2013). The standards provide all students with opportunities to experience real-world science and gain engineering knowledge and skills through the three dimensions of learning (NRC, 2012; NGSS Lead States, 2013). Specifically, the engineering-practices component provides students with engineering experience to increase their interest in the field. Lent et al. (1994) advanced that positive learning experiences can improve self-efficacy, which in turn, increases interest in the respective field of study.

The state of Oregon adopted the NGSS in the spring of 2014 (Oregon Department of Education, n.d.) and the case study site began integrating the standards into the curriculum in

2015. The curriculum was aligned with the NGSS by the 2016–17 academic year and students began participating in engineering tasks that same year. The purpose of this case study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. Aims were to gain a clearer understanding of the level of student engagement in the lessons and reasons for engagement or lack of engagement. A summary and discussion of the results will be presented, as well as a discussion on how the results relate to past literature, the limitations of the current study, implications of the results, recommendations for future research, and the study conclusion.

Summary of the Results

The theoretical framework for this study was the social cognitive career theory (SCCT) developed by Lent et al. (1994). These researchers formed this theory on the concept of self-efficacy influencing interest, goals, and career choice. This construct guided the design of this study including development of the research questions and selection of the methodology. SCCT was developed from the Bandura (1977) social learning theory, the Betz and Hackett (1981) research on career choice, and the Bandura (1986) social cognitive theory. An individual tends to avoid tasks in which they have low self-efficacy (Bandura, 1977). However, those who believe they can be successful in a task are more likely to develop an interest in the respective field (Fouad et al., 2010). Research has shown that persistence in engineering is directly linked to self-efficacy and students pursuing a career within the field (Lent et al., 2003; Lent et al., 2013; Navarro et al., 2014).

Traditionally, women have not chosen careers requiring math or engineering skills (Betz & Hackett, 1981). Lent et al. (1994) postulated that interest in a career stems from high self-efficacy in the respective area of study, which subsequently leads to goals and action toward a career in the field. The low percentage of women within the field of engineering might be due to low self-efficacy in engineering skills. Hardin and Longhurst (2016) found that undergraduate, female, introduction-chemistry students experience lower STEM self-efficacy than do their male counterparts. Betz and Hackett (1981), as well as Novakovic and Fouad (2012), found that women experience lower self-efficacy in fields of work typically considered less traditional for women such as math, engineering, and accounting. At the college level, Litzler et al. (2014) and Inda et al. (2013) found that women have less confidence in their ability to complete an engineering program.

The NGSS encourage students to acquire knowledge, skills, and experience in science and engineering practices (NGSS Lead States, 2013). The development of engineering skills provides students with the opportunity to improve their confidence in that area of study and the opportunity to understand the role of an engineer within the workplace. The intent of the NRC (2012) and the NGSS (NGSS Lead States, 2013) writing team was that more students would be interested in science and engineering careers.

This current case study was conducted at an Oregon high school. This study-site was selected because it represented a typical Oregon high school and integrates the NGSS into its science courses. The small group of female students who participated in the study were typical 4-year high-school students. The purpose of the study was to develop insight from the self-perceptions of a small group of female students attending an Oregon high school regarding their self-efficacy in engineering. The following research questions guided the research:

1. How do female students attending an Oregon high school perceive their self-efficacy in engineering?

2. What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?
3. How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?
4. Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?

To participate in this study, students needed to be female, enrolled in a science course, and attending a school integrating the NGSS. Participating teachers needed to be teaching science integrating the NGSS, trained in the NGSS, and have five or more years' experience teaching science. Those eligible to participate numbered 517 female students and six science teachers. After presenting the study to all eligible students, 311 indicated they were interested in study participation and 33 of these students returned a signed parent and student consent form. Of these 33 students, 23 provided an e-mail address for the survey. A total of 17 students responded to the survey invitation. Of the eight science teachers at the study-site high school, six were eligible to participate in the study; a total of five teachers consented to participate.

Data collection involved a student survey, student interviews, student artifacts, and teacher interviews. Collection and analysis of the survey data were supported by a computer-software program and a spreadsheet facilitated calculations. The survey results indicated the average level of science and engineering self-efficacy for each student participant. The interviews were audiotaped; transcribed; and subsequently coded for patterns, themes, and categories (Saldaña, 2016). The coding methods included Holistic Coding, Values Coding, In Vivo Coding, and Focused Coding.

The following primary themes emerged from the student interviews: (a) self-discovery, (b) challenging assignments, (c) insufficient task frequency, (d) hands-on engagement, (e) self-assessment, (f) knowledge of engineering tasks, and (g) career in science. The themes that emerged from the artifacts are (a) pride and (b) engagement. The survey data revealed student belief in their own abilities in science and engineering practices. The following themes were developed from the teacher interviews: (a) problem-solving skills, (b) high engagement, (c) activity and teaching difficulty, (d) real-world correlation. Collectively, the data collected allowed me to answer the research questions.

Discussion of the Findings

Research Question 1

Research Question 1 asked, “How do female students attending an Oregon high school perceive their self-efficacy in engineering?” According to the survey results, this sample of students perceived their engineering self-efficacy to be above the average-ability range but below the high-ability range. When the survey results were separated into two categories—science skills, and engineering skills—it became evident that the students viewed their self-efficacy in these two areas differently. Their science self-efficacy was higher than their engineering self-efficacy. The students rate their ability in science skills in the high to very high range.

Responses to the individual survey items indicated that 64.71% of the students rated themselves with a very high ability to “earn an A in science,” whereas only 18.75% of this student sample self-assessed that they could “earn an A on an engineering project” and 0.00% of the students rates themselves as able to “do an excellent job on engineering-related problems and tasks assigned." Overall, the difference between rated ability levels in engineering and science skills was notable. The students perceived they had lower ability in engineering-related tasks; however, the engineering tasks were integrated into their science courses. The students still expressed that they could earn an A in science because the engineering tasks were a low percentage of their overall science grade.

During the study interview, the students provided their perceptions of their own engineering self-efficacy. Eight out of the 10 students perceived themselves as "good enough" in engineering to continue to earn an A in science. One interviewee stated, "I think so. It's good enough to get a high grade." Another responded, "Sure; I am good enough. I don't go home and study engineering every day. I do my best. I never give up." The interviews allowed for an understanding of why students rate themselves lower in the engineering skills compared to the science skills. They did not claim a high ability in engineering; however, the majority of respondents reported usually earning an A in science or made reference to earning a high grade in science overall. One student stated, "For the most part, I get good enough grades to keep my A," which was similar to other responses.

The perceived ability of the students was also indicated in their responses to the following question: "Would you want to be an engineer?" Only 20% of the students responded affirmatively to this query. The two students who wanted to become engineers still had a higher science self-efficacy than engineering self-efficacy; however, it was not as high as other students who desired to enter the medical field. An additional 20% of the students perceived themselves with the ability to be an engineer but were more interested in another field. These students also had a higher science self-efficacy compared to their engineering self-efficacy. However, the two students who perceived themselves with the ability to be an engineer had a higher overall self-efficacy score than the other students.

Students who earned high grades on their engineering assignments still perceived their engineering self-efficacy to be between average and high ability. One student earned over 100% on her project. She described the project in great detail and with enthusiasm. She reported high ability overall but average ability in the area of designing and describing an engineering project. Another student also excelled in her engineering project. She also rated her engineering ability as average to high. The student who reported the highest self-efficacy overall on the survey, stated she “was not good at math” and “didn’t really understand algebra.” She also reported, “I usually tend to get really good grades in my science classes. The engineering assignments are a little different because they are harder, but I can still keep my good grade.” When she described her photo of a building project, she was enthusiastic and expressed her enjoyment while also stating it was “really hard” and “I wasn’t sure if I could do it.”

The findings related to Research Question 1 correspond to those for Research Question 2. All of the participating students reported that engineering projects are not assigned with sufficient frequency. Therefore, they were unable to gain the experience in engineering that they did with science. Additionally, the teachers reported that engineering tasks are difficult to teach, as one educator succinctly stated in an interview comment. She added, “They are long; they take a lot of time. The redesigning component is very time consuming. It is not easy to do on a frequent basis.” This is a theme that was repeated by all four participating teachers.

Research Question 2

Research Question 2 asked, “What are the perceptions of female students attending an Oregon high school regarding their exposure to learning experiences grounded in the engineering practices of the NGSS?" The participating students perceive their learning experiences with the engineering practices of the NGSS as challenging, which pushed them to try harder. They enjoyed the assignments, even though they were "pushed to work harder." It was evident they enjoyed the tasks because one emerging theme from every student interview was the frustration that engineering tasks are not assigned with sufficient frequency.

Several students participating in this study perceived the challenging aspects of the engineering tasks as stemming from the math component of the exercises. One student stated, "Well, it's like the part of science I struggle with because of the math involved. I get good grades, usually." Another student referred to the math involved in engineering assignments by stating,

> I get excited to learn engineering, but nervous too, because engineering has a lot of math involved that we don't necessarily learn or see in our math classes. So, it's hard. I push myself to do it, but I want to do it because it's a challenge and we don't always get that type of challenge.

Other students view the challenge as stemming from the need to "think on our own without set steps." One student interviewee commented, "The remodeling is confusing and challenging because we don't have instructions. I have to think about it. It makes me feel that I can be more intelligent than the average or we are all the same." Another student reported,

> I feel that they are more involved. Instead of following someone else's process, we have to think of it on our own. We kind of like come up with our own thing and do our own thing. I really need to think. So, they are more fun because they are more involved and you kind of put more of yourself into it, not just like kind of, I mean, you really have to think.

As a whole, the student sample in this study were able to reflect on their learning experiences and articulate the need to “work harder to get an A in that class.”

Although students expressed that the engineering tasks require more effort, they still enjoyed the tasks. They expressed a level of frustration because they were not experiencing them as often as they would like. Of the 10 participating students, all commented on not experiencing engineering tasks with sufficient frequency. These responses were unsolicited because the student interviewees were not asked about the frequency of the tasks. Although the students viewed the tasks as challenging, the tasks were not so far above their ability that they quit trying. On the contrary, they wanted to try harder and experience the tasks with greater frequency in order to gain a clearer understanding of the engineering field. The following excerpt from a student interview supports the comments of other interviewees:

> So, yes, we haven’t, or we don’t really, I would say, do them often enough. I wish we did. I have liked those type[s] of assignments since grade school. It makes me feel more interested to learn about engineering, although we never spend a whole lot of time on engineering so I have fallen away from it. So, when we do get an engineering assignment, it’s, like, “Oh yay.” It’s, like, the once in a lifetime thing.

Research Question 3

Research Question 3 asked, “How do the teachers of female students attending an Oregon high school and exposed to the engineering practices of the NGSS perceive the learning experiences of these students?” The teachers participating in the study interviews perceived their female students as highly engaged in assigned engineering tasks. They viewed the curriculum as designed to engage a greater number of students compared to other types of activities. The students are more engaged because the tasks are hands-on and they have opportunities to reflect on their projects and redesign them when necessary. One teacher stated,

> They are engaging activities; it is more hands on. It's not just book work. They are manipulating things. Whether it is an egg drop or catapult, they have time to think about it [and] redesign [the project if necessary]. It enhances their learning because there is such high engagement and "buy-in."

Another teacher reported,

> There is high engagement in the activities. The assignments require students to reflect and make changes. It requires students to be engaged and they want to be highly engaged. They get opportunities to fix their design and then test it again. The ability to fix mistakes provides more thought and time to tie things together, which leads to more students involved because they know they can make it right.

The participating teachers observed no difference between male and female students in terms of engagement or problem-solving skills. As long as the students demonstrated "good problem-solving skills," they were more likely to successfully complete the lessons. According to one teacher, the "engineering activities are a good equalizer between male and female students. It really is about problem solving." This teacher perceived the curriculum as designed to include all students, not only boys or only girls. Another educator explained,

> When I was in high school, it was one sided. The boys thought they had more skills and the girls let them take over. Now both boys and girls are equally engaged in the activities. Everybody is on it; everybody is problem solving. It's an "even playing field."

Research Question 4

Researcher Question 4 asked, “Why or why not are female students attending an Oregon high school engaged in lessons addressing the engineering practices of the NGSS?” The students participating in this study viewed themselves as engaged in the engineering-practice lessons. All stated they were engaged in the activities because the lessons were challenging, hands-on, and interactive. One student reported, “I enjoy the engineering tasks because it [*sic*] is more hands-on and I am more of a, like, physical person. When I can see it or touch it, I can do things better.” Another student interviewee stated, “I definitely like the doing of engineering. I love the hands-on stuff,” and another commented,

> It’s fun to be able to build something with your hands and figure out how something works. I think it makes it more fun. It’s just more interesting to do things with my hands. It’s more interactive compared to the things we do in science normally.

The participating teachers agreed that the engineering tasks are more engaging because of the hands-on aspect of the lessons. One teacher stated,

> They are engaging activities. It is more hands on. It’s not just book work. They are manipulating things. Whether it is an egg drop or catapult, they have time to think about it [and] redesign [the project if necessary]. It enhances their learning because there is such high engagement and “buy-in.”

The teachers view of the engineering lessons as more engaging compared to other assignments was evident when they reported that nearly every student in their classrooms is engaged in the learning.

The engineering lessons required students to think about their learning when asked to create the design, then redesign their product when the original design did not work as planned.

This process required the students to be reflective, creative, and engaged. One student commented, “I really like being able to make the assignment my own instead of having to follow specific instructions. I get to think about it. I get more involved in the project when it’s like that.” The teachers also believe the engineering assignments require students to reflect and think about their learning. One teacher stated, “The vast majority enjoy the assignments. It is the reengineering component. It is the freedom to fail. They know they can do it and then take the data and reapply it to improve the design. It makes it so all the students are highly engaged.” As another teacher explained during her study interview,

> There is high engagement in the activities. The assignments require students to reflect and make changes. It [*sic*] requires students to be engaged and they want to be highly engaged. They get opportunities to fix their design and then test it again. The ability to fix mistakes provides more thought and time to tie things together, which leads to more students involved because they know they can make it right.

Results in Relation to the Literature

Historically, female students do not choose to enter the field of engineering (Buse et al., 2017; NSB, 2018; NSF, 2017; U.S. Bureau of Labor Statistics, 2016). Recently, the low number of female students entering STEM-related careers has become an issue because the number of positions is expected to dramatically increase (Kildee, 2017; Langdon et al., 2011). The NGSS were written to provide students with opportunities to explore and experience the roles of scientists and engineers within the workplace in order to increase student interest in science and engineering (NRC, 2012; NGSS Lead States, 2013).

All 10 students interviewed for this case study desired to pursue a science-related field upon high-school graduation. Miller et al. (2006) found that female high-school students show little interest in physical science and math but are interested in life and social sciences. Of the student sample in this current study, six expressed interest in biological science, one desired to study physics, one was “maybe” interested in astronomy or “possibly” engineering, and two students wanted to be engineers. These data run parallel to the number of women currently working in science and engineering fields (NSB, 2018). In 2018, women comprised 53.3% of all biological and medical scientists in this country, 16.7% of physicists, and 14.5% of all engineers.

Of the student sample interviewed in this current study, 20% definitely desired to be engineers, which is similar to the number of female students graduating with an engineering degree in the United States (NSB, 2018). The students in this study experienced engineering tasks and learning new skills; however, they were not experiencing these tasks with sufficient frequency and did not know or understand the role of an engineer within the workplace. This was supported by the teachers who explained the lack of time to integrate engineering projects and tasks into their teaching due to the time it takes to teach engineering concepts and the number of science standards that must be concurrently taught.

The low interest of students in an engineering career, as well as their lack of understanding surrounding the role of engineers within the workplace, may be due to the dearth of engineering learning experiences. According to Bandura (1977), four factors influence self-efficacy—successful performance of a given task, viewing others perform the task, verbal persuasion, and support or barriers from others. These factors work to increase or decrease overall self-belief in the ability to succeed. Betz and Hackett (1981) postulated that the first factor—learning experiences—is the most influential to self-efficacy in career choice. Lent et al. (1994) postulated that the self-efficacy of students, as well as their outcome expectations, have a direct impact on interest, goals, and academic and career choice. Students have reported not experiencing engineering lessons with sufficient frequency, and the teachers interviewed for this current study opined that it would be difficult for students to know the role of engineers within the workplace from two or three engineering projects per year.

Sheu et al. (2018) conducted a meta-analysis of 104 research studies published over 37 years from 1977 through 2013. This body of research involved samples of students interested in STEM-related fields. These researchers found that successful learning experiences and verbal persuasion might work together to create self-efficacy. The two students desiring to be engineers in this current study commented that they received positive feedback from their teachers and one of the students participated in a field trip to a college campus where postsecondary students discussed their engineering experiences. Another student, who was undecided between astronomy and engineering, attended an engineering summer camp. The experience left this participant with a positive impression of the field of engineering as a career.

Students with high self-efficacy and interest are more likely to continue in an engineering program (Lent et al., 2013; Navarro et al., 2014). A prediction of student interest in engineering can be made by examining the self-efficacy of the students (Lent et al., 2013; Lent et al., 2016). They must believe they can learn the necessary engineering skills to build interest in an engineering career. The students in this case study may have been more interested in other fields of study because they had a higher self-efficacy in those areas. The students perceived themselves as able to earn an A in science but not in engineering tasks. Confidence leads to an interest in engineering and eight of the 10 participating students perceived themselves as "good enough" in their engineering lessons.

The findings of this case study did not indicate whether female students have a higher or lower engineering self-efficacy compared to male students because male students were not included in the study. In a recent meta-analysis, Sheu et al. (2018) found that female students experience higher levels of performance anxiety in STEM-related activities compared to their counterparts. In this current case study, the student sample found the engineering activities to be “harder” and more “challenging” and they expressed a level of excitement when the tasks were presented. However, one student did mention being “nervous, too, because engineering has a lot of math involved that we don’t necessarily learn or see in math classes.” Another student confided, “I struggle a little bit; it makes me nervous because it is not something I normally do.”

The students participating in this study did not have low self-efficacy in engineering; however, they did not report a high to very high engineering ability. According to the survey data, the engineering ability of the students was self-reported as between average and high, although their self-efficacy was lower in engineering than in science. They reported having higher ability in science with average scores between high and very high ability. The students reported that they perceived themselves as “good enough” in engineering to maintain their grade point average in science. Their self-efficacy in engineering could be reflective of their reported lack of instructional experience.

Although student self-efficacy was lower in engineering than in science, the students who participated in this study enjoyed engineering tasks and displayed positive attitudes toward the field. The data collected from both students and teachers indicated that the students were engaged in the engineering lessons because they were challenging, interactive, and hands-on; they expressed the desire to experience the lessons more often. These data are similar to that reported in past literature. When instructors consistently provide challenging lessons and activities, students are cognitively engaged in applying scientific skills (Kang et al., 2016), which is necessary for engineers. Brown et al. (2016) found that students began to understand the value of STEM as they engaged in problem-based learning. Additionally, student desire to continue to learn in STEM areas strengthened. Kim (2016) found that the attitudes of female students toward science improved when the activities were fun, and Brown et al. reported that female students understood the value of STEM as they engaged in related learning. Hugerat (2016) also found that students were more positive when they were actively engaged in science.

The teachers participating in this current study reported that both female and male students were equally engaged in the engineering lessons. One educator stated, “The engineering activities are a good equalizer between male and female students.” The writing team of the NGSS ensured that all students would be engaged and challenged by the standards (Lee et al., 2014), which was confirmed in the data analysis of this research. The students who had photos of their past engineering projects were able to articulate every aspect of the projects, demonstrating their level of engagement.

As noted earlier, both the students and teachers in this study reported that engineering lessons were not delivered with sufficient frequency. The resulting lack of experience may be why 80% of the student sample did not know the role of engineers within the workplace. One student even stated that if she understood “more about engineering,” then she “would do it.” She reported that it was difficult to enter a field when unfamiliar with the routine job requirements. Students are clearly not experiencing instruction in engineering very often, and having no understanding of the role of engineers within the workplace could correlate with the self-reports of teachers that they are unsure themselves of daily activities performed by engineers. The teachers also reported an insufficient amount of time to assign engineering tasks and deliver related instruction.

Prior to the NGSS, the majority of science curriculum across this nation did not include engineering concepts or expose students to engineering instruction (Moore et al., 2015). U.S. teachers did not have sufficient knowledge of the role of engineers within the workplace (Page et al., 2013), which corroborated the data gathered from the teachers participating in this current study. Whitworth and Wheeler (2017) noted that science teachers desire to incorporate engineering tasks into the curriculum but “don’t know how” (p. 26). It is difficult for teachers to provide such descriptions when they are unsure themselves. After the NGSS were created, teachers reported a lack of training and resources, as well as insufficient time to teach the standards (Haag & Megowan, 2015). Those participating in this case study attended professional development on the use and implementation of the NGSS. However, these educators continued to struggle with time issues and the need for additional resources to address the engineering practices integrated into the standards.

Limitations

In this case study, participating students completed a Web-based survey. Ten students signed the consent form but did not provide the e-mail address required to participate in the survey. Another six did not respond to the survey request that was sent via e-mail. An option to participate in a face-to-face survey might have produced a greater response rate and decreased the number of students who opted out of the interview portion of the study by not responding to the online survey. Economically disadvantaged students may not have had an e-mail address or, if they provided an e-mail, may not have had access to a computer. The students could have used a school computer; however, they might not have felt comfortable using the school equipment due to the Acceptable Use Policy signed by the students at the beginning of the academic year.

Another limitation of this study was my decision to have two participants check for accuracy of their interview transcripts, rather than having each participant involved in this member-checking process (Creswell, 2013). Both students believed their transcripts were accurate. Following this review, they were shown the transcript coding and themes that emerged from the analysis. Neither participant provided feedback on these, other than to express they viewed the coding and themes accurate and interesting. I established credibility in the study by employing several of the validity strategies recommended by Creswell such as data triangulation, peer review, member checking, revealing any researcher bias, and providing a rich description of the data. Additionally, all facets of this research were conducted by me (see Appendix D).

Implications of the Results for Practice, Policy, and Theory

The implications of this study demonstrate the need for a greater number of opportunities for female students to experience engineering tasks. Although the NGSS include engineering practices, the students participating in this study reported that the frequency of engineering lessons is insufficient, and the teachers reported a lack of time to provide instruction on engineering with fidelity. The students did not report their engineering self-efficacy to be as high compared to their science self-efficacy. If female self-efficacy in engineering is to increase, students must be offered additional opportunities to experience engineering instruction.

The implications of the study findings evidence the need for continued professional development for science teachers, as well as additional preparation time to create real-world engineering scenarios and to implement the NGSS. When the NRC (2012) introduced science recommendations, Bybee (2014) suggested changes to teacher-education programs to ensure educator readiness for teaching science by incorporating science and engineering practices. However, nearly 90% of science teachers within the United States were teaching prior to introduction of the NGSS (National Center for Education Statistics, 2017) and did not attend a school with a reformed science-education program. When the NGSS were adopted in the United States, according to Boesdorfer and Greenhalgh (2014), less than 10% of the existing science teachers felt “very well prepared to teach engineering” (p. 51). The results of this current study continue to reflect the need for additional teacher training on engineering concepts and how to deliver instruction on engineering practices. The teachers did not know the role of engineers and voiced the need for additional teaching tools and training. Not only did they voice these needs, but they also expressed the need for additional preparation time to integrate engineering tasks into their classrooms.

High-school students would also benefit from additional teacher training. Teachers must know the role of engineers within the workplace so they can pass this information on to their students. Mullet, Kettler, and Sabatini (2018) recently found that gifted high-school students studying STEM excelled when their “teachers were highly competent, passionate about teaching, experts in their subjects, and modeled dedication through hard work” (p. 87). The teachers participating in the current study model dedication; however, they need additional support to provide students with more real-world engineering experiences. The students are engaged in engineering tasks, but they are not taught engineering concepts with sufficient frequency.

The students in this study who reported participating in an engineering summer camp or field trip had a more positive perception of engineering. Sheu et al. (2018) advanced that observing others might be key to students persisting with tasks that are unfamiliar and hence uncomfortable for them (p. 131). Students who participated in engineering activities outside the classroom demonstrated a greater understanding of the role of an engineer within the workplace and wanted to learn more about the engineering field, which aligns with social cognitive career theory (SCCT). According to Lent et al. (1994), positive learning experiences influence interest and goals in career choice. Students benefit from hands-on experience that is correlated to specific career options (Kekelis, Larkin, & Gomes, 2014). The teachers in this study also expressed that students would benefit from observing what engineers do on a college campus. Understanding the engineer role is impossible with small, infrequent projects. Both students and teachers would benefit from attending engineering camps, visiting engineers on college campuses, or having an engineer visit their classrooms.

Recommendations for Future Research

The findings from this case study have led to recommendations for future research. The inclusion of male students, drawing data from students and teachers within additional high schools, and increasing the duration of the study would allow for valuable comparative data. The teachers in this study perceived no difference between male and female students regarding engagement. Because I did not collect data on the self-perceptions of male students regarding their engineering self-efficacy, it is unknown as to whether male students view themselves as engaged and proficient at classroom engineering tasks. Collecting data from male students would allow researchers to compare the self-perceptions of both males and females regarding engineering self-efficacy after participating in a curriculum aligned to the NGSS.

Several NGSS-aligned curricula are currently implemented within high schools throughout the state of Oregon. Expanding this research to more study sites would allow researchers to determine whether a difference exists in student self-perceptions of engineering ability after participation in a curriculum that incorporates engineering tasks with greater frequency. Additionally, collecting data prior to an engineering-related task and again at the end of the respective school year would allow for measurement of student growth in this area. The data collected in this study represented student self-perceptions in a moment of time. It is unknown as to whether their self-perceptions of engineering self-efficacy improved over any specific timeframe.

Collecting data from other high schools within the state of Oregon and other states would further understanding of the perceptions of female students with regard to engineering self-efficacy. This current study could be expanded to high schools across the country that adopted the NGSS and schools that did not adopt the standards to obtain comparative data. Finally, a single study-site high school in Oregon was not representative of a diverse population; however, it was typical for its region of Oregon. Expanding the study to other states would give a more representative sample of U.S. student populations and facilitate educator understanding of why female students tend to lack interest in a future engineering career.

Conclusion

Students who participated in this case study rated their engineering self-efficacy from average to high. Those who participated in the study interviews viewed themselves as “good enough” in the engineering tasks to earn a high grade in science. They expressed that engineering tasks are assigned with insufficient frequency; however, those that were assigned were challenging. They enjoyed the challenge because the tasks were hands-one, involved, and required them to think about their learning and try harder to maintain their overall grade point average in science. Although the students were experiencing engineering tasks, they did not know the role of engineers within the workplace. They indicated they might choose a career in engineering if they understood that role. The number of female students interested in engineering as a career ran parallel to the number of women working within the engineering field

(NSB, 2018). Students who participated in extracurricular engineering activities had a positive attitude toward the engineering field.

The teachers who participated in this case study perceived that female students are engaged in engineering tasks assigned within the high-school classroom. They viewed the level of engagement as equal to that of male students. The teachers expressed frustration over insufficient time during the school year to teach a greater number of engineering tasks and concepts. They freely divulged that they did not know the role of engineers within the workplace. The types of assignments they generated could not adequately describe the various types of engineers and their real-world activities. The teachers believe an outside source could better increase the understanding of female students regarding the role of engineers.

Providing female students with additional opportunities to experience engineering through camps, visits to college campuses, or speakers could be helpful in increasing the interest of this student population in the field of engineering. Providing teachers with additional professional development specific to the engineering practices of the NGSS, along with the time to teach and implement the standards, would be helpful to teachers as they work to provide students with greater opportunities to experience engineering tasks within the high-school classroom. The results of this study indicate that the inclusion of engineering practices in high-school curriculum provides students with engineering experience, albeit limited. The small group of female students in this case study rated themselves with average to high engineering self-efficacy. The students were engaged in engineering tasks because the tasks were challenging, hands-on, involved, and required the students to think about their learning. They expressed a desire for additional learning experiences within this field. Perhaps giving female students greater opportunities to experience engineering will increase their self-efficacy within this area of study, as well as the number of female students subsequently choosing to enter this dynamic field.

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Appendix A: Consent Forms

TEACHER CONSENT FORM

Title: High School Female Students Engineering Self-Efficacy with an NGSS Aligned Curriculum
Investigator: Joyce Russo
Institution: Concordia University-Portland
Faculty Advisor: Dr. Mark Jimenez

Dear Participant,

You have been invited to participate in a research study that is examining female students engineering self-efficacy. The purpose of the study is to understand why or how female students choose to become Engineers. I will begin collecting data for the study once permission slips are received from the students', guardians, and teachers.

To be in the study, the students will participate in a survey that will take approximately five minutes to complete. The survey asks general questions about the student's belief in their engineering abilities. Ten students will be randomly chosen to participate in a short interview. During the interview, the students will be asked to expand on their survey answers. Teachers will be invited to participate in a brief interview. The interview consists of seven questions on the level of female students' engagement in engineering lessons. The interview should take less than 30 minutes of your time.

There are no psychological risks to participating in this study. The researcher will protect all participants information. I will record the interviews to ensure accuracy. The recordings will be transcribed by me, the principal investigator, and the recordings will be deleted when the transcription is completed. Any information provided will be coded so that it cannot be linked to a particular student or teacher. Any name or identifying information will be kept secure. When the investigator looks at the data, none of the data will have a name or identifying information. The participants or school will not be published. The information collected will be kept in a secure place for three years and then destroyed.

The information may help educators understand why female students do or do not choose a career in Engineering. And, may lead to more female students choosing a career in engineering. This information will not be distributed to any other agency and will be kept private and confidential. The only exception to this is if the participant tells me of abuse or neglect that makes me seriously concerned for the participant's immediate health and safety.

Your participation is greatly appreciated. You are free to choose not to participate or can stop the study at any point. You can skip any question, and there is no penalty for not participating. You may withdraw consent at any point in the study.

You will receive a copy of the signed consent form. If you have any questions, you can talk directly to me. If you would like to speak to someone other than the primary researcher, you can call Concordia University-Portland Oralee Branch directly at 503-493-6390 or obranch@cu-portland.edu

Your Statement of Consent:

I have read the above information. I asked questions if I had them, and my questions were answered. I volunteer my consent for this study.

______________________________ ___________
Participant Name Date

______________________________ ___________
Participant Signature Date

______________________________ ___________
Investigator Name Date

______________________________ ___________
Investigator Signature Date

Investigator: Joyce Russo
c/o: Professor Mark Jimenez
Concordia University – Portland
2811 NE Holman Street
Portland, Oregon 97221

STUDENT CONSENT FORM

Title: High School Female Students Engineering Self-Efficacy with an NGSS Aligned Curriculum
Investigator: Joyce Russo
Institution: Concordia University-Portland
Faculty Advisor: Dr. Mark Jimenez

Dear Student Participant,

You have been invited to participate in a research study that examines female students engineering self-efficacy. The purpose of the study is to understand why or how female students choose to become Engineers. Science teachers at the high school are invited to participant in the study as well. Participants will not be paid to be in the study. The researcher will begin collecting data once permission slips are received from the guardians of the participants and the teachers.

To be in the study, you will participate in an on-line survey that will take approximately five minutes to complete. The survey asks general questions about your belief in your engineering abilities. Six to ten students will be randomly chosen to participate in a short interview. During the interview, you will be asked to expand on your survey answers. The interview will take approximately 30 minutes.

There are no psychological risks to participating in this study. The researcher will protect all participants information. I will record the interviews to ensure accuracy. The recordings will be transcribed by me, the principal investigator, and the recordings will be deleted when the transcription is completed. Any information provided will be coded so that it cannot be linked to a particular student or teacher. Any name or identifying information will be kept secure. When the investigator looks at the data, none of the data will have a name or identifying information. The participants or school will not be published. The information collected will be kept in a secure place for three years and then destroyed.

The information may help educators understand why female students do or do not choose a career in Engineering. The research may lead to more female students choosing engineering as a career in the future.

This information will not be distributed to any other agency and will be kept private and confidential. The only exception to this is if you tell me of abuse or neglect that makes me seriously concerned for your immediate health and safety.

Your participation is greatly appreciated, but I acknowledge that the questions I am asking are personal in nature. You are free, at any point, to choose not to engage with or stop the study. Participants can skip any question, and there is no penalty at school for not participating. You may withdraw consent at any point in the study.

You will receive a copy of the signed consent form. If you have any questions, you can talk directly to me. If you would like to speak to someone other than the primary researcher, you can call Concordia University-Portland Oralee Branch directly at 503-493-6390 or obranch@cu-portland.edu

Your Statement of Consent:

I have read the above information. I asked questions if I had them, and my questions were answered. I volunteer my consent for this study.

___________________________________ ____________
Participant Name Date

___________________________________ ____________
Participant Signature Date

___________________________________ ____________
Investigator Name Date

___________________________________ ____________
Investigator Signature Date

Investigator: Joyce Russo
c/o: Professor Dr. Mark Jimenez
Concordia University – Portland
2811 NE Holman Street
Portland, Oregon 97221

MINOR CONSENT FORM

Title: High School Female Students Engineering Self-Efficacy with an NGSS Aligned Curriculum
Investigator: Joyce Russo
Institution: Concordia University-Portland
Faculty Advisor: Dr. Mark Jimenez

Dear Guardian,

Your child has been invited to participate in a research study that is examining female students engineering self-efficacy. The purpose of the study is to understand why or how female students choose to become Engineers. Science teachers at the high school are invited to participant in the study as well. Participants will not be paid to be in the study. The researcher will begin collecting data once permission slips are received from the guardians of the participants and the teachers.

To be in the study, the students will participate in a survey that will take approximately five minutes to complete. The survey asks general questions about the student's belief in their engineering abilities. Ten students will be randomly chosen to participate in a short interview. During the interview, the students will be asked to expand on their survey answers. The interview will take approximately 30 minutes.

There are no psychological risks to participating in this study. The researcher will protect all participants information. I will record the interviews to ensure accuracy. The recordings will be transcribed by me, the principal investigator, and the recordings will be deleted when the transcription is completed. Any information provided will be coded so that it cannot be linked to a particular student or teacher. Any name or identifying information will be kept secure. When the investigator looks at the data, none of the data will have a name or identifying information. The participants or school will not be published. The information collected will be kept in a secure place for three years and then destroyed.

The information will help educators understand why female students do or do not choose a career in Engineering. The research may lead to more female students choosing engineering as a career in the future.

This information will not be distributed to any other agency and will be kept private and confidential. The only exception to this is if the student tells me of abuse or neglect that makes me seriously concerned for the student's immediate health and safety.

The student's participation is greatly appreciated, but I acknowledge that the questions I am asking are personal in nature. The student is free, at any point, to choose not to engage with or stop the study. Participants can skip any question, and there is no penalty at school for not participating. You may withdraw consent at any point in the study.

You will receive a copy of the signed consent form. If you have any questions, you can talk directly to me. If you would like to speak to someone other than the primary researcher, you can call Concordia University-Portland Oralee Branch directly at 503-493-6390 or obranch@cu-portland.edu

Your Statement of Consent:

I have read the above information. I asked questions if I had them, and my questions were answered. I volunteer my consent for this study.

___________________________________   ____________
Participant Name   Date

___________________________________   ____________
Participant Signature   Date

___________________________________   ____________
Investigator Name   Date

___________________________________   ____________
Investigator Signature   Date

Investigator: Joyce Russo
c/o: Professor Dr. Mark Jimenez
Concordia University – Portland
2811 NE Holman Street
Portland, Oregon 97221

Appendix B: Student-Engineer Self-Efficacy Survey

Students Survey

Thank you for participating in the research study Female Students Engineering Self-Efficacy.

Please indicate your ability to do each of the following statements.

1=Very High Ability
2= High Ability
3=Average Ability
4=Low Ability
5=Very Low Ability
No value = Uncertain

1. Earn an A in science.
2. Earn an A on an engineering project.
3. Get an A in science throughout high school.
4. Design and describe a science experiment.
5. Design and describe an engineering project.
6. Construct and interpret a graph.
7. Develop a hypothesis.
8. I can master the content in the engineering-related projects in science.
9. I can master the content in even the most challenging engineering assignments.
10. I can do a good job on almost all my engineering assignments.
11. I can do an excellent job on engineering-related problems and tasks assigned.
12. I can earn a good grade on my engineering related assignments in science.

13. I can perform experiments independently.
14. I can analyze data resulting from experiments in class.
15. I can communicate results of the experiments.

16. I can work with tools in the lab.
17. I can manipulate components and devices.
18. I can assemble things.
19. I can apply difficult concepts in engineering.

20. I can design an experiment.
21. I can identify a problem in a design.
22. I can develop design solutions.
23. I can evaluate a design.
24. I can recognize changes needed for a design solution.

Appendix C: Interview Protocol

Thank you for participating in this interview about the engineering practices in your science class. By participating in this interview, you are supporting my research and helping educators better understand female students engineering attitude and confidence level. The main purpose of this interview is to talk about the engineering practices experiences in science and how these experiences impact how you feel about engineering and your skills in engineering.

If at any time during the interview you want to stop participating, let me know and I will stop the interview process. You may skip any question that you do not want to answer. With your permission, I am going to record our interview. It allows for accuracy of the conversation. Are you comfortable with the recording of the interview?

We will begin if you are ready.

Questions for Student Interview

1. Do you enjoy the engineering assignments in science? Why or Why not?
2. What is it about the engineering assignments that makes science fun? Is there anything about the assignments that makes science boring?
3. How does participating in engineering practices make you feel about being able to learn engineering and why does it make you feel that way?
4. Is there anything about the engineering assignments that motivates you to want to do better or try harder in science? Why?
5. Is there anything about the engineering assignments that makes you want to give up and not learn science? Why?
6. If you were to pick your most favorite part of the engineering assignments, what would that be and why?

7. Do you think you are good at the engineering assignments? Why or why not?
8. Do you know what an Engineer does in their everyday work day?
9. Would you want to be an Engineer? Why or Why not?
10. Is there anything you would like to share about the engineering assignments in science?

Teacher Interviews

Thank you for participating in this interview. By participating in this interview, you are supporting my research and helping educators better understand female students attitude, confidence level and experiences in engineering. The main purpose of this interview is to talk about how you perceive your female students experience with the engineering practices of NGSS.

If at any time during the interview you want to stop participating, let me know and I will stop the interview process. You may skip any question that you do not want to answer. With your permission, I am going to record our interview. It allows for accuracy of the conversation. Are you comfortable with the recording of the interview?

We will begin if you are ready.

Questions for Teachers

1. Describe the type of student that you see successful in the engineering assignments. Why are those students achieving success?
2. Describe the type of student that you see being unsuccessful with the engineering assignments. Why are those students not successful?
3. Do you think your female students enjoy the engineering assignments? Why or why not?
4. Do you think that the engineering assignments help female students understand what an Engineer does during the day? Why or Why not?
5. Have the engineering assignments impacted your ability to enhance female students' involvement in the learning? Why or why not?
6. Describe what your students say about the lesson or learning during or after an activity.
7. Do you witness female students engaged in the activities on a regular basis?

Appendix D: Statement of Original Work

The Concordia University Doctorate of Education Program is a collaborative community of scholar-practitioners, who seek to transform society by pursuing ethically-informed, rigorously researched, inquiry based projects that benefit professional, institutional, and local educational contexts. Each member of the community affirms throughout their program of study, adherence to the principles and standards outlined in the Concordia University Academic Integrity Policy. This policy states the following:

Statement of academic integrity.

> As a member of the Concordia University community, I will neither engage in fraudulent or unauthorized behaviors in the presentation and completion of my work, nor will I provide unauthorized assistance to others.

Explanations:

What does "fraudulent" mean"

"Fraudulent" work is any material submitted for evaluation that is falsely or improperly presented as one's own. This includes, but is not limited to texts, graphics and other multi-media files appropriated from any source, including another individual, that are intentionally presented as all or part of a candidate's final work without full and complete documentation.

What is "unauthorized" assistance?

"Unauthorized assistance" refers to any support candidates solicit in the completion of their work, that has not been either explicitly specified as appropriate by the instructor, or any assistance that is understood in the class context as inappropriate. This can include, but is not limited to:

- Use of unauthorized notes or another's work during an online test
- Use of unauthorized notes or personal assistance in an online exam setting
- Inappropriate collaboration in preparation and/or completion of a project
- Unauthorized solicitation of professional resources for the completion of the work.

Statement of Original Work (Continued)

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University-Portland Academic Integrity Policy during the development and writing of this dissertation.

2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association.*

Joyce E. Russo

Digital Signature

Joyce E. Russo

Name (Typed)

4/10/19

Date