PRE-COLLEGE STEM LEARNING EXPERIENCES AND THEIR EFFECT ON UNDERGRADUATES' STEM SELF-EFFICACY, OUTCOMES, INTERESTS, AND GOALS: A MIXED METHODS STUDY

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Abstract: The experiences students have in their early life and in school have an impact on the development of their future career interests and choices, and understanding the influence of those experiences can provide educators and policymakers the necessary tools to meet society's future needs. This mixed-methods study examined how undergraduates at one large university perceived their pre-college learning experiences and how those experiences affected their self-efficacy, outcome expectations, interests, and goals in STEM. Participants were surveyed about their experiences and attitudes, and eight participants with a range of STEM self-efficacies were interviewed about the specifics of their experiences. Results indicated that many students participated in learning experiences that were easy to implement and required few resources, while those experiences that required substantial knowledge or outside resources occurred less often. These less common experiences, which often centered on STEM careers or future studies in STEM, were more common among students who are majoring in a STEM degree. Other factors influencing STEM attitudes included course performance, course selection, teachers, and out-of-school opportunities. The out-of-school experiences were selected less often and were generally targeted experiences that related to individuals' interests. These findings suggested the need for schools and teachers to engage in more complex and career-focused activities in STEM classes to enhance the development of interests in all students. There is also a need to provide opportunities for students to be involved in out-of-school STEM activities that relate to the students' interest or draw them into STEM fields of study.

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INTRODUCTION

The experiences students have in their early life and in school have an impact on the development of their future career interests and choices (Maltese, Melki, & Wiebke, 2014), and understanding the influence of those experiences can provide educators and policymakers the necessary tools to meet society's future needs. Development of quality science, technology, engineering, and mathematics (STEM) graduates is essential, and the demand for these graduates will continue to grow as the workforce becomes more dependent on critical thinking skills and knowledge of technology and engineering (World Economic Forum, 2017a). Between 2019 and 2029, STEM jobs are projected to grow by 8.0% compared to 3.4% for non-STEM jobs (U.S. Bureau of Labor Statistics, 2020). Students who are preparing themselves to enter this new workforce must be equipped to handle new situations, technologies, and careers. Simply putting students on a track to enter this workforce may not be enough, as industries will need workers that come to them prepared to deal with problems that have never existed before (Camilli & Hira, 2019).

In order to meet these new and growing demands, educational reform must target practices that develop students who are both interested in and prepared for a STEM career. Research on what motivates students to enter the STEM workforce has focused primarily on initial development of interest and sustaining that interest (Dabney, et al., 2013; Maltese et al., 2014; Maltese & Tai, 2010, 2011; Sadler, et al., 2012; Tai, et al., 2006). These studies indicate that STEM interest and career choice develop from a variety of influences, such as experiences with STEM subjects in and out of school, family, friends, coursework, and innate interest or ability, among others.

All students are exposed to in-school experiences, though STEM opportunities differ widely depending on the context afforded by families and schools. Schools that offer a variety of course options, well-qualified teachers, well-equipped labs and classrooms, and challenging curriculum generally produce students that are more prepared for STEM studies in college than students who lack these benefits (Steenbergen-Hu & Olszewski-Kubilius, 2017; Thiry, 2019). Out-of-school experiences are less common, but participation in these experiences can have a positive impact on STEM attitudes and aspirations (Bonnette et al., 2019; Goff et al., 2019).

The purpose of this study is to examine the in-school and out-of-school STEM learning experiences that undergraduate students have prior to college to determine how these factors affect their attitudes toward STEM and career goals. As such, this study is situated in social cognitive career theory (Lent et al., 1994), which provides a model that connects background and contextual factors, learning experiences, the constructs of self-efficacy, outcome expectations, and interests, and career choices and goals.

Defining STEM

The term STEM is ubiquitous in educational circles today, but there is little consensus about what it means. While the letters of the acronym clearly specify science, technology, engineering, and mathematics, the application of the term can vary considerably. Many authors use STEM to mean the integration of the disciplines in some meaningful way, while others may use it to refer to the individual disciplines that make it up. The lack of consistency can cause confusion among policymakers, educators, and the public alike (Siekmann & Korbel, 2017). For the purpose of this study, STEM will be used to refer to all subjects that make up the individual disciplines of science, technology, engineering, and mathematics. While these subjects are inexorably connected to each other, the term will not be used to mark an integrated approach, but rather as a shortened form of the subjects within the study. Using this definition for STEM, the following sections will detail the variables of interest in the study.

Learning Experiences

Every day individuals encounter opportunities to learn. These opportunities occur naturally during normal life through intentional actions by the individual, aided by the guidance of a knowledgeable person, and during school classes and activities. Each of these occasions represents a learning experience. Spence (2001) describes people as constant learners who can master a multitude of concepts and details, and says learning experiences are the vehicles that get them there. These experiences play a role not only in developing knowledge, but also in initiating interest in the subjects at hand (Maltese et al., 2014). However, while these experiences play a part in the development of knowledge and interest, there is still much to be learned about the process through which this happens. This study looks at individual learning experiences occurring in or out of school to gauge which were influential, while understanding that it is the sum of these experiences that matter to the development of knowledge, skills, self-efficacy, interests, and beliefs (Allen & Peterman, 2019).

Self-Efficacy and Outcome Expectations

Self-efficacy and outcome expectations are constructs developed by Albert Bandura (1977) to explain what drives people's motivation and behavior through cognitive processes. Self-efficacy describes people's belief about their own ability to succeed in a given task and is based on prior experiences, relationship to others doing the same task, discussion with peers or authorities, and situational factors. Outcome expectations are people's beliefs about the results that come from performing a task in a certain way (Bandura, 1977). These factors are highly related to behavior, because individuals will choose to engage in behavior in which they believe they can have success (Schunk & Pajares, 2005).

The role of self-efficacy and outcome expectations in behavior makes them important factors in the career decision-making process. A variety of studies have demonstrated the value in these constructs toward the development of interest in STEM (Brown et al., 2016; Byars-Winston et al., 2010; Ferry et al., 2000), the decision to pursue a STEM career (Halim, et al., 2018; Lent et al., 1991; Moakler & Kim, 2014), and persistence in STEM (Chemers, et al., 2011; Larson et al., 2015; Lent et al., 1984). This study will look at participants' self-efficacy and outcome expectations in science, mathematics, and engineering to examine the connections that these constructs have to the experiences that sparked them and the choices that result.

Statement of the Problem

The experiences that drive people's beliefs and choices are important to the development of the new STEM workforce. STEM industries have a need for workers who not only have a STEM education, but also come to the workforce prepared to engage in the tasks and challenges that are presented. As educators prepare the next generation of workers for higher education and the workforce, there exists a need for these educators to understand the factors that influence students to pursue and develop confidence in a STEM field of study. Educational standards such as the Next Generation Science Standards (NGSS Lead States, 2013) and Principles and Standards for School Mathematics (National Council for Teachers of Mathematics, 2016) have provided frameworks for learning science, mathematics, and engineering to meet these ever-growing needs. However, there is still much to learn about how to engage students in STEM.

Many students develop their interest in a STEM career at an early age, generally from out-of-school experiences, innate interest, or hands-on school experiences (Maltese & Tai, 2011). However, many of those students who develop interest later do so as a result of classroom learning experiences or teacher influence (Dawes et al., 2015; Maltese et al., 2014). Moreover, the selection of courses in high school plays an important role in the development of skills and beliefs that may be necessary for success in the pursuit of a STEM career. Students who take advanced mathematics and science courses or applied STEM courses that demonstrate how to connect mathematics and science to technological, computer, and engineering tasks are more likely to choose a STEM career at a later time (Gottfried & Bozick, 2016; Sadler et al., 2014; Sasson, 2020; Watt, 2006). Understanding the experiences and coursework that motivate students to pursue and persist toward STEM careers will be important for the development of a capable workforce for the future. As schools and teachers make decisions that affect student outcomes, they should be informed of what opportunities are valuable and meaningful for the advancement of the STEM pipeline.

Purpose of the Study

School and learning environments are vital parts of the development of STEM self-efficacy, outcome expectations, and interests on the path to STEM career goals and actions (Lent et al., 1994). The purpose of this study is to elucidate the experiences that undergraduate students perceive as important to the development of these factors, along with the challenges that may constrain them. This dissertation sought to answer the following research questions:

1. What learning experiences do students perceive to affect their self-efficacy, outcome expectations, interests, and goals in STEM?
    a. How do these learning experiences differ between students in STEM and non-STEM majors?
2. What learning experiences affect students' self-efficacy, outcome expectations, and interests in mathematics, science, and engineering?
3. How do self-efficacy, outcome expectations, and interests in mathematics, science, and engineering affect students' intent to pursue a career in STEM?

Significance of the Study

This study is significant because it provides understanding of the learning experiences undergraduate students perceived as formative in their STEM self-efficacy, outcome expectations, interests, and goals. These experiences can act as gateways, boosters, or obstacles toward the pursuit of a STEM degree. As a result, educators may be able to find ways to support positive connections and mend barriers that get in the way.

Assumptions, Limitations, and Delimitations

This study is delimited to undergraduate students enrolled at Oklahoma State University (OSU) during the fall semester of 2020. The target for recruitment included those students in their first or second year of college, though a few upper-level students participated as well. This population of students allowed the researcher to gain an understanding of the research questions with regard to STEM and non-STEM majors. Additionally, the choice of variables and questions under study have been delimited by the choice of SCCT as a theoretical perspective. A selection matrix using survey responses aided in the selection of a smaller subset of willing participants to be selected for follow up interviews. This method helped to reduce researcher bias in participant selection and to help ensure that interviews are more representative of the population.

In this study, it is assumed all participants answered the questions truthfully, they gave correct responses regarding their completed secondary coursework, and they can accurately remember their experiences in high school STEM classes. To help ensure honest responses, surveys were confidential and pseudonyms were reported for interview data.

Although 5,000 students were invited to participate in this study, the findings were limited by the response rate of those who chose to respond. As such, the sample may not be representative of the population at the university. Further, the sample may not be representative of undergraduate students outside of the university. To accommodate for this limitation, the researcher reported the outcomes in reference to the sample and was careful not to generalize to the entire population of college students.

Overview of the Study

This study used explanatory sequential mixed-methods design (Creswell & Plano Clark, 2017). The first phase included an online questionnaire containing questions related to the quantitative portion of the study, including a question about willingness to participate in a follow-up interview. The questionnaire for the survey was created on Qualtrics (https://www.qualtrics.com), and included four sections of questions. The first section contained demographic data, including college major and intent to pursue a STEM career. The second section asked participants to identify the mathematics, science, technology, and engineering courses that they took in high school. The third section asked participants to identify learning experiences in and outside of school that influenced their STEM self-efficacy. The final section was made up of self-efficacy, outcome expectations, and interest instruments for science, mathematics, and engineering. After the survey results were analyzed, the researcher used STEM self-efficacy scores to develop a selection matrix to select participants for a follow-up interview. The interview was semi-structured, with questions designed to help participants recall the experiences they perceived as influential to their career decisions. The data from both phases was then analyzed and reported according to the research questions. Finally, the researcher compiled the results from both phases of the study and discussed their implications for practice, policy, and research.

CHAPTER II

REVIEW OF LITERATURE

This chapter examines the literature related to background and learning experiences in science, technology, engineering, and mathematics (STEM) subjects, as well as the constructs of social cognitive career theory (Lent et al., 1994). The chapter begins by describing the theoretical framework and studies supporting its design. Then, it will examine the literature related to the constructs included within the theoretical framework, including background factors and contextual influences, self-efficacy and outcome expectations, interest, and goals. It continues by exploring the various in- and out-of-school learning experiences that may influence STEM career decision. Finally, the chapter provides a summary for the study.

Theoretical Framework

Social Cognitive Career Theory (SCCT) is a framework posited by Lent et al. (1994) to describe how people make and implement choices based on a complex interaction of personal traits and environmental factors. The framework posits that these traits and factors work together to lead toward career decision making and persistence. SCCT has its roots in the work of Bandura (1986), where the interactions among personal traits, behaviors, and external factors all play a role in people’s choices and actions. These interactions form a triadic relationship, in which each factor is reciprocally dependent on the other (Bandura, 1986). Each interaction is dynamic, and shifts in one factor can affect the others as well. SCCT uses social cognitive theory as the basis for understanding career choice while also bringing in other research on career development, such as the relationships between subject-specific self-efficacy (Hackett & Betz, 1981) or social learning theory (Mitchell & Krumboltz, 1990) and career choice. SCCT builds on these models, combining multiple background experiences and constructs to describe the dynamic process by which career choice occurs.

The constructs that make up SCCT include personal inputs, background contextual affordances, learning experiences, self-efficacy, outcome expectations, interests, goals, actions, and contextual influences (Lent et al., 1994). The personal inputs, which include demographic factors (i.e., race, gender, and socioeconomic status) and background contextual affordances (i.e., access to opportunities) guide what learning experiences are available and how they are perceived. These learning experiences then provide an opportunity for the development of self-efficacy and outcome expectations. The SCCT model indicates that people are likely to develop interests in activities in which they have high self-efficacy and they foresee positive outcomes. This interest development, in conjunction with self-efficacy, outcome expectations, and contextual influences, then leads to career goals and actions toward particular areas. As a person begins to make choices based on their interest development, the actions provide feedback that may affect his or her self-efficacy beliefs or outcome expectations. These then either further cement the interests or cause those interests to change. Thus, the SCCT model for career selection is a dynamic and interactive feedback loop that can change over time as each construct adjusts according to its environment.

SCCT has been used considerably since its development to examine the factors related to career choice, often in the realm of STEM fields. Ferry et al. (2000) surveyed nearly 800 undergraduates to examine the role of person inputs, particularly family context, on the development of their career choices in mathematics and science. They found that parent encouragement, gender, and age had an effect on learning experiences, which in turn had a direct effect on mathematics and science specific self-efficacy and outcome expectations. Both self-efficacy and outcome expectations had direct effects on interests and goals, demonstrating the effectiveness of the SCCT model to this sample. Another study examined minority undergraduate biology and engineering students at two universities and also found that self-efficacy and outcome expectations were related to career interests and goals (Byars-Winston et al., 2010). Lent et al. (2018) conducted a meta-analysis of 196 studies that used SCCT as a framework and found that the model was a good fit for the data of overall groups as well as minority and female groups, and that SCCT accounted for much of the variance in the paths to interests and goals. The following sections will examine individual constructs of SCCT and discuss the relationships between the constructs from the relevant literature.

Background, Characteristics, and Context

Background factors are the sum of personal inputs and contextual affordances that SCCT points to as having an effect on the sources of self-efficacy. These are the factors that shape how a person views themselves within their cultural environment, such as gender, race, and family involvement.

The first demographic variable of interest is gender. Males enter STEM majors at a much higher rate than females, even though females have a similar achievement rate as males (World Economic Forum, 2017). While factors such as gender bias from teachers, the male leaning of STEM subjects, and motivation may play a role, self-efficacy seems to influence the STEM major choices between genders. While males and females reported similar self-efficacy beliefs in a study of middle school students (Brown et al., 2016), there is a change that can occur through high school, as STEM self-efficacy beliefs from a sample of undergraduate students were higher in males than females (Betz & Hackett, 1983). Interestingly, studies of high school students do show that females tend to have higher self-efficacy beliefs than males in science, but lower self-efficacy in engineering and mathematics (Betz & Hackett, 1983; Halim et al., 2018; Uitto, 2014).

Another demographic variable studied in the literature is a person's race and its relationship to the selection of and persistence in STEM careers. According to a study by Steenbergen-Hu and Olszewski-Kubilius (2017), white and Asian students were substantially more likely to pursue a STEM career than their minority counterparts. MacPhee et al. (2013) studied 175 students who are part of an underrepresented group in STEM (i.e., female; low socioeconomic status; first generation college student; or African American, Latino/a, or Native American) and reported that these groups reported a lower self-efficacy in STEM than non-minority students. Furthermore, they suggested that an increase in these students' self-efficacy would help improve their persistence. Other studies have shown STEM career selection and persistence among minorities can be influenced by mathematics and science instruction and high performance in STEM classes in secondary schools (Bonous-Hammarth, 2000; Chang et al., 2014).

A third demographic variable is family involvement, which plays a role in both STEM achievement and career selection. A study of undergraduate students by Ferry et al. (2000) suggested parent encouragement had a positive effect on both learning experiences and outcome expectations, and Byars-Winston and Fouad's (2008) study of undergraduates found a similar connection between family involvement and outcome expectations. The source of these influences may often come from positive messages about STEM and support from parents (Bonnette et al., 2019; Burt & Johnson, 2018; Jahn & Myers, 2015). Students who have a family member in a STEM career or in any field that requires a college degree are more likely to also choose a STEM career (Dabney et al., 2013; Moakler Jr & Kim, 2014; Sahin et al., 2017). Together, these background factors provide support for the learning experiences that students experience and development of their attitudes toward STEM.

Self-Efficacy and Outcome Expectations

Self-efficacy and outcome expectations are affective constructs that were developed as a part of social learning theory to describe the beliefs that people hold about their abilities and the outcomes that derive from their decisions (Bandura, 1977). While these two constructs are separate, they are connected by their influence on people's choice to engage in a particular behavior. Many of the behavioral choices people make are because they envision an outcome of their behavior, while also deciding whether they are capable of producing the actions necessary to be successful in that behavior (Bandura, 1997).

Outcome expectations are "a person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p. 193). While it is important to consider the actions that lead to desired results, the outcome expectation considers only the products of those actions. These outcome expectations should be considered with regard to efficacy expectations because the combination of these factors drives behavior (Bandura, 1997). Additionally, the value of outcome expectations to behavior is improved when people feel that the outcome is connected to their actions (Bandura, 1997).

Self-efficacy is a descriptor of the overall cognitive mechanism that drives decision-making in many areas of life, including daily decisions, classroom decisions, and career choices. This decision-making process involves an array of inputs, including environmental factors and expectations of what the outcomes may be, but self-efficacy has been revealed to act as one of the primary constructs that predict behavior (Betz & Hackett, 1986; Eccles, 1994; Williams & George-Jackson, 2014). While people look at the possibilities that may result from a particular behavior, their choice to engage in that behavior is based on whether they believe they can do what is required to generate those results (Bandura, 1977).

Engagement in behavior, then, is not necessarily the result of what people can in fact accomplish, but rather the result of what they believe they can accomplish (Schunk & Pajares, 2005). The cognitive processes involved in decision-making compile the information from the environment and process this information through self-efficacy beliefs. The decision to act in a certain situation is guided in part by these beliefs, which provide value because appropriate judgements achieve continued success and avoid costly mistakes (Bandura, 1997).

It is important to distinguish self-efficacy as a belief in what one can accomplish, rather than an evaluation of the characteristics someone possesses. These related but different affective constructs have been referred to as self-efficacy and self-concept (Bong & Skaalvik, 2003; Pajares & Schunk, 2005). While self-concept describes the beliefs that people have about their personal characteristics, self-efficacy focuses on their potential to perform certain tasks (Zimmerman, 2000). Moreover, while people may compare their qualities to others, self-efficacy is a private evaluation about the ability to perform a task independent of whether others may also be able to do so (Bong & Skaalvik, 2003).

Self-efficacy is developed through a variety of methods, and both public and private encounters shape the way people view their own abilities. One way this development happens is through personal construction of self-efficacy in concert with social engagement (Schunk & Pajares, 2005), where people engage in tasks alongside others who can guide or support them in their learning. While each task and situation may build on prior self-efficacy beliefs, the overall construct is built over a series of events and takes place over a long period of time (Schmid & Bogner, 2017). Learners who are developing skills can enter a positive cycle of learning by developing a sense of self-efficacy toward a task, which then promotes further learning (Bandura & Locke, 2003). As learners continue to engage in similar tasks, their self-efficacy is likely to grow if they continue to have positive experiences with those tasks (Bong & Skaalvik, 2003). A study by Byars-Winston et al. (2017) revealed that college students were less influenced by recent experiences than by early experiences, suggesting the need to develop self-efficacy beliefs early in the educational path.

Self-efficacy is then exhibited through behavioral, cognitive, and motivational engagements. Behavioral engagements include effort, task selection, and persistence; cognitive engagements involve coping efforts, self-regulation, and strategy use; and motivational engagements include interest and value (Linnenbrink & Pintrich, 2003).

One of the clearest examples of how self-efficacy affects choice of behavior is task selection. When people are given a choice in what they can take on, they will make decisions based on their prior experiences with the task and their beliefs about whether they can successfully complete the task. Numerous studies have demonstrated that people tend to select tasks that they believe they can complete successfully and avoid those in which they fear they may fail (Bandura, 1977, 1991; Guay et al., 2006; Krueger & Dickson, 1993; Schunk & Pajares, 2005).

When people have a high self-efficacy toward a task, they tend to view the task as a challenge that they can conquer, which in turn will give them fulfillment (Bandura, 1991; Pajares & Schunk, 2005). Additionally, they select activities despite their difficulty and exhibit confidence in their ability to handle themselves well (Bandura, 1977). Efficacious people also look for those tasks that they believe to be worth their time and effort, with a focus on the successful completion of the task (Bandura & Locke, 2003).

In contrast, when people have low self-efficacy toward a task, they avoid situations they deem intimidating or uncomfortable (Bandura, 1977; Pajares & Schunk, 2005). Rather than considering the possibilities of success that efficacious people do, they focus on the hazards of engaging in the activity and the negative consequences it may have for them (Bandura & Locke, 2003). Guay et al. (2006) found that individuals with low self-efficacy exhibited low autonomy toward these tasks.

Self-efficacy can manifest itself cognitively through the application of self-regulation techniques. Pajares and Schunk (2005) found that students with a high self-efficacy used a greater variety of learning strategies, including metacognitive strategies, to accomplish learning tasks. These students were able to engage in learning more effectively because they spent more time on task and were able to develop a sense of autonomy in their learning. Additionally, people who believe that they are capable in a particular setting will set challenging goals for themselves (Zimmerman et al., 1992).

When people encounter situations in which they are challenged, they enact cognitive mechanisms to cope with the challenges at hand. Coping efforts are often connected to self-efficacy because efficacious people anticipate that they will be successful in the end. Because of this positive belief, efficacious people develop more effective coping strategies to help persist through the obstacle (Bandura, 1977).

Self-efficacy can also be demonstrated through people's motivation to complete tasks, their interest in a task, and their views of a task's value. When students see a STEM subject as useful and important to their lives, self-efficacy grows and influences their motivation to continue the pursuit of that subject (Brown et al., 2016; Nugent et al., 2015). Additionally, STEM self-efficacy has direct connections to the development of interest in STEM subjects and careers (Lent et al., 1991; Lent et al., 2018).

Context and Measurement

Self-efficacy acts within the confines of the context in which it is learned and applied. Self-efficacy towards the completion of one task does not necessarily correspond to the completion of a task in a different domain, and the way in which self-efficacy affects behavior is different for each (Eccles, 1994; Zimmerman, 2000). Bong and Skaalvik (2003) demonstrated that changes in self-efficacy in one academic area are not associated with change in self-efficacy in another. This has far-reaching implications for teachers and learners as they seek to improve self-efficacy toward subjects and tasks.

Measurement of self-efficacy, then, must be attuned to the specific domains that are being tested (Pajares & Miller, 1995). Moreover, Bandura (1977) states that assessments must detail "the magnitude, generality, and strength of efficacy expectations commensurate with the precision with which behavioral processes are measured" (p. 194). Pajares and Miller (1995) also support the adaptation of self-efficacy measures to the specific task being addressed.

STEM Self-Efficacy

The contextual nature of self-efficacy has implications for the study STEM behavior and cognition. The four categories that make up STEM are connected to each other in many ways and depend on each other regularly in education. However, they also present differences that should be considered when studying self-efficacy. A study by Usher et al. (2019) found that students in a rural setting developed mathematics self-efficacy from a combination of positive learning experiences and physiological states while science self-efficacy came primarily from learning experiences. This is consistent with other studies of students demonstrating that self-efficacy in mathematics and science develop from different sources (Britner & Pajares, 2006; Usher & Pajares, 2009), supporting the need to study them separately.

Evaluating self-efficacy in each of the STEM subjects can prove difficult, because within each subject there is an array of subcategories and tasks that may be related from an expert's point of view but disjointed in the eyes of a novice learner (National Research Council, 2000). The very general field of science itself includes subjects such as physics, chemistry, biology, and geology that share a common set of skills and principles but vary widely in content. Engineering has branches that deal with mechanics, electricity, chemicals, the environment, and more. Even mathematics, which tends to be lumped into one subject regularly, involves the use of algebraic reasoning, geometric proofs, and number sense that require different skills and knowledge.

Studies of science self-efficacy examine how students view their understanding of content along with their ability to participate in the practices of science. Williams and George-Jackson (2014) studied a variety of variables related to undergraduates' ability to use scientific practices effectively, and found that scientific self-efficacy had the most profound impact. Dalgety and Coll (2006) found that students in a college chemistry course had high self-efficacy toward some chemistry tasks but not all, furthering the idea that self-efficacy is highly task-dependent (Pajares & Schunk, 2005).

Studies in mathematical task completion and mathematical problem-solving demonstrate that high self-efficacy beliefs resulted in better performance on those tasks (Pajares & Miller, 1994; Tossavainen et al., 2019). Hall and Ponton (2005) demonstrated that undergraduate students who had taken a calculus class in high school had a stronger belief in their potential to perform well in a college mathematics course than those who had taken less advanced mathematics classes.

Fantz et al. (2011) revealed that students with pre-college engineering classes or hobbies developed a higher engineering self-efficacy than those who had not. A study by Hutchison et al. (2006) examined the formation of self-efficacy through the lens of Bandura's sources of self-efficacy, demonstrating that a college engineering class could provide each of these sources and benefit engineering self-efficacy.

An interesting research subset within STEM self-efficacy involves the gender differences that exist in each area. Many STEM fields are viewed as male-dominated, and a recent study demonstrated that males across cultures and geographical locations had higher mathematics and science self-efficacy than females (Reilly et al., 2019). Pajares (1996) found that the group of gifted middle school girls in his study surpassed boys in mathematics performance, but the two groups' self-efficacy was the same. Another study by Larose et al. (2006) followed high school students from their senior year through their second year in college, and found that females had a lower science self-efficacy in high school but were four times more likely than boys to have an increase in self-efficacy in the transition to college. Halim et al. (2018) found in their study that high school boys had a higher engineering self-efficacy, while high school girls had a higher science self-efficacy. The various findings in these studies suggest the need to better understand why these disparities exist and if there are any differences in the experiences of males and females that lead to these results.

STEM Self-Efficacy in Relation to Career Choice

High self-efficacy in any or all of the STEM fields is defined as a greater belief in one's ability to be successful in future pursuits involving those subject areas. One aspect of STEM education and self-efficacy that is important for consideration is its effect on career interest, career choice, and college major. If increased STEM self-efficacy improves peoples' beliefs about their abilities in STEM, then it may also increase their belief in their ability to succeed in a STEM-focused career. The following section will present studies that connect STEM self-efficacy with STEM interest, career intention, and persistence.

STEM Interest

The development of interest in STEM fields can have a profound impact on students' choice of a career. A study of disadvantaged high school students in a STEM program suggested that interest in a career is the most important factor in the consideration of that career (Post-Kammer & Smith, 1986). Students may develop interests through a variety of pathways, but several studies suggest a connection between STEM self-efficacy and interest. One study of middle school students in a science class found that STEM self-efficacy had a significant impact on the students' interest in the subject (Brown et al., 2016), while Blotnicky et al. (2018) found that middle school students who demonstrated low self-efficacy in mathematics also had lowered interest in pursuing a STEM career. Two studies of college students also indicated that self-efficacy had a direct effect on interests and goals (Byars-Winston et al., 2010; Ferry et al., 2000). A meta-analysis of 196 studies that use social cognitive career theory as a framework concluded that self-efficacy and outcome expectations play a large role in predicting STEM interests (Lent et al., 2018).

STEM Career Goals

In addition to the development of interest in STEM fields, high STEM self-efficacy can increase students' desire to pursue a STEM career. While there are many factors that go into the choice of a STEM career, STEM self-efficacy does have predictive value toward this end (Lent et al., 1986). A variety of studies demonstrate that there is a relationship between STEM self-efficacy and the intention to pursue a STEM career (Eccles, 1994; Halim et al., 2018; Lent et al., 1991; Luzzo et al., 1999; Moakler & Kim, 2014; van Aalderen-Smeets et al., 2019). Other studies have shown the relationship between mathematics self-efficacy and the choice of science- and mathematics-based majors in college (Betz & Hackett, 1983; Hackett & Betz, 1989). Additionally, Betz and Hackett (1986) posit that mathematics self-efficacy is a good predictor of STEM career choice because it leads to the selection of more challenging classes and a STEM-based college major. Lent et al. (2003) also found that self-efficacy acts as a mediator between sociocultural inputs and career choice goals and actions. Further studies involving the connection between self-efficacy and career intention provide additional reasoning. Bandura et al. (2001) suggest that the development of self-efficacy in skills related to particular careers corresponded to students' desires to pursue those careers. Lent et al. (1986) suggested that increased self-efficacy resulted in a greater range of perceived career possibilities, while Post-Kammer and Smith (1986) showed a relationship between subject confidence associated with a career and a desire to pursue that career.

STEM Persistence and Actions

These factors can lead to initial pursuit of a STEM career, but many students who begin college majoring in a STEM field do not persist in that field. Weston (2019) conducted a study in which a random sample of 7800 college students were surveyed at three separate time points over a six year period. According to this study, about 28% of students who begin college in a STEM major switch to a non-STEM major, while another 20% of students leave the college entirely. Reasons for persistence vary, but passion and interest in a field, achievement, positive learning experiences, good teachers, and a variety of challenging and interesting classes all appear to be valuable (Maltese et al., 2014; Thiry, 2019). Many of these factors are also related to self-efficacy, which has been shown to have connections to persistence in STEM. Multiple studies of college students and graduates have demonstrated that high STEM self-efficacy is connected to persistence in a STEM field and completion of a STEM degree (Chemers et al., 2011; Larson et al., 2015; Lent et al., 1984; Pajares & Schunk, 2005). Longitudinal studies that look at change in self-efficacy have shown that students whose self-efficacy increases during college are more likely to persist in their major (Guay et al., 2006; Larose et al., 2006). Thus, the research described above suggests that development of STEM self-efficacy can lead to a number of results that positively impact interest in and action toward STEM careers.

Sources of Self-Efficacy

Self-efficacy beliefs develop over the course of time through various interactions with the environment. Bandura (Bandura, 1977, 1997) described four sources for the development and modification of self-efficacy beliefs: mastery experiences, vicarious experiences, verbal persuasion, and physiological states. These four sources work together to shape the efficacy beliefs of individuals through their experiences.

Mastery experiences represent all of the personal accomplishments and performances that lead people to believe that they can or cannot accomplish a task. Repeated success at a task will increase self-efficacy, while failures reduce these beliefs (Bandura, 1977, 1997; Schunk & Pajares, 2005). Early failures may diminish the development of self-efficacy, but as self-efficacy beliefs are strengthened toward a task, failure becomes less likely to have a negative influence on self-efficacy beliefs (Bandura, 1977, 1997).

Vicarious experiences involve the modeling of a task by another person. The use of vicarious experience helps learners believe that if someone else can do it, then they can also perform the task at least at some level. This is particularly meaningful if the task is one that the learner believes they will be performing at some point (Amelink et al., 2015). Additionally, Schunk and Pajares (2005) determined that the vicarious experience would be amplified if the model shares similarities to the learner, though Bandura (1977) asserts that viewing models with a variety of characteristics improves the likelihood of increasing self-efficacy.

Social or verbal persuasion is the act of outside sources providing verbal feedback or encouragement to the learner. This can come in the form of praise, correction, instruction, and suggestion. Schunk and Pajares (2005) state that "effective persuaders must cultivate people's beliefs in their capabilities, while at the same time ensuring that the envisioned success is attainable" (p. 88). Bandura (1977) adds that physical aids are often useful in conjunction with verbal persuasion.

The physiological state describes the various physical and emotional conditions that accompany learning experiences and contribute to efficacy beliefs. Learners in a stressful environment may attribute their feelings about a particular task to that environment and develop negative self-efficacy toward that task. However, positive physical environments may improve self-efficacy, which can make people feel better about themselves, creating a loop of positive reinforcement (Schunk & Pajares, 2005).

Studies that track the value of these four sources on the development of positive self-efficacy have varying results. A logical and common result is that a combination of sources results in the most improvement in self-efficacy (Betz & Schifano, 2000; Chen & Usher, 2013; Dunlap, 2005; Luzzo et al., 1999; Sheu et al., 2018). Other studies assert that the single most important source of self-efficacy is mastery experience (Britner & Pajares, 2006; Byars-Winston et al., 2017; Lent et al., 1991; Zientek et al., 2019). An interesting finding in studies that compared genders is that mastery experiences were more important for males, while vicarious experiences and social persuasion were more important for women (Zeldin et al., 2008; Zeldin & Pajares, 2000). In other studies, task success or failure tended to have a greater influence on self-efficacy in females than it did in males (Betz & Hackett, 1986; Usher et al., 2019).

While these sources provide the impetus for the development of self-efficacy, people still have to process these experiences and develop a sense of how it affected them. Sometimes, accomplishment through mastery or vicarious experiences will be attributed to external factors, such as the difficulty of the task and effort by the model. The resulting conclusions about the value of these experiences then depends on how people interpret them and the meaning that is given to them (Bandura, 1977, 1997; Campbell & Hackett, 1986).

Learning Experiences in STEM

These sources of self-efficacy are key components of the learning process, and SCCT presents these sources as learning experiences. Learning is a process that happens over time through a variety of experiences and contexts that shape the way people understand specific content, develop interests and goals, and how they feel about their own abilities. This section will focus on learning experiences that happen in the STEM disciplines, and how those experiences impact outcomes for learners.

Learning experiences are the individual occurrences that influence what and how people learn, and can take the form of in-school classroom activities, instances in the everyday lives of students, or in purposeful out-of-school environments (Allen & Peterman, 2019; Maltese & Tai, 2010). While these experiences happen on an individual basis, it is the sum of these experiences, along with values, beliefs, and community and cultural influences that leads to the development of knowledge and identity (Allen & Peterman, 2019). Because of the intersectionality of learning experiences with other aspects of peoples' lives, it is important to consider that individual interventions or experiences are simply one piece of the overall picture. However, studies of specific learning experiences along with student perceptions of their overall experience has demonstrated effects on self-efficacy, identity formation, enjoyment, content knowledge, collaborative skills, and application of knowledge (Dou et al., 2019; Ferry et al., 2000; Mohd Shahali et al., 2019).

Learning does not happen in only one setting, but rather through the connections that are made through multiple experiences and among a variety of sources. School experiences and teacher roles may first come to mind when considering learning in STEM, but often family influence, informal learning environments such as museums and camps, and extracurricular activities play a significant role as well. Kang et al. (2018) found that experiences in different settings played important and unique roles in the development of STEM identity and career interest of middle school girls of color. Halim, et al. (2018) examined high school students of both genders and found that in-school and out-of-school STEM activities were important for the development of STEM self-efficacy and outcome expectations. Interviews of women in a college STEM program revealed that strong STEM classrooms and participation in extracurricular activities were important factors in their decision to pursue STEM (Petersen, 2014). The results of these studies suggest that involvement with learning experiences in a variety of contexts results in stronger STEM attitudes.

Because learning experiences happen in these various settings, it is also clear that these experiences can occur at different ages. STEM experiences can begin in early life through engagement with informal STEM learning at zoos, museums, and camps along with family-directed activities. They often follow with continuous exposure to experiences through elementary school, middle school, high school, and college classes. The timing of experiences connected to STEM learning influences how that learning impacts students. A number of studies have demonstrated that people who are interested in STEM as a career or pursue a STEM degree in college are most likely to have developed their interest at a young age, typically prior to middle school (Banerjee et al., 2018; Lane, 2019; Maltese et al., 2014; Maltese & Tai, 2010; Tai et al., 2006).

While early STEM experiences seem to have the greatest influence for those that eventually pursue STEM as a career, experiences in learning environments at later times can also be valuable. For example, Maltese et al. (2014) surveyed nearly 8,000 people at universities and colleges throughout the country and found that those who reported becoming interested in STEM in middle school, high school, or college were more likely to complete a STEM degree than those who expressed interest earlier. Beier et al. (2018) also showed that positive learning experiences in early college led to better STEM attitudes and aspirations.

STEM learning experiences provide an important avenue for the development of skills, aspirations, and attitudes. It is important to study the experiences that are beneficial to students so educators can help facilitate those experiences for others. STEM learning experiences can help students develop self-efficacy, STEM career aspirations and goals, interest in STEM subjects, and sustain course-taking through their school career.

Classroom Environment and Instruction

One of the most prevalent places in which learning experiences take place is in the classroom. The classroom provides opportunities for students to develop an understanding of the STEM subjects along with STEM attitudes. While students gain an exposure to STEM subjects, their experiences in the school setting do not always result in positive feelings. Because the classroom provides the opportunity for all students to participate in STEM, it is important to understand the effects that learning experiences have in this context. The classroom provides opportunities for the development of STEM attitudes, and this can happen through individual experiences, connection with or mentorship by teachers, the schools' commitment to STEM education, and the specific coursework that students take.

Early STEM Experiences

The experiences that students have in STEM classrooms can have an effect on many aspects of their understanding and attitudes. Early experiences in elementary school can be influential for students' attitudes toward STEM subjects, which can have a ripple effect into their later schooling, including course-taking and confidence in STEM classes (Banerjee et al., 2018). These STEM experiences can be especially influential when they are linked to personal goals (Dasgupta & Stout, 2014).

Learning experiences in STEM subjects have demonstrated a positive effect on students' desire to pursue a STEM career. Early experiences in the use of technology have the potential to help students see STEM careers as future options (Schlegel et al., 2019). Beier et al. (2018) demonstrated that project-based learning was associated with self-efficacy and application of STEM subjects, leading to interest in a STEM career. Also, Dou et al. (2019) found that students were over 20 times more likely to choose a STEM career with a high STEM identity than those at the low end of the spectrum. Lee et al. (2020) found that students who viewed lab learning as a method for developing science skills had high science learning self-efficacy.

Some classroom experiences, however, do not show positive outcomes toward STEM. Some students are not able to make meaningful connections between STEM learning in the classroom context and real-world applications of that learning (Nugent et al., 2015), or they don't identify themselves as scientists even though they experienced real-world application (Schlegel et al., 2019). Bathgate and Schunn (2017) found that students who believed in their abilities in a science subject but were not motivated to engage in the class did not see gains in their content knowledge during the class.

Effective and student-centered STEM activities in early grades are likely to have a positive effect on students' interest in STEM subjects or careers. Students who enjoy mathematics and science in elementary school have a greater chance of developing and maintaining interest in STEM later (Burt & Johnson, 2018). Maltese and Tai's (2010) interviews of STEM graduate students revealed that 65% of the interviewees gained interest in STEM prior to middle school, and 40% of those claimed a school-based experience or camp as their initial source of interest. Additionally, the study found that those who gained this interest during elementary school were likely to attribute that interest to specific activities, labs, or projects completed during school. When these STEM experiences were not present, students lacked the opportunities to develop these interests (Petersen, 2014).

Early STEM experiences seem to be a valuable aspect of STEM interest development. However, sustaining that interest is more difficult as students move into higher grade levels. Studies have shown that students' STEM interest begins to decrease or fails to increase between the 6^{th} and 11^{th} grades (Bonnette et al., 2019; George, 2000). Two studies that measure student interest after specific interventions showed improvement in student engagement and learning, but failed to increase interest (Bathgate & Schunn, 2017; Guzey et al., 2019). A longitudinal study by Shahali et al. (2019) indicated an increased interest in STEM subjects immediately after intervention, but a decrease after two years away from the program. The various experiences that students have early in life, both in school and out of school, can make a difference in how students see STEM subjects and careers.

Types of Classroom Learning Experiences

Because classroom experiences are important to the development of students' attitudes, interests, and goals toward STEM, it is valuable to look at the types of classroom learning designs that lead to these experiences. This section demonstrates effective classrooms are often those that engage the students in interesting real-world problems, encourage problem solving, and center instruction on student learning and needs.

Petersen (2014) interviewed female undergraduate STEM majors about their classroom experiences. The results of these interviews revealed effective classrooms "included the use of higher-level questioning and problem solving, hands-on activities and experiments, and…real-life examples in the classroom" (p. 73). These techniques can be coupled with a student-centered approach to learning and the opportunity for students to collaborate with each other and STEM professionals (Struyf et al., 2019; Thiry, 2019).

Hampden-Thompson & Bennett (2013) examined data from over 11,000 high school students in the U.K. to see which types of learning experiences affected the students' views about science. They found when students experienced more lessons that asked them to explain concepts, design tests for scientific ideas, and apply them to the outside world, students increased their enjoyment, motivation, and future orientation. Investigations in the science classroom were the most common technique reported, but it had a negative effect on enjoyment and future orientation toward science. The authors posit this may be because many teachers use this as their only method of teaching, and that students do not like this repetitive approach.

The National Research Council (2000) states that effective classrooms feature instruction that is learner-centered and allows students to be actively involved in the learning process. Student-centered learning can integrate activities that are both hands-on and mentally engaging to drive learning. Hands-on activities have shown to help students retain content knowledge, improve collaborative skills, make connections to the world around them, and improve enjoyment of and motivation toward STEM subjects (Mohd Shahali et al., 2019). Lee et al. (2020) found that students involved in active laboratory activities develop higher self-efficacy for learning the skills and practices of science.

Students who engage in an active inquiry process while learning STEM subjects also have the potential to develop stronger content understanding and skills that strengthen STEM abilities. Banerjee et al. (2018) found that inquiry experiences in a life science course could help students find connections to real-world applications as well as to other subjects. Other studies demonstrate the value of inquiry experiences in the development of critical thinking and research skills to support STEM learning (Scott-Parker & Barone-Nugent, 2019; Thiry, 2019).

Practical Application of Learning in STEM

A useful instructional tool in STEM is the application of classroom learning to real-world scenarios, which can be useful in everyday situations or easily transferrable to STEM careers. This can be accomplished through a variety of techniques, including problem-based or project-based learning. Both approaches task students with the application of in-class content and skills to situations that occur outside of the classroom. Studies on these application-style learning techniques have shown gains not only in student learning, but also motivation, enjoyment, and skill-development. Struyf et al. (2019) analyzed twenty-four high school integrated STEM lessons and found the use of realistic, relevant problems made a positive impact on student engagement, especially when the problems were closely tied to student experiences. Another integrated lesson that incorporated principles of linear algebra into business decision-making processes demonstrated increased interest and understanding of mathematical concepts (Izquierdo et al., 2016). Ng & Chan (2019) used a 3-D printing design lesson to integrate concepts, which led students to discover the need to incorporate mathematical principles into their designs. Other studies found that these learning techniques also enhanced STEM attitudes, improved mathematics and science knowledge, and increased students' abilities to apply classroom learning to the real world (Lou et al., 2010; Mohd Shahali et al., 2019). Han et al. (2015) found that STEM project-based learning in schools resulted in a larger growth rate in mathematics scores for low achieving students than high achieving students, providing an avenue to reduce the achievement gap.

Learning experiences that specifically connect class learning to STEM careers can influence students' understanding, awareness, and interest in STEM careers. When students engaged in STEM activities with STEM professionals, they increased their awareness of STEM careers as well as their understanding of the tools of scientists and engineers (Mohd Shahali et al., 2019). In a study by Guzey et al. (2016), students who were asked to apply scientific concepts to solve an authentic engineering challenge increased their science and engineering interest. College students who took a project-based learning class early in their studies were more likely to feel they had the skills necessary to succeed in STEM disciplines and aspire to a STEM career (Beier et al., 2018). When these authentic experiences are lacking, however, students often do not have the knowledge to seek out or understand STEM careers. Jahn & Myers (2015) found that classes that engaged in authentic activities but did not make explicit connections to STEM careers improved learning but did not increase interest in STEM careers. Overall, the various learning experiences that students have in the classroom can change students' perceptions of STEM in both negative and positive ways. It is important to gain an understanding of how these experiences happen and how teachers and schools can develop them in a meaningful way.

The Role of the Teacher

For many students, the individual learning experiences in the classroom make the most difference to their interest, enjoyment, and aspirations toward STEM subjects and careers. However, the teacher often has a profound impact on students' attitudes toward STEM subjects and careers as well. This section demonstrates that teachers can impact student understanding and enjoyment of particular subjects based on their presentation, their own attitudes toward the subject and teaching, and how they develop relationships with students.

When students look back on the factors that influenced them to pursue particular careers or paths of study, they often name teachers they have had as being an influence on their choices (Dawes et al., 2015). A study by Banerjee et al. (2018) examined the influences of twenty-seven women who were initially not interested in STEM but ended up in STEM careers or who were initially interested in STEM but ended up in a career other than STEM. They found that teachers were influential in career choice for 85% of their participants. In another study, Maltese and Tai (2010) interviewed people who had attained a PhD or were working on their PhD in science, and found that teachers were influential in sparking initial interest in 40% of participants. Reilly et al. (2019) found that teachers can help students develop positive views of science by exhibiting science-friendly attitudes and providing meaningful science learning experiences. In a qualitative study of women regarding their STEM classroom experiences, interviewees indicated that teachers' delivery and ability to explain material made science classes more enjoyable (Banerjee, 2018). Similarly, in a qualitative study of black male graduate students, interviewees suggested an engaging teaching style made class more enjoyable, while teachers that were regarded as boring made class less enjoyable (Burt & Johnson, 2018).

When teachers act as role models for students, there are positive effects for both STEM learning and career aspirations. Thiry (2019) found that students who were actively mentored by a STEM teacher in high school were more likely to persist in their STEM major in college, while Dasgupta & Stout (2014) found that females with a female STEM teacher as a role model gained confidence in their STEM abilities and were more likely to pursue a STEM career.

Teachers who put STEM subjects in a negative light or do not provide STEM learning experiences can also be influential to students in an unfavorable way. During the vital years of elementary school, teachers who lack confidence in their abilities or have low content knowledge will leave out instruction, provide shallow experiences, or fail to teach the broader skills and practices of STEM subjects (Appleton, 2013; Kind, 2014; Sanders et al., 1993; Yoon et al., 2011). A longitudinal study of middle school students found that a STEM-focused program significantly increased student interest in STEM. However, two years later students' interest in STEM decreased to levels below their original interest. Students said that their regular teachers did not provide the same learning experiences that had drawn their interest in the STEM-focused experience (Mohd Shahali et al., 2019). An interview with a female college student about her experiences in elementary school revealed that she had lost her confidence in mathematics because a teacher expressed to her that she was not capable in that subject (Banerjee et al., 2018). Teacher methods and actions can play an important role in how students develop interest and attitudes toward STEM.

Teacher characteristics

Since teachers have such a strong influence on students' aspirations, attitudes, and beliefs in STEM subjects and careers, it is important to look at the characteristics of those teachers who have been influential. The qualities of a good teacher, especially regarding their influence on particular students, is subjective for each student. However, there are several qualitative and quantitative studies that offer insight into which characteristics are valuable.

A survey of over 1,000 upper elementary school students revealed that when teachers were caring, challenged their students, and were oriented toward subject mastery, students' mathematics self-efficacy was higher (Fast et al., 2010). Another study showed that high school students valued teachers who offered them the ability to think for themselves while still delivering guidance when necessary. Additionally, strong teacher-student relationships created engaging and collaborative learning environments (Struyf et al., 2019). A large study of college STEM majors at six different institutions asked about high school teachers, and many described their teachers as highly qualified, some even having PhDs or coming out of practice in science and engineering (Thiry, 2019).

Interviews with students can provide a more detailed but individual view of teacher qualities. A study that examined the perspective of black girls in middle school found learning was supported most by teachers who were intentional about developing learners as a community, communicated effectively, and encouraged critical thinking (King, 2017). Another study of college females in STEM majors revealed influential teachers were passionate about their subject, shared their experiences, encouraged their students, and challenged them to really understand their subjects (Petersen, 2014). Thus, teachers can play an important role in the development of confident and competent students.

The Role of Coursework and the School

Knowing that the individual learning experiences that students have in P-12 schools makes a difference in their attitudes, beliefs, and interests toward STEM, and that teachers also play an important role in these developments, it is worth looking at the courses that provide these experiences. While course selection is limited to nonexistent in elementary schools, high schools often provide students with a variety of course offerings that fit students' needs, interests, and aspirations. The decision to enroll in STEM courses may be driven by a variety of factors. Interest in a subject and course selection seem to be related to each other, but one of the questions that remains is whether interest drives the selection of courses in high school or if courses develop interest. Maltese and Tai (2011) found indications that subject interest in STEM develops prior to middle school and therefore preceded the selection of high school coursework. However, not all students develop these interests until high school, and for these students it is often a course that sparks the interest that drives students toward a particular major (Dawes et al., 2015; Maltese et al., 2014).

Type and Number of Courses Taken

The number of STEM courses taken during high school has a connection to enrollment in a STEM major in college. Watt (2006) found that students intending to pursue mathematics-related careers were more likely to take high-level mathematics classes in high school, and Maltese & Tai (2011) found that the number of science classes were also positively correlated to the completion of a STEM degree. An Israeli study found that adults who had chosen a STEM career were likely to have majored in STEM subjects in high school (Sasson, 2020). Furthermore, the number of physics, chemistry, and calculus courses taken has been positively associated with success in college science classes and STEM career interest (Redmond-Sanogo et al., 2016; Sadler et al., 2014).

The types of STEM classes taken also has an impact on the selection of a STEM major in college. Thiry (2019) found many students who reach college well-prepared for STEM courses had taken advanced courses such as AP Calculus or challenging STEM electives like computer programming or organic chemistry. Those who persisted in their STEM degree path, however, were most likely to have taken an advanced chemistry class in high school. A study by Sadler, et al. (2014) revealed that while calculus, chemistry, and physics were significant predictors of STEM career interest, biology and other sciences were not.

An increasing number of schools are also offering applied STEM courses that focus on engineering design or information technology in combination with mathematics and science curriculum. Sublett and Plasman (2018) showed students who took applied STEM courses in high school gained self-efficacy in both mathematics and science. Students who took an applied STEM course in lower high school grades were more likely to later enroll in higher-level mathematics and science courses, and were more likely to major in STEM once they reached college (Gottfried, 2015; Gottfried & Bozick, 2016).

Why Students do not Take STEM Courses

Taking advanced STEM courses has an influence on the development of STEM interest and aspirations toward STEM careers. If this is the case, why are people not taking these courses? Naturally, many students have interests and aspirations outside of STEM and pursue those goals. Some students fail to take more mathematics and science courses because they have low self-efficacy in those subjects (Zeldin & Pajares, 2000). Other students don’t take more advanced science and mathematics classes because they were placed on a track earlier in their schooling that didn’t allow them to meet the prerequisites (Thiry, 2019). This practice of tracking negatively effects students of color at a greater level because they are more likely to be placed onto lower tracks at early stages (Oakes, 2005). Some students who may have wanted to take advanced mathematics and science coursework were not able to because their schools did not offer those courses, or the science teaching was lacking. Many students who feel unprepared for STEM courses in college did not have access to advanced classes because they came from high schools that were small and lacked resources (Thiry, 2019). Furthermore, students who came from schools with a shortage of science teachers were less likely to pursue STEM careers (Hampden-Thompson & Bennett, 2013).

In contrast, students from schools that specialize in STEM or have strong STEM programs often have well-stocked science labs, cooperate with universities and industry, promote independent projects, and offer numerous advanced science courses (Steenbergen-Hu & Olszewski-Kubilius, 2017). The findings from these studies align well with recommendations from Bottia et al. (2015) for increase in the variety of STEM programs and learning experiences in high schools.

School Achievement

Mastery experiences are an important source of self-efficacy, and high achievement in school science and mathematics as well as on national standardized tests can provide those experiences necessary to develop strong self-efficacy beliefs. Several studies have demonstrated a positive correlation between self-efficacy and academic achievement, with either variable being the indicator of the other (Heilbronner, 2011; Lent et al., 1984, 1986). Bonous-Hammarth (2000) examined two cohorts from the Cooperative Institutional Research Program, one of minority students and another comparative study of non-minorities, and found high school GPA and SAT-mathematics scores were associated with STEM retention in college. Because success breeds a feeling of accomplishment and a belief for a student that he or she may have continued success in that area, it is not a surprise that many students choose majors based on what they excel in at school (Dawes et al., 2015). School achievement, along with many other school factors, aids in the development of STEM attitudes as students progress through school.

Informal (Out-of-School) Learning Experiences

Informal learning experiences in STEM involve an array of out-of-school experiences that incorporate STEM in a real, applied, or firsthand way. The Center for Advancement of Informal Science Education (2021) defines informal experiences as “lifelong learning in science, technology, engineering, and mathematics (STEM) that takes place across a multitude of designed settings and experiences outside of the formal classroom” (subtitle of webpage). These may include large or well-structured events such as robotics competitions, science fairs, or camps as well as more subtle experiences such as the use of mathematics while shopping or observations in nature. In general, these experiences are different from in-school experiences because they involve individual choice and are not associated with grades or other high-stakes assessment (Allen & Peterman, 2019).

These out-of-school STEM experiences play an important role in the development of STEM attitudes for many people. Steenbergen-Hu and Olszewski-Kubilius (2017) conducted a study on many of the factors that led gifted students to pursue a STEM pathway, and determined that these out-of-school experiences were often the most influential elements. A study of students attending a science summer internship program found that participants were more sure of their STEM degree interests and developed a greater awareness of the career opportunities that are available in STEM (VanMeter-Adams et al., 2014). A larger study of 750 primarily first-year STEM students revealed that students who had participated in out-of-school STEM experiences prior to college were more likely to have higher interest and career aspirations in science and mathematics (Goff et al., 2019). A study of 983 middle school students demonstrated that participation in out-of-school science learning experiences improved students' fascination with science (Bonnette et al., 2019).

Out-of-school learning experiences are often valuable when they happen early in life. Studies on these experiences have demonstrated that interest and motivation for participation in STEM activities develops prior to middle school, and that early experiences are important for the development of STEM identity and career interest (Bonnette et al., 2019; Dou et al., 2019; Maltese & Tai, 2010). These experiences can come from many sources, which will be discussed throughout this section. It should be noted, however, that out-of-school experiences don't explain all connections to STEM interest and career aspirations (Sahin et al., 2017; Verdín et al., 2018), signifying the need to study a variety of places in which learning and development of interest and self-efficacy can happen.

Sources of Out-of-school Experiences and Influences

While school-related STEM learning experiences are connected to common curricula and goals, out-of-school learning experiences can take many forms, some of which are difficult to even define. For example, two studies of college students majoring in STEM indicated that the students did not have specific experiences that led them to their career choices, but rather they developed an intrinsic interest early in life (Maltese et al., 2014; Maltese & Tai, 2010). Additionally, Allen and Peterman (2019) stated intrinsic motivation was important for the continued pursuit of learning in STEM, and that out-of-school experiences are often sources of that motivation.

Other out-of-school experiences are more easily defined and connected to STEM interest and learning. A study of black engineering graduate students found that several participants remembered early play as an important factor toward the development of their STEM interest (Burt & Johnson, 2018). Other studies specify the importance of outdoor play as well as experiences involving nature or astronomy (Maltese et al., 2014; VanMeter-Adams et al., 2014). Another common experience for the development of STEM interest is consumption of media related to STEM, including television shows, movies, and books related to STEM or science fiction (Dou et al., 2019; Maltese et al., 2014). Physical locations that encourage STEM learning, such as zoos and museums are becoming more prevalent as providers of out-of-school learning experiences (Allen & Peterman, 2019). For many students, the opportunity to take part in research opportunities outside of the classroom was important in their journey to becoming a scientist (Thiry, 2019).

Another factor regularly cited as an important influence for the pursuit of a STEM career is family influence. While family can act as a background contextual influence as a general characteristic of what makes a person who they are, they can also provide specific experiences that impact a student. For example, multiple studies suggested conversations with family, especially those who have a STEM career, were important to the development and maintenance of interests (Dou et al., 2019; Steenbergen-Hu & Olszewski-Kubilius, 2017; VanMeter-Adams et al., 2014). Morris et al. (2019) asked 26 upper elementary and middle school students to track their STEM experiences through an app and found that most of their STEM-related activities happened at home with family. Dabney et al. (2013) stated that when parents were more highly educated and supportive, they provided a greater variety of out-of-school experiences to their children.

Another set of informal experiences that may develop STEM interest and skills are curricular programs that occur outside of the classroom, such as after-school programs or summer camps. Extracurricular programs that focus on STEM have shown an increase in students' interest in STEM subjects and careers (Anderson & Gilbride, 2003; Campbell et al., 2012; Mohd Shahali et al., 2016). Students report these programs are most effective when they use realistic presentations and hands-on activities to engage the participants (Campbell et al., 2012; Sasson, 2020). Several studies have demonstrated the effectiveness of programs centered on the use of robotics, design, and information technology (Duran et al., 2013; Nugent et al., 2010; Ziaeefard et al., 2017). Interestingly, a study of females in STEM found that extracurricular activities that involved mentorship and volunteering were particularly influential to the participants' decisions to pursue their field (Petersen, 2014). Bottia et al. (2015) conducted a study in which they developed policy recommendations for schools to help increase preparation for STEM careers, one of which is the development of more STEM extracurricular activities.

Summer camps have also demonstrated the potential to improve students' interest and beliefs in STEM. A study of girls in a science camp indicated that participants were more likely to take a science class in the following year, and that the skills they had learned would prepare them for these classes (Scott-Parker & Barone-Nugent, 2019). This sentiment was echoed by Roberts et al. (2018), who reported students were able to make connections between their camp learning and their learning in the classroom. A study by Kitchen et al. (2018) found that students who participated in their summer camp were nearly twice as likely to pursue a STEM career. This is supported by multiple studies indicating the connection between summer camps and STEM self-efficacy (Heiselt, 2014) and career interest (Ayar, 2015; Hammack et al., 2015; Kong et al., 2013; Mohr-Schroeder et al., 2014). These purposeful, out-of-school experiences demonstrate a variety of opportunities for students to develop the constructs that lead to career choice in an array of settings.

Summary

This chapter began with an introduction of SCCT as the theoretical framework for the study, followed by a description of the constructs of SCCT in relation to the literature. Self-efficacy and outcome expectations were connected to career interests, goals, and actions. Then, learning experiences were defined as the sources of self-efficacy and outcome expectations. The chapter detailed different forms of learning experiences that have indicated an effect on the SCCT constructs.

SCCT has been studied considerably since its inception, especially in the STEM fields (Lent et al., 2002). While a substantial amount of research has demonstrated the effectiveness of the model with various populations, there are still opportunities to look closely at the classroom structures and outside-of-school experiences that are meaningful to students and how they affect career goals. This study will build on the existing literature on SCCT and learning experiences to demonstrate how individual experiences in STEM prior to college lead to the development of STEM attitudes and career goals.

CHAPTER III

METHODS

This chapter details the methods and organization of this explanatory sequential mixed-methods research study. The first section presents the research methodologies for the study while specifying the purpose and structure of the mixed-methods design. Then the quantitative phase will be described, including participant sample and instruments used for data collection. The third section includes a description of the process by which interview participants were selected based on the quantitative data. The final section describes the qualitative phase of the study, provides a rationale for the interview protocol, and describes the process for the interviews and analysis.

Purpose and Research Questions

The purpose of this study is to elucidate the experiences that are important to the development of science, mathematics, and engineering self-efficacies, outcome expectations, and interests on the path to STEM career goals. Overall, the study worked toward these goals by answering the following research questions:

1. What learning experiences do students perceive to affect their self-efficacy, outcome expectations, interests, and goals in STEM?
    a. How do these learning experiences differ between students in STEM and non-STEM majors?
2. What learning experiences affect students' self-efficacy, outcome expectations, and interests in mathematics, science, and engineering?
3. How do self-efficacy, outcome expectations, and interests in mathematics, science, and engineering affect students' intent to pursue a career in STEM?

Research Design

This study used an explanatory sequential mixed-methods design (Creswell & Plano Clark, 2017) to examine the research questions above. Figure 3.1 provides a visual diagram for the implementation of the study. In the first, quantitative phase, survey methodology was used to gather information from participants about their background, experiences, and beliefs about STEM. Survey methodology is appropriate for this study because it allowed the researcher to ask questions about subjective data that could not be measured directly without gathering information from the individual (Groves et al., 2011). Additionally, surveys allowed the researcher to gather information about a larger group from a sample of that group.

During an intermediate phase, a selection matrix was developed from the self-efficacy scores reported in the quantitative portion of the study. The purpose of this selection matrix was to find interviewees with a variety of attitudes toward STEM that could provide details about their experiences. In the qualitative phase, the study sought deeper understanding about the learning experiences of participants prior to college. A phenomenological approach was used for the interviews to capture the experiences that participants had throughout their schooling. A phenomenological approach is suitable to gain an understanding of the lived experiences of the participants and how those experiences shape their views of STEM learning (Marshall & Rossman, 2014).

Figure 3.1

Explanatory Sequential Research Design

Phase	Procedures	Product
Quantitative Data Collection	• Internet Survey (N=5000)	• Quantitative Data (n=312)
Quantitative Data Analysis	• Examine the learning experiences selected by participants • Examine the perceptions of those chosen experiences • Comparison of learning experiences between STEM and non-STEM majors • Grouping of learning experiences into factors • Relationship between factors and SCCT constructs • Relationship between SCCT constructs and intent to pursue a STEM career	• Percentage of sample for each experience selected • Percentage of positive, neutral, negative responses • Percentage of each group; chi-square test; Mann-Whitney U test • Principle components analysis factor loadings • Multiple regression analysis • Simple logistic regression analysis
Case Selection	• Purposeful selection of interviewees ○ Two with high self-efficacy in all subjects ○ Two with low self-efficacy in all subjects ○ One with median self-efficacy in all subjects ○ Three with low self-efficacy in one or two subjects, but high self-efficacy in the other(s)	• Cases (n = 8)
Qualitative Data Collection	• Individual interviews with 8 participants via Zoom • Researcher reflections	• Interview transcripts • Researcher reflective journal
Qualitative Data Analysis	• Coding • Theme development	• Codes and themes • Connection of themes

Phase One: Quantitative

The first phase of the study used an internet survey to gather information from primarily first- and second-year students at a university. The data collected from this study was used to investigate the research questions related to learning experiences, career goals, and the intermediate constructs of social cognitive career theory (SCCT) that link the two. The instruments for the study support the SCCT framework relative to the domains of science, mathematics, and engineering.

Participants

The target population for the first phase of the study was undergraduate students enrolled at a large, midwestern, land-grant university in the fall semester of 2020. Email addresses were obtained from the university's Institutional Research and Analytics department, and an email database was established. The university enforces a limit on the number of email addresses given out for surveys, so the researcher chose to focus on those students in their first and second year at the university, who would be more likely to clearly recall the experiences they had prior to college. Then, the researcher sent an email to all students (N=5,000) in the database with a recruitment letter for the survey and a link to the questionnaire on Qualtrics (https://www.qualtrics.com). After two weeks, another email was sent to all students in the database as a reminder to complete the questionnaire. Additionally, the researcher posted flyers in visible spaces on campus with a recruitment statement, a QR code, and written link that directed students to the questionnaire.

A total of 5,000 emails were sent out to students at the university, and the questionnaire was completed by 375 students. Only one of the responses was completed from the QR codes on the flyers, and the remainder were completed from the email link. This resulted in a 7.5% response rate. However, some of the respondents did not answer some of the questions, and were removed from the data. As a result, 312 participants were used for this study, with a final response rate of 6.2%. Table 3.1 presents the demographics of the sample and those of the university. Comparing the sample to the university, the race breakdown is very similar, but there were considerably more females than males in the sample. The sample was primarily geared toward freshmen and sophomores, so it makes sense that those students were the primary respondents to the survey. Finally, just under half of students at the university are studying STEM majors, while about two-thirds of the sample are studying STEM majors.

Table 3.1

Demographics of Survey Participants

		Sample n (%)	University N (%)
Gender			
	Male	97 (31%)	9747 (49%)
	Female	212 (68%)	9999 (51%)
	Non-Binary	3 (1%)	Not reported
Race			
	American Indian/Native Alaskan	23 (7%)	984 (5%)
	Asian	3 (4%)	460 (2%)
	Black	8 (3%)	952 (5%)
	Hispanic/Latino/a	21 (7%)	1945 (10%)
	White	247 (79%)	15405 (78%)
Ethnicity			
	Hispanic or Latino/a	31 (10%)	Not reported
	Not Hispanic or Latino/a	272 (87%)	Not reported
	Prefer not to respond	9 (3%)	Not reported
Classification			
	Freshman	184 (59%)	4962 (25%)
	Sophomore	108 (35%)	4347 (22%)
	Junior	16 (4%)	4479 (23%)
	Senior	5 (2 %)	5958 (30%)
Major			
	STEM	206 (66%)	8771 (44%)
	Non-STEM	106 (34%)	10975 (56%)

Data Collection

The questionnaire for this study was developed to answer the research questions above along with a set of research questions for another study related to high school course selection. All sections of the questionnaire were informed by SCCT and the instruments are described in detail in the ensuing section. The data for this questionnaire was collected using Qualtrics. The questionnaire was written into the software and prepared for distribution upon the receipt of the email list of participants. The questionnaire used tools available on Qualtrics, such as the ability to use selections from one list to populate a smaller, focused second list that asks for more details related to the participants' selections.

The researcher allowed the questionnaire to remain open and available for approximately three weeks. After all responses had been collected, the data was downloaded from Qualtrics to a Microsoft Excel (Version 16.16.27) file. At that point, each participant was assigned a code, and their name was removed from the file for data analysis. Codes and names were maintained on a master file in a separate location. The deidentified file was then organized and prepared for quantitative analysis. Six questions required reverse coding, which the researcher carried out. Then, all subscales were added and averaged when necessary to prepare for analysis. At this point, the organized data was transferred to IBM SPSS Statistics (Version 24) for analysis.

Measures

The first three sections in the questionnaire were developed by the researcher to meet the needs of this study's research questions. These sections contained the demographics of the participants, coursework each participant completed in high school, and STEM learning experiences. The fourth section of the questionnaire examined the constructs of SCCT: self-efficacy, outcome expectations, and interests. Table 3.2 contains the variables of interest in the study along with the data sources for each variable.

The researcher conducted a search to find instruments that measured self-efficacy, outcome expectations, and interests, are based in SCCT, and are appropriate for use with undergraduates. Lent and Brown (2006) specify that instruments used in social cognitive research should be domain-specific for the variables of interest. No single instrument met all these criteria, so the instruments selected for this study consisted of subscales collected from other validated instruments. Each subscale was modified to relate specifically to mathematics, science, and engineering to keep the measurement relevant to the domain in question. This method has been used and validated in this manner for each of the subscales as described in the subsequent sections. The subscales are derived from the Patterns of Adapted Learning Scales (Midgley et al., 2000), the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976), and the Career Interest Survey (Christensen et al., 2014). The full questionnaire is provided in Appendix B.

Self-Reported Demographics. The first section of the questionnaire contained questions about the participants' demographics. It asked for their classification, race, ethnicity, gender, highest level of parents' education, college major, and whether they intend to pursue a career in STEM. The question regarding parents' education status was used as a proxy for the participants' socioeconomic status (SES), as one of the recommended key components of SES by Cowan et al. (2012) in their recommendation to the National Center for Education Statistics.

High School Coursework. The second section of the questionnaire was not used for this study, but will be used for future studies related to STEM coursework in SCCT. This section asked students to indicate the high school courses that they took prior to attending the university. This section provided a list of courses in science, mathematics, engineering, technology, and applied STEM. Applied STEM courses "emphasize the application of academic mathematics and science concepts to practical job experiences while incorporating quantitative reasoning, logic, and problem solving skills" (Gottfried, 2015, p. 383). According to the U.S. Department of Education, these courses are classified into either scientific research and engineering (i.e. engineering, drafting) or information technology (i.e. computer programming, computer science).

The classes included in the instrument were selected from the list of course codes provided by the Oklahoma State Department of Education (2020), and each section also includes an 'other' option to add any courses that are not listed. After selecting the courses in each category, the questionnaire opened a page with all the remaining courses that had not been selected and asked participants to select any course they would have taken if their school had offered it.

Learning Experiences. The third section contained three multi-part questions in which participants indicated the learning experiences they had experienced prior to their college studies. The first question asked participants to select the experiences in which they participated during a mathematics, science, engineering, or technology-related class in grades K-12. The experiences include statements such as “discussion of STEM careers”, “lectures by the teacher”, and included an “other” choice where participants could add to the list. The list of experiences used for this study was developed based on the results of prior research on learning experiences in STEM (Maltese et al., 2014; Maltese & Tai, 2010, 2011). These studies also have highlighted the importance that teacher influence can have on students’ assessment of their abilities and interests. Therefore, the second question asked students to identify whether certain teacher characteristics, such as encouragement or personality, influenced their STEM interests or confidence. The third question asked participants to select the STEM experiences they had participated in outside of school throughout their lives. These experiences included statements such as “tinkering with electronics” and “reading about STEM or science fiction”, along with an “other” choice where participants could add to the list. The list of experiences used for this portion of the study was developed based on the results of prior research on informal learning experiences in STEM (Burt & Johnson, 2018; Dou et al., 2019; Maltese et al., 2014; Maltese & Tai, 2010, 2011).

After participants selected all the learning experiences in which they had participated, they were directed to a second page that contained only the experiences or factors the participants had selected. The question on this page asked participants to indicate whether each learning experience or factor increased their confidence in their ability to succeed in STEM, had no effect on their confidence in their ability to succeed in STEM, or decreased their confidence in their ability to succeed in STEM.

SCCT Construct Instruments. The fourth section of the survey included questions from each of the following instruments measuring self-efficacy, outcome expectations, and interests in science, mathematics, and engineering. Each instrument used a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. The questions in section four were numbered 21 through 42, and were mixed so that the constructs were varied throughout the section. Questions 21, 25, 29, 33, and 38 examined self-efficacy, questions 22, 23, 26, 27, 30, 31, 34, 35, 36, 39, 40, and 41 examined outcome expectations, and questions 24, 28, 32, 37, and 42 examined interests.

Patterns of Adapted Learning Scales. The self-efficacy scale is based off a subscale of the Patterns of Adapted Learning Scales (PALS) (Midgley et al., 2000), which relates the learning environment to affective constructs in students. The PALS was originally written to examine patterns of learning that result in mastery and performance goals, along with the beliefs and attitudes of students and teachers and their relation to the classroom. This revised version considers that measures for students should be subject-specific. The developers of the instrument specify that subject-specific scales are at least as reliable as general scales. In the original use of the scale, the authors reported a Cronbach's alpha of .78.

The self-efficacy subscales measure students' perceptions of their ability to complete class work in a particular subject. The measure includes 5 items (e.g. "I'm certain I can figure out how to do the most difficult class work in mathematics") with a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. The items were repeated for mathematics, science, and engineering, providing a self-efficacy score for each domain. A study by van Aalderen-Smeets et al. (2019) used a similarly modified version of this scale in a study of STEM interest and ability beliefs and reported a Cronbach alpha of .83. Additionally, Shin et al. (2016) measured self-efficacy in the student body of a large university in a study of STEM interests, affective constructs, and role models, and reported an alpha of .92 for their modified version of this scale.

Fennema-Sherman Mathematics Attitudes Scales. Outcome expectations were measured using the Usefulness of Mathematics Scale, which is a subscale of the Fennema-

Sherman Mathematics Attitudes Scales. This is a 12-item measure that assesses how participants view the relevance of their studies in STEM to their future life and work. The Fennema-Sherman scale was originally designed to assess the affective variables that correspond with students' mathematics learning and course choices. In the original work, the authors reported a split-half reliability coefficient of .88 for the Usefulness of Mathematics subscale.

The items are answered using a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree, and there are both positively and negatively worded items on the scale. Each item was listed with the subject as mathematics, science, and engineering, so that an outcome expectation score could be determined for each subject. This scale has been used effectively in previous studies of outcome expectations in social cognitive career theory. Lopez and Lent (1992) and Lent et al. (2001) used versions of this scale and reported a Cronbach alpha of .92 and .89, respectively. The latter version of the scale also used a combination of science and mathematics subjects in the responses, demonstrating the scale's effectiveness beyond the mathematics domain alone.

Career Interest Questionnaire. Interests were measured using a subscale of the career-interest questionnaire (CIQ) developed by Christensen et al. (2014). This questionnaire originated from an analysis of STEM interest in Hawaiian students (Bowdich, 2009) and was then adapted into the CIQ. The Cronbach's alpha reported for the scale in the original study was .93.

The interest subscale measure consists of 5 items on a 5-point Likert scale which ranges from (1) strongly disagree to (5) strongly agree. The items on the scale were modified for mathematics, science, and engineering, providing an interest score for each subject. A study that looked at the use of the CIQ for STEM subjects through two interventions reported Cronbach's alphas of .97 and .96 for the intent subscale (Peterman et al., 2016). This study also indicated that intent scores were significant predictors of participants' STEM career intentions.

Table 3.2

Data Sources

Variable of Interest	Data Source
Learning experiences	Learning experiences instrument
Self-efficacy	PALS self-efficacy subscale
Outcome expectations	Fennema-Sherman: Usefulness of mathematics subscale
Interests	CIQ intent subscale
Intent to pursue a STEM career	Demographics

Data Analysis

The researcher first determined the frequency of each learning experience and the percentage of participants that reported participating in each. The learning experiences were grouped as in-school experiences, teacher characteristics and experiences, and out-of-school experiences to break them apart for ease of analysis, interpretation, and presentation. Subsequently, the researcher totaled the positive, negative, and neutral responses for each activity and characteristic. The researcher calculated the difference between positive and negative responses to determine which activities participants perceived to be the most beneficial and harmful to their STEM interests and self-efficacy.

To find the relationship of these selections and perceptions between STEM and non-STEM students, the researcher needed to determine which students were majoring in a STEM subject and which were not. The researcher compiled a list of all majors offered by the university where the study took place and sorted the majors into STEM and non-STEM categories based on the list used by Maltese and Tai (2011). Table 3.3 lists the university's available majors according to these categories.

The researcher compared the learning experiences selected by participants in STEM majors and non-STEM majors. For both groups, the researcher also examined the total numbers of each activity or characteristic chosen as well as those that are listed as positive, negative, or neutral learning experiences to compare the similarities and differences for each. Statistical comparison between STEM and non-STEM groups' learning experiences was completed using a Chi-Square test of independence. The perceptions of these experiences were recorded as ordinal variables on a scale from 0 to 3, where 0 indicated that the participant had no experience with the learning experience, 1 indicated a negative experience, 2 indicated an experience that had no perceived effect on STEM confidence or interest, and a 3 indicated a positive experience. The researcher then compared the STEM and non-STEM groups' perceptions of the learning experiences using this index. Because the dependent variables are ordinal rather than continuous, a Mann-Whitney U test was chosen to compare the two groups.

In addition to the participants' self-reporting of the value of the learning experiences to their confidence and interests in STEM subjects, the researcher examined the connection between participants' participation in the learning experiences and their self-efficacy, outcome expectations, and interest scores. Before this analysis was conducted, the researcher reduced the number of learning experiences by applying a principle component analysis. This process reduced the independent variable from 49 learning experiences to 11 factors for study. These factors were then used in a multiple regression analysis as predictors of participants' self-efficacy, outcome expectations, and interest in mathematics, science, and engineering. Those construct scores were then used in a simple logistic regression as predictors of participants' intent to pursue a STEM career.

Table 3.3

Classification of University's Majors into STEM and Non-STEM Categories

STEM	Non-STEM
Aerospace Engineering	Accounting
Architectural Engineering	American Studies
Chemical Engineering	Apparel Design
Civil Engineering	Architecture
Computer Engineering	Art
Construction Engineering Technology	Art History
Electrical Engineering	Child and Family Services
Industrial Engineering	Communications
Mechanical Engineering	Early Child Care
Mechanical Engineering Technology	Education (all fields not designated in a STEM category)
Chemistry	
Geology	Economics
Medicinal and Biophysical Chemistry	English
Physics	Entrepreneurship
Biochemistry	Fire Protection
Molecular Biology	Finance
Biology	Foreign Language
Entomology	Business
Microbiology and Molecular Genetics	Geography
Physiology	Geospatial Information Science
Plant Biology	Graphic Design
Zoology	History
Mathematics	Hospitality
Statistics	Interior Design
Aerospace Administration and Operations	Landscape Architecture
Computer Sciences	Management
Communication Sciences and Disorders	Management Information Systems
Exercise Science	Marketing
Health Education and Promotion	Merchandising
Nursing	Multidisciplinary Studies
Nutritional Sciences	Journalism
Recreational Therapy	Music
Agribusiness	Philosophy
Agricultural Education	Political Science
Agricultural Leadership	Psychology
Animal Science	Recreation Management
Biosystems Engineering	Sociology
Environmental Science	Sports Media
Food Science	Theatre
Horticulture	
Natural Resource Ecology and Management	
Plant and Soil Sciences	

Intermediate Phase

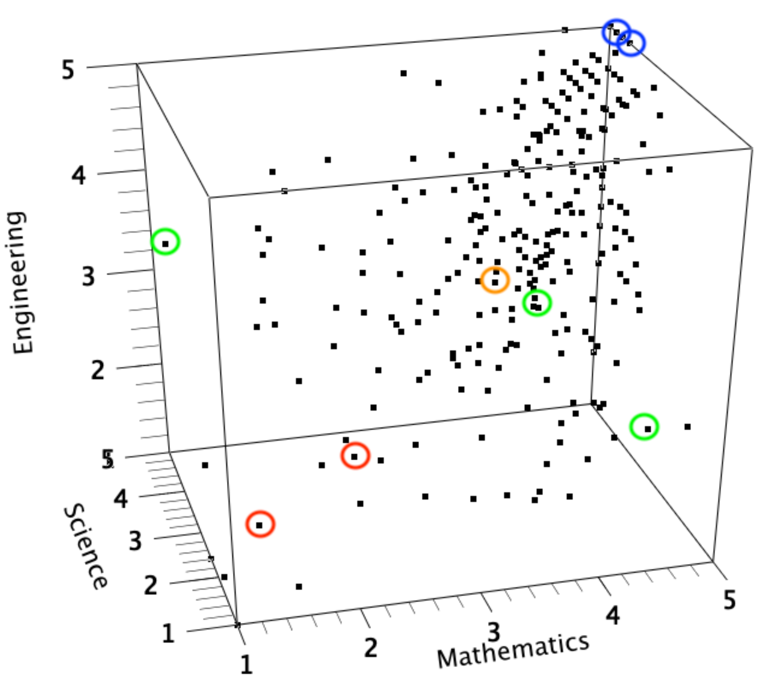
After the data was reviewed and analysis started, the researcher began the process of selecting interview candidates. The original questionnaire ended with an option to provide contact information if students were willing to participate in a follow-up interview. The researcher developed a selection matrix to select a purposive sample of eight participants to interview. The selection matrix was based on participants' self-efficacy scores, ensuring that participants had a range of beliefs about their STEM ability.

The self-efficacy scores from each subject area (science, mathematics, and engineering) were calculated from participant responses on the PALS subscale. These results were plotted onto a three-dimensional graph using QTI Plot software (Version 5.9.7), with the mathematics self-efficacy score on the x-axis, science self-efficacy on the y-axis, and engineering self-efficacy on the z-axis. Figure 3.2 shows this three-dimensional graph complete with data points from all participants. Two interviewees were selected that display high self-efficacy scores in all three subjects (circled in blue on Figure 3.2). Two interviewees were selected that display low self-efficacy scores in all three subjects (circled in red). Three interviewees were selected that have a mixed set of self-efficacy scores (circled in green), meaning they had a low score in one or two subjects but a high score in the others. These three participants were selected so that there was at least one interviewee with a very low score and a very high score in each domain. Finally, one interviewee was selected that is near the median of all three domains (circled in yellow). This selection criteria provided eight interview candidates with a variety of beliefs about STEM and their abilities in STEM to discuss how learning experiences shaped their self-efficacy, outcome expectations, and interests prior to coming to college.

The researcher began the actual selection process by selecting eight participants according to the selection matrix, then matching those codes to emails from the master code list. The researcher sent emails to each of these eight participants with a recruitment letter asking them to participate in an interview via the online web conferencing platform Zoom (https://www.zoom.us). After the initial round of emails, only two participants responded to schedule their interview. The interviewer then sent a second round of emails to the remaining six selected participants, and one responded for the interview. The researcher then selected another group of participants that met the criteria from the selection matrix and followed the same procedures as above to send an email recruitment. Four more participants responded to this second round of solicitation for interview participants. After one more round of selection and emails, the final participant responded and agreed to an interview. In all, ten of the participants that were selected by the matrix did not respond to the email recruitment. Table 3.4 displays the participants that completed interviews (using their pseudonyms), along with the self-efficacy scores for each subject.

Figure 3.2

Scatterplot of Self-Efficacy Scores for Interview Selection



Note: High self-efficacy scores in all three subjects are blue, median self-efficacy is yellow, low self-efficacy are red, and mixed self-efficacy are green.

Table 3.4

Interview Selections and their Self-efficacy Scores for Each Subject

Selection Criteria	Interviewee	Math self-efficacy	Science self-efficacy	Engineering self-efficacy
Low self-efficacy in all domains	Regina	1.4	3.0	1.0
	Noah	2.2	2.6	2.0
Mixed: Low math self-efficacy	Evan	1.0	5.0	3.2
Mixed: Low science self-efficacy	Annabelle	4.4	1.2	2.4
Mixed: Low engineering self-efficacy	Neely	4.4	5.0	2.2
Median self-efficacy in all domains	Ashley	3.6	3.6	4.0
High self-efficacy in all domains	Blake	5.0	4.4	5.0
	Nolan	5.0	4.8	5.0

Phase Two: Qualitative

The second phase of this explanatory sequential study involved interviews with the selected participants. This phase was meant to answer the research question regarding the effect of learning experiences on participants' perceptions of their self-efficacy, outcome expectations, interests, and goals. The interviews take on an explanatory role in this mixed-methods design, where the purpose is to explain and provide depth for the original quantitative results (Creswell & Plano Clark, 2017).

Participants

The eight participants that were selected and responded to the call for interviews are described in Table 3.5. Half were male and half were female, and three-fourths were White while the other one-fourth were American Indian. Four of the eight intend to pursue a STEM career, three did not intend to pursue a career in STEM, and one was undecided.

Table 3.5

Interview participant demographics

Name	Classification	Gender	Race	Major	Intends to pursue a STEM career
Regina	Freshman	Female	American Indian	Global Studies	No
Noah	Sophomore	Male	White	Secondary Education/History	No
Evan	Freshman	Male	American Indian	Animal Science	Yes
Annabelle	Freshman	Female	White	Interior Design	No
Neely	Freshman	Female	White	Zoology	Yes
Ashley	Junior	Female	White	English/Creative Writing	Unsure
Blake	Freshman	Male	White	Mechanical Engineering	Yes
Nolan	Freshman	Male	White	Computer/Electrical Engineering	Yes

Data Collection/Interviews

Interview participants who responded to the recruitment emails scheduled a time to meet with the researcher to conduct the interview. These interviews took place through Zoom due to social distancing precautions associated with the coronavirus pandemic and in accordance with university protocols. The researcher conducted semi-structured interviews with each of the participants, with the purpose of connecting the in- and out-of-school learning experiences that played a role in the development of their self-efficacy, outcome expectations, interests, and goals in science, mathematics, and engineering. During the interview process, the researcher took notes of major ideas or key points made by the participants. At the end of each interview, the researcher also wrote a summary of the interview, including impressions of the participant, nonverbal cues, personality, and emotion that the participant exhibited, along with major ideas that were conveyed during the interview.

The researcher developed the semi-structured interview protocol based on the constructs of SCCT (Lent et al., 1994). Each question in the interview was designed to elicit a response related to the participant's experiences and views of STEM (a) learning experiences, (b) self-efficacy, (c) outcome expectations, (d) interests, and (e) goals. Table 3.6 demonstrates how each of the ten questions in the interview protocol fits into the SCCT constructs. The structure of the interview focused on these constructs, but followed a phenomenological approach, which emphasized the lived experiences of the participants and how those experiences shaped their understanding of STEM (Marshall & Rossman, 2014). Using this framework as a background allowed the researcher to ask follow-up questions when appropriate to gather more information about participants' experiences. It also provided insight into how the experiences related to participants' decision-making and attitudes through an SCCT lens. The interview protocol is presented in Appendix C.

Table 3.6

Semi-structured Interview Construct Organization

Construct	Learning Experiences	Self-efficacy	Outcome Expectations	Interests	Goals
Question	3, 4, 7, 8, 9	3, 4, 7, 9, 10	5, 6	1, 2, 7, 9	1, 2

Data Analysis

The researcher followed the analytical procedures described by Marshall and Rossman (2014): organization of the data, immersion, generation of summaries and possible themes, coding, interpretations, thinking about alternative meanings, and writing results. First, the researcher recorded and transcribed each interview, ensuring that the transcripts were accurate and organized. Each transcript and interview summary was then entered into Provalis Research QDA Miner (Version 6.0.3) software for organization and consistency of analysis. The researcher then read and reread each transcript and summary to become immersed in the material. At this point, the researcher developed a general summary for each case and begin to develop some broad themes based on the collected data. Next, the researcher began the coding process through a combination of first cycle coding techniques. The researcher used provisional coding (Saldaña,

2015) to develop an initial code list based on the literature on learning experiences and SCCT. While reading through the interview transcripts, the researcher used structural coding to categorize phrases and paragraphs based on learning experiences in the literature (i.e., the learning experiences listed in the questionnaire). Additionally, the researcher used values coding to examine the participants' views, attitudes, and beliefs about STEM learning (Saldaña, 2015). The researcher used QDA Miner software to apply and organize these codes for further analysis. Throughout this process, the researcher wrote notes about the analytic process, connecting the emerging data to theory (i.e., SCCT) and identifying clusters of information along with gaps in the data. Interpretation of the data involved evaluation of the findings for meaning, developing explanations, conclusions, and inferences, and ascribing significance to the data (Patton, 2014). Finally, the researcher carefully analyzed the findings, checking for reasonableness and connection to existing literature to look for alternate meanings or interpretations. Finally, the data and interpretations were compiled into the final report for this study.

Establishing Validity and Trustworthiness

Determining validity in qualitative research involves the establishment of trustworthiness. Hays and Singh (2012) provide criteria for trustworthiness, including credibility, confirmability, and authenticity. The researcher sought to establish trustworthiness with these criteria using a variety of strategies. Throughout the research process, the researcher kept notes and wrote analytic memos keeping track of key ideas interviewees were conveying and the researcher's evolving thoughts concerning the topics of the study. While writing, the researcher used vivid and descriptive explanations of the interviewees' comments in a process called thick description (Hays & Singh, 2012). These strategies were part of the process to establish credibility in the qualitative research.

The researcher also implemented member checking (Hays & Singh, 2012) in an effort to confirm that the analysis was being done in a way that truly reflected the thoughts of the interviewees. Transcripts of the interview and brief preliminary interpretations were sent to each interviewee requesting confirmation of the analysis or changes to be made. Of the eight interviewees who were sent this email, four responded and confirmed that the transcript and analysis appropriately reflected the conversation. The researcher also analyzed the data throughout the collection process. By taking notes during and after each interview, the researcher was able to determine whether he gathered all the appropriate information possible. This allowed for flexibility in the semi-structured interviews, and the protocol changed slightly as the interviews progressed. Based on this, the researcher was better able to anticipate responses and react with suitable follow-up questions that met the purpose of the study. These strategies helped the researcher establish the confirmability and authenticity of the qualitative data.

Summary

This chapter described the explanatory sequential design of a study to examine the relationship between students' STEM learning experiences and their self-efficacy, outcome expectations, interests, and goals, as well as the differences in these experiences between STEM and non-STEM students. The purpose of a mixed-methods design was to elicit responses from a variety of students regarding their experiences in and beliefs about STEM, and then use that data to create a set of interviewees for follow-up that would explain and strengthen the quantitative data (Creswell & Plano Clark, 2017). The chapter described the first quantitative phase, including a description of participants and measures, along with the processes of data collection and analysis. Next, an intermediate phase was used to select interview participants based on the results of the quantitative data. In the second phase, the researcher discussed the use of semi-structured interviews based in SCCT, and the process by which these interviews were conducted and analyzed. The next chapter will provide the results of the data analysis.

CHAPTER IV

RESULTS

The purpose of this mixed methods study was to investigate the STEM experiences, attitudes, and choices of undergraduates at a university. This explanatory sequential design first surveyed a sample of students, and then a select group of students was interviewed to gain a deeper understanding of the results. In the initial steps, an online questionnaire was used to gather data from 312 students, primarily in their first or second year at the university, about the in- and out-of-school learning experiences that influenced their confidence and interests in STEM and their attitudes about science, mathematics, and engineering. In an intermediary phase, self-efficacy scores were used to select a group of eight students to be interviewed. These interviews probed deeper into the personal experiences of each student to gain understanding about the things that made a difference in their STEM journeys. This chapter will present the data that came from each of these phases of the study. The research questions guiding this study were:

1. What learning experiences do students perceive to affect their self-efficacy, outcome expectations, interests, and goals in STEM?
    a. How do these learning experiences differ between students in STEM and non-STEM majors?
2. What learning experiences affect students' self-efficacy, outcome expectations, and interests in mathematics, science, and engineering?
3. How do self-efficacy, outcome expectations, and interests in mathematics, science, and engineering affect students' intent to pursue a career in STEM?

In this chapter, four sections will be presented. The first section details the overall results of the survey, along with scale reliability. The second section presents the results of the quantitative data, focusing on each research question and the relationship to social cognitive career theory (SCCT). In the third section, qualitative data will be examined to gain an understanding of how learning experiences relate to personal attitudes and goals. The fourth section provides a summary of the quantitative and qualitative results.

Quantitative Results

Before the data were analyzed, Cronbach's alpha values were calculated to determine the internal consistency of each subscale in the questionnaire. There were five items in each of the self-efficacy subscales, with math subscale $\alpha = .91$, science subscale $\alpha = .88$, and engineering subscale $\alpha = .91$. There were twelve items in each of the outcome expectations subscales, with math subscale $\alpha = .90$, science subscale $\alpha = .89$, and engineering subscale $\alpha = .91$. There were five items in each of the interest subscales, with math subscale $\alpha = .91$, science subscale $\alpha = .94$, and engineering subscale $\alpha = .95$. Each of these values is consistent with the literature and demonstrates the high internal consistency of each subscale used in the study.

Research Question 1

The first research question examined the learning experiences that participants reported and their perception of how these experiences affected their self-efficacy, outcome expectations, interests, and goals in STEM. The following results include the overall selections of the learning experiences, perceptions of those learning experiences, and how those perceptions differ between students in STEM and non-STEM majors.

Learning Experience Selections

This analysis began with an examination of the learning experiences that were reported by the participants. First, the percentage of all participants that selected each learning experience was examined and organized using bar graphs. On average, each participant selected 15 in-school learning experiences and 12 out-of-school learning experiences. Then, to explore which learning experiences were selected differently by STEM and non-STEM students, the researcher conducted a chi-square test for each experience. Seven in-school experiences, two teacher factors, and seven out-of-school experiences showed significant differences between groups. All but one of these were selected more often by the STEM group than by the non-STEM group.

Figure 4.1 displays the percentage of the sample (n = 312) that reported having participated in each experience while in a STEM classroom. More than 80% of participants reported experiencing lectures by the teacher, paper assignments, projects, hands-on activities, science demonstrations by the teacher, step-by-step laboratory experiments, and use of computers for class assignments. Fewer than half of the participants reported taking a class with an emphasis on further study in STEM, seeing speakers from professional STEM fields, participating in a science fair, discussing STEM careers in class, participating in student-designed laboratory experiments, taking a class with an emphasis on problem solving, or taking a class with an emphasis on memorizing.

Figure 4.1

Percentage of Participants (n = 312) who Selected Each In-school Learning Experience

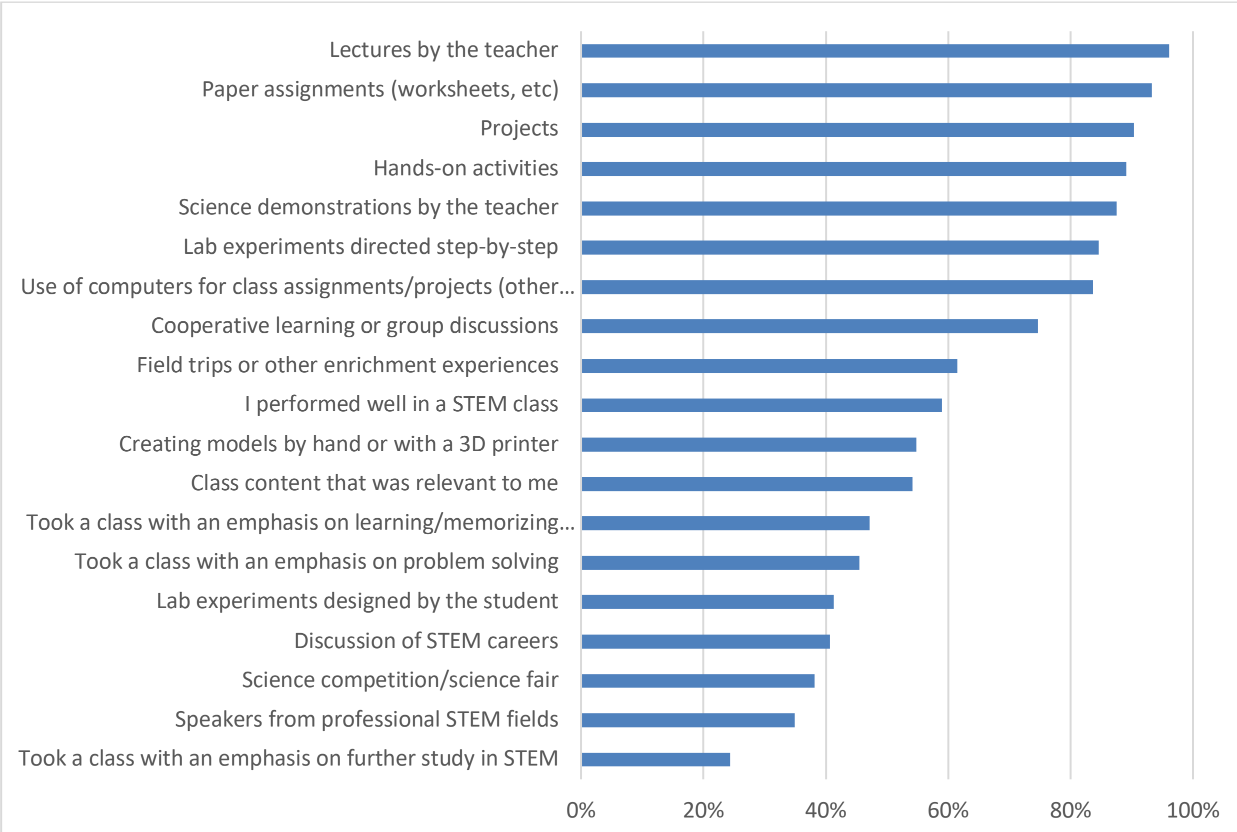
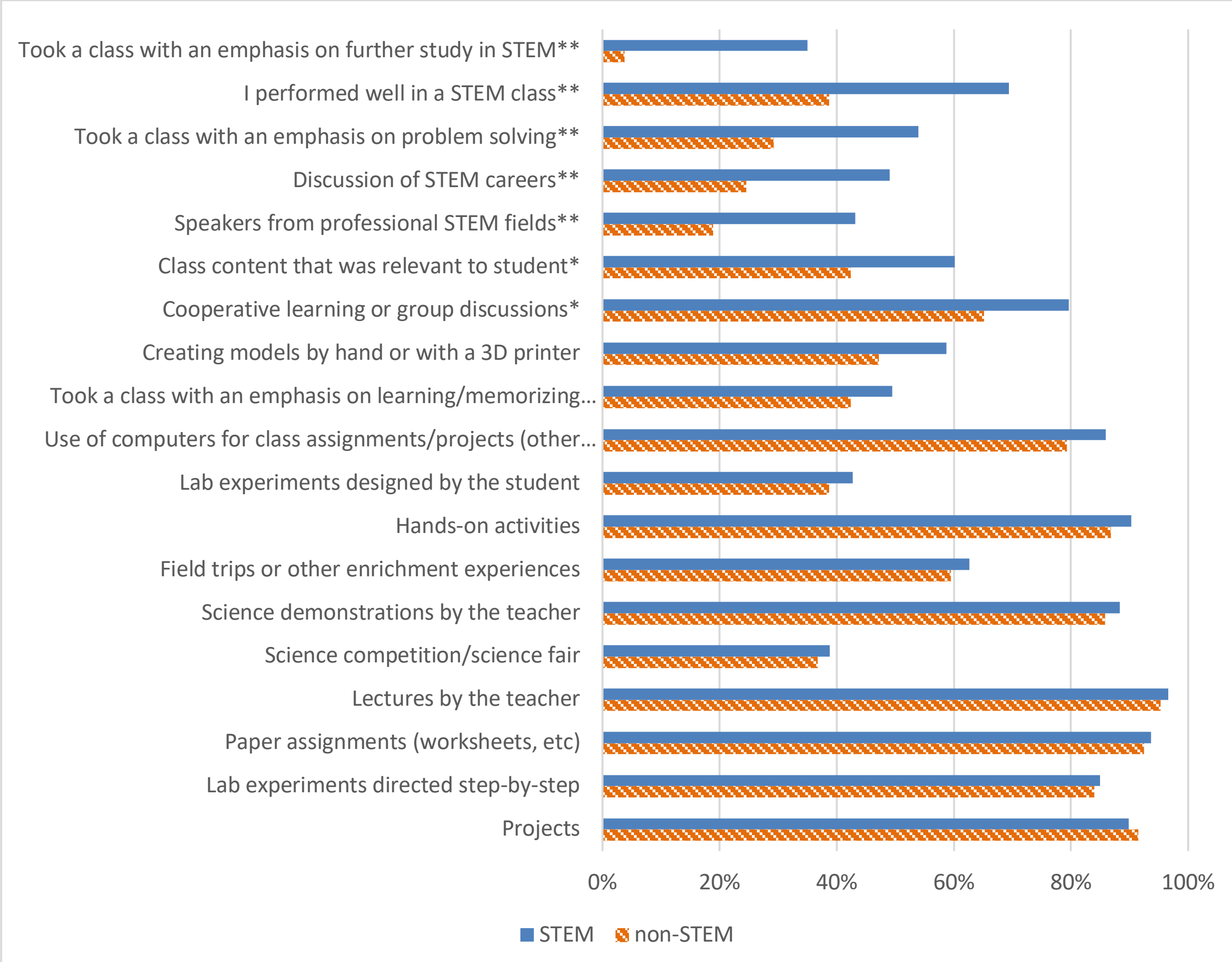


Figure 4.2 displays the in-school experiences by STEM students (n = 206) and non-STEM (n = 106) students. The in-school experiences that were selected significantly more by STEM students than non-STEM students include cooperative learning, $\chi^2(1, N = 311) = 8.09$, p = .004, speakers from professional STEM fields, $\chi^2(1, N = 311) = 17.83$, $p < .001$, discussion of STEM careers in classes, $\chi^2(1, N = 311) = 16.95$, $p < .001$, taking classes with content that is relevant to the student, $\chi^2(1, N = 311) = 8.43$, $p = .004$, taking classes with an emphasis on further study in STEM, $\chi^2(1, N = 311) = 36.53$, $p < .001$, taking a class with an emphasis on problem solving, $\chi^2(1, N = 311) = 16.63$, $p < .001$, and performing well in a STEM class, $\chi^2(1, N = 311) = 26.55$, $p < .001$.

Figure 4.2

Percentage of STEM (n = 206) and non-STEM (n = 106) Students who Selected Each In-school Learning Experience



Note: Categories are ordered by difference between STEM and non-STEM majors.

*$p<.05$, **$p<.001$

The next question dealt with participants' views of teachers and whether they felt that certain teacher actions or characteristics influenced their confidence or interests in STEM. The percentage of the sample that responded that these teacher factors had an influence on them is displayed in Figure 4.3. All the factors listed were influential to between 60% and 80% of the sample, with teacher personality and teacher encouragement reported most frequently.

Figure 4.3

Percentage of Participants (n = 312) who Selected Each Teacher Characteristic or Experience

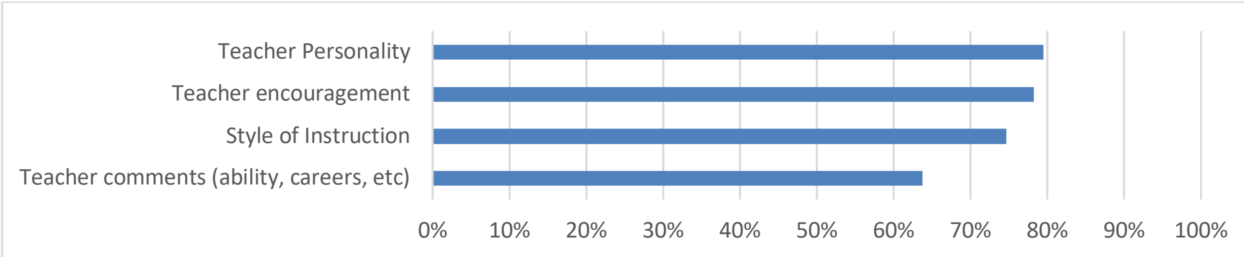
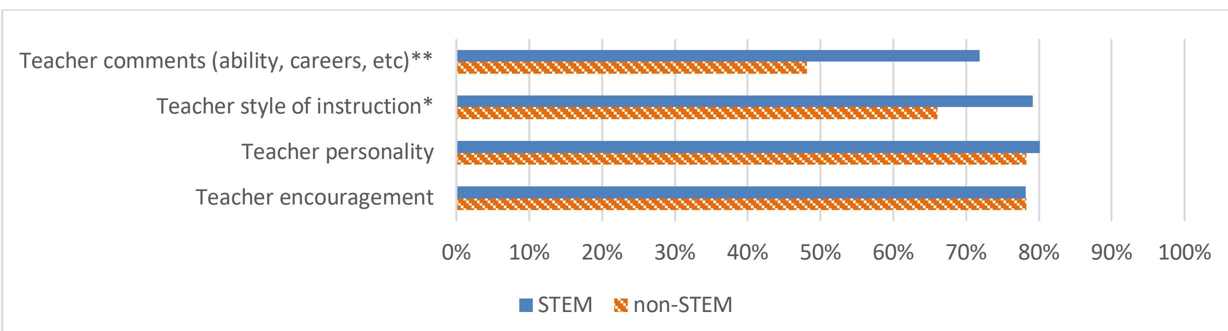


Figure 4.4 displays the teacher factors for STEM students and non-STEM students. The teacher factors that were selected significantly more by STEM students than non-STEM students include teacher comments about ability, future, careers, etc., $\chi^2(1, N = 311) = 17.65$, $p < .001$ and teacher style, $\chi^2(1, N = 311) = 6.60$, $p = .01$.

Figure 4.4

Percentage of STEM (n = 206) and non-STEM (n = 106) Students who Selected Each Teacher Characteristic or Experience



Note: Categories are ordered by difference between STEM and non-STEM majors.

*$p<.05$, **$p<.001$

The third question asked participants about the out-of-school STEM-related experiences in which they had participated. The percentage of the sample that reported having these out-of-school experiences is displayed in Figure 4.5. Only visits to a zoo or aquarium, visits to a museum or learning center, and spending time outdoors were reported as experiences by over 75% of participants. Fewer than 20% of participants reported being involved in after-school STEM programs, going to a STEM camp, having STEM be a part of family activities, writing computer programs or designing web pages, or experiencing family pressure to pursue STEM.

Figure 4.5

Percentage of Participants (n = 312) who Selected Each Out-of-school Learning Experience

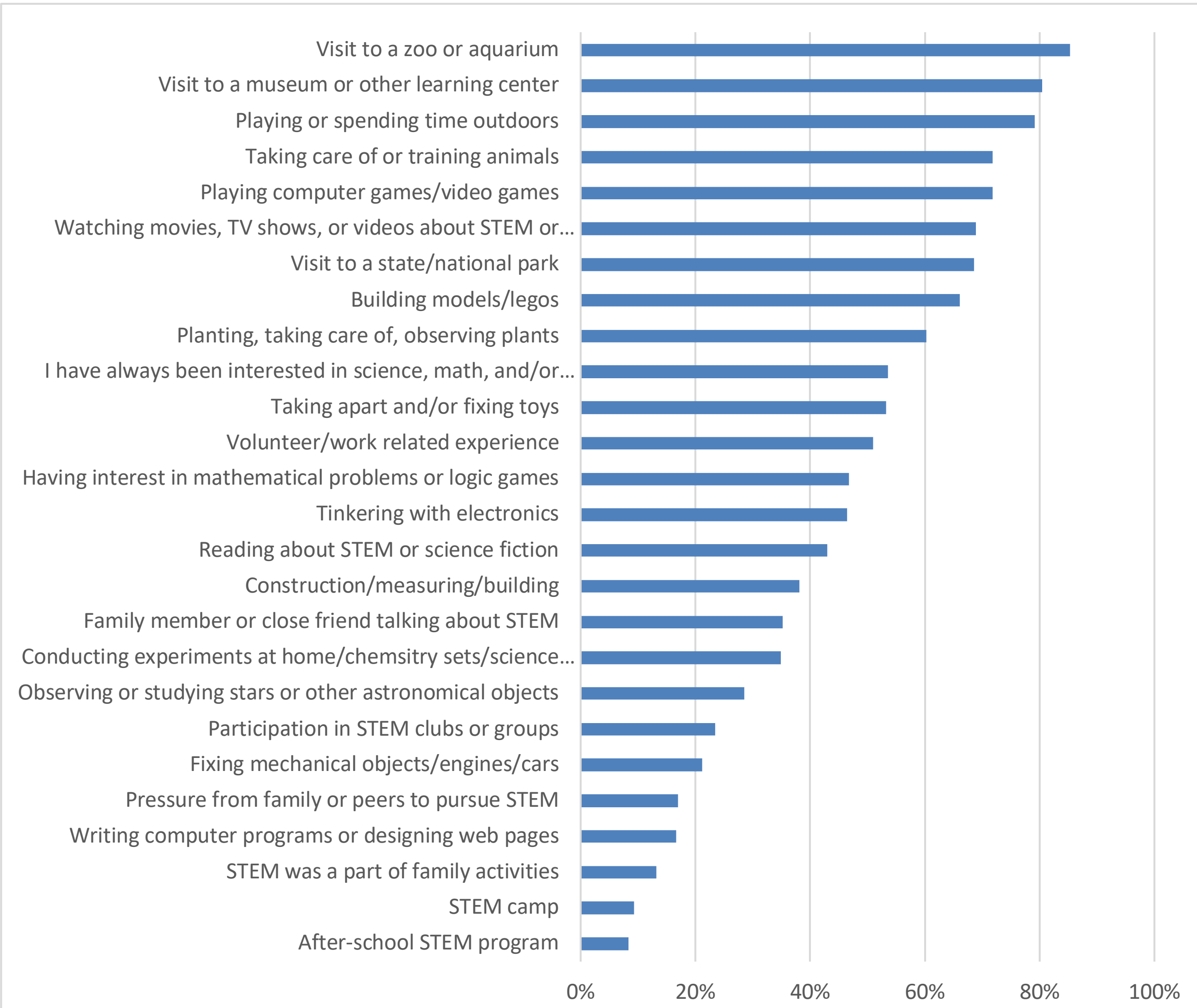
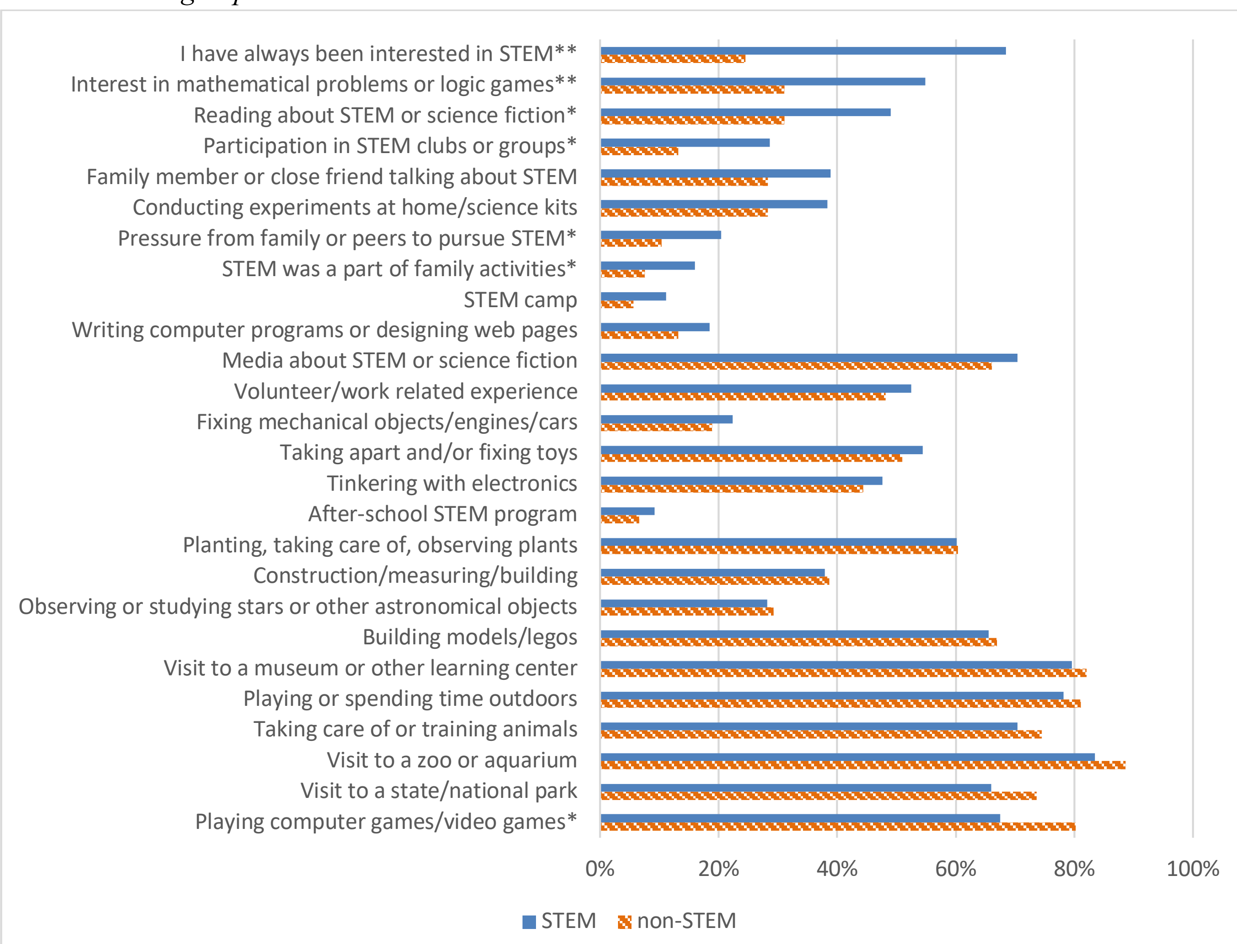


Figure 4.6 displays the out-of-school experiences for STEM students and non-STEM students. The out-of-school experiences that were selected significantly more by STEM students than non-STEM students include reading about STEM or science fiction, $\chi^2(1, N = 311) = 8.79$, *p*

= .003, having STEM as a part of regular family activities, $\chi^2(1, N = 311) = 4.29$, $p = .038$, pressure from family or peers to pursue STEM, $\chi^2(1, N = 311) = 4.83$, $p = .028$, participation in STEM clubs or groups, $\chi^2(1, N = 311) = 9.07$, $p = .003$, having interest in mathematical problems or logic games, $\chi^2(1, N = 311) = 15.32$, $p < .001$, and always having an interest in science, math, and/or engineering, $\chi^2(1, N = 311) = 55.68$, $p < .001$. The single activity that was selected significantly more by non-STEM majors than STEM majors was playing video games, $\chi^2(1, N = 311) = 5.38$, $p = .020$.

Figure 4.6

Percentage of STEM (n = 206) and non-STEM (n = 106) Students who Selected Each Out-of-School Learning Experience



Note: Categories are ordered by difference between STEM and non-STEM majors.

*$p<.05$, **$p<.001$

Overall Participant Perceptions of Learning Experiences

When completing the online questionnaire, participants selected the experiences above according to their recollection of participation in each experience. Using logic fields, the questionnaire then took them to a page containing only those experiences they selected, and asked the participants whether that experience had a positive impact on their confidence and/or interest in STEM, no impact on their confidence and/or interest in STEM, or a negative impact on their confidence and/or interest in STEM. This provided a self-report of how each participant viewed the experience in relation to their STEM journey.

For each in-school experience that was selected, a breakdown of the positive, neutral, and negative responses is given in Figure 4.7. Overall, the experiences were viewed more positively than negatively. To better understand how each experience was viewed by participants, the difference between the percentage of participants that reported the experience as affecting them positively and the percentage of participants that reported the experience as affecting them negatively was calculated. These differences are displayed in Table 4.1. The positive impacts exceeded the negative impacts for at least 80% of the participants who selected the following learning experiences: hands-on experiences, high performance in a STEM class, field trips, relevant class content, class with an emphasis on further study in STEM, and science demonstrations by the teacher. Additionally, high class performance and relevant class content had zero negative reports from participants. There were two experiences in which participants reported more negative views than positive views. These were paper assignments and classwork with an emphasis on learning or memorizing facts.

Figure 4.7

Percentage of Participants Selecting Each In-School Learning Experience that Viewed the Experience as Having a Positive Effect, No Effect, or a Negative Effect on Their Confidence or Interest in STEM

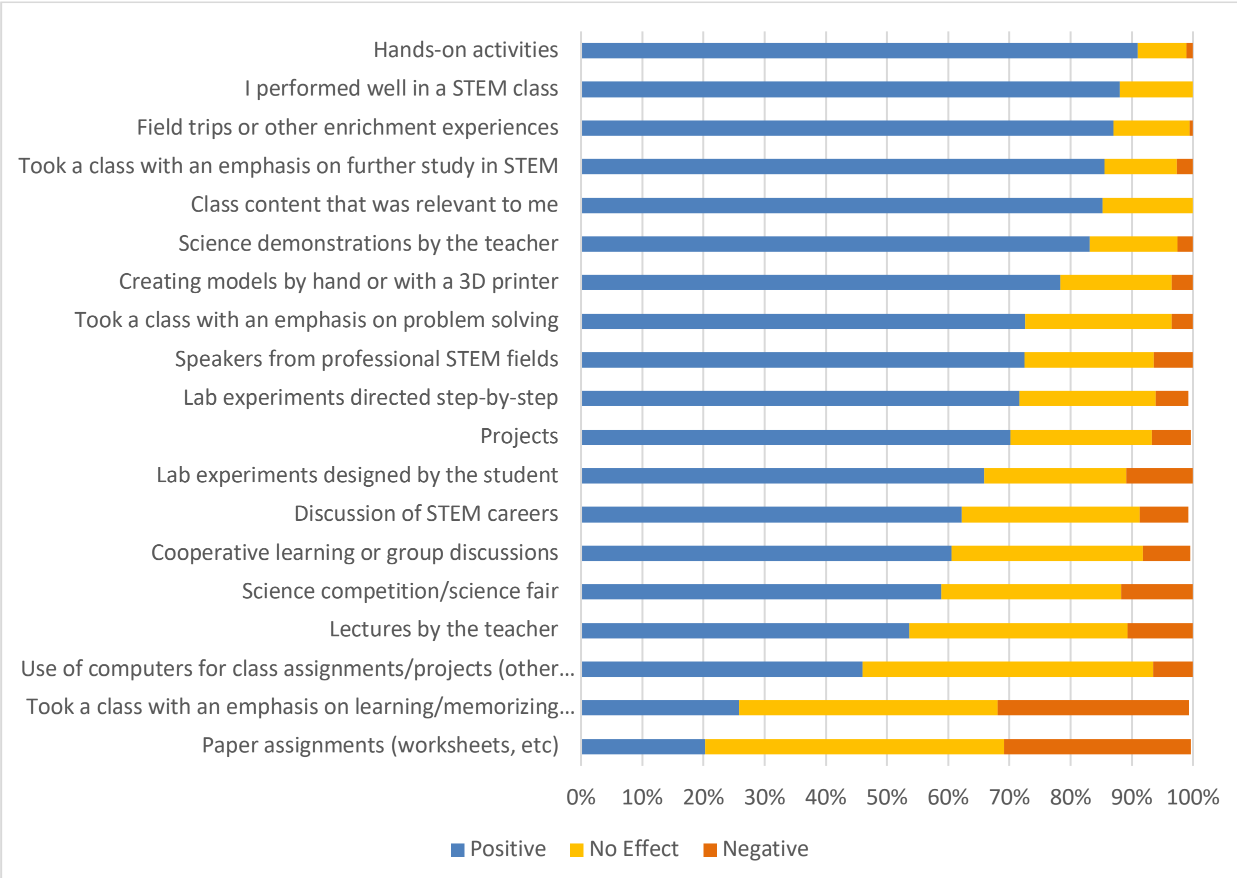


Table 4.1

Difference Between Percentage of Participants that Perceived Each In-School Learning Experience Positively and Negatively

Learning Experience	Difference Between Positive & Negative
Hands-on activities	89.9%
I performed well in a STEM class	88.0%
Field trips or other enrichment experiences	86.5%
Class content that was relevant to me	85.2%
Class with an emphasis on further study in STEM	82.9%
Science demonstrations by the teacher	80.6%
Creating models by hand or with a 3D printer	74.9%
Took a class with an emphasis on problem solving	69.0%
Lab experiments directed step-by-step	66.3%
Speakers from professional STEM fields	66.1%
Projects	63.8%
Lab experiments designed by the student	55.0%
Discussion of STEM careers	54.3%
Cooperative learning or group discussions	52.8%
Science competition/science fair	47.1%
Lectures by the teacher	43.0%
Use of computers for class assignments/projects	39.5%
Class with emphasis on learning/memorizing facts	-5.4%
Paper assignments (worksheets, etc)	-10.3%

For each teacher factor that was selected, a breakdown of the positive, neutral, and negative responses is given on Figure 4.8. Of the participants that selected teacher factors as being influential to their confidence and/or interests in STEM, a high percentage indicated that teachers had a positive effect on them. All four factors were reported as positive impacts by over 75% of the participants that marked them. The difference in percentages was calculated for the teacher factors, and this data is displayed in Table 4.2. The positive impacts exceeded the negative impacts by more than 70% of the participants for each factor, and no factor had more than 8.2% of participants respond negatively.

Figure 4.8

Percentage of Participants Selecting Each Teacher Characteristic or Experience that Viewed the Experience as Having a Positive Effect, No Effect, or a Negative Effect on Their Confidence or Interest in STEM

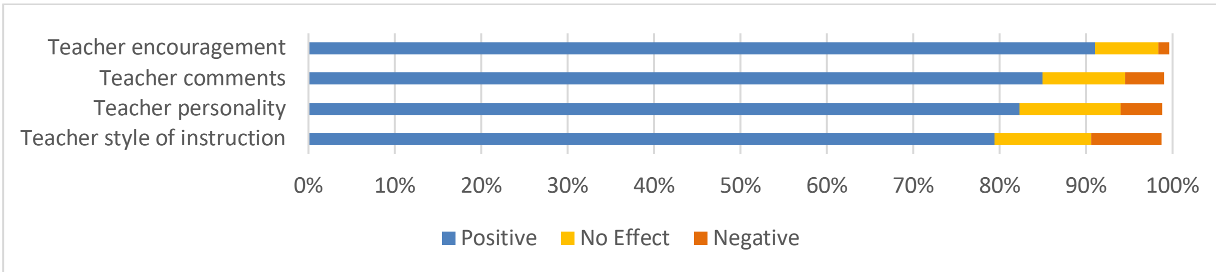


Table 4.2

Difference Between Percentage of Participants that Perceived Each Teacher Experience Positively and Negatively

Teacher Characteristic or Experience	Difference Between Positive & Negative
Teacher encouragement	89.8%
Teacher comments (about ability, future, careers, etc)	80.4%
Teacher personality	77.4%
Teacher style of instruction	71.2%

For each out-of-school experience that was selected, a breakdown of the positive, neutral, and negative responses is given on Figure 4.9. The out-of-school experiences received primarily positive responses on the questionnaire, with some neutral responses. None of the experiences in this section received a negative response, so no differences needed to be calculated.

Figure 4.9

Percentage of Participants Selecting Each Out-of-School Learning Experience that Viewed the Experience as Having a Positive Effect, No Effect, or a Negative Effect on Their Confidence or Interest in STEM

STEM vs non-STEM Perceptions of Learning Experiences

In addition to examining the perceptions of the learning experiences for all students, the researcher compared the perceptions of the experiences between students majoring in STEM and students not majoring in STEM. The participants had the opportunity to indicate whether each experience in which they had participated made them more confident and/or interested in STEM, less confident and/or interested in STEM, or the experience had no effect on their confidence or interest in STEM. These results were recorded on a scale where 0 indicated no experience, 1 indicated a negative experience, 2 indicated having the experience with no effect, and 3 indicated having a positive experience. These were then compared using Mann-Whitney U test, and the results are displayed in Table 4.3.

These results indicate that there were multiple learning experiences with a more positive perception from STEM majors than from non-STEM majors. STEM majors were more likely to prefer creating models, projects, cooperative learning, classes with relevant content, having a teacher with a particular teaching style, doing home science kits, reading STEM or science fiction books, watching STEM or science fiction shows and movies, talking about STEM with their families, having STEM activities as a part of their family life, feeling pressure from family or peers to pursue STEM, and participating in a STEM club. STEM majors were much more likely to have a positive perception of lectures, paper assignments, speakers from professional STEM fields, discussion of STEM careers in school, classes with an emphasis on further study in STEM, classes with an emphasis on problem-solving, having high performance in a STEM class, experience with teacher comments, having interest in mathematical problems or logic games, and always being interested in STEM. Only performance ($r = .31$), further study ($r = .35$), and always being interested ($r = .44$) had effect sizes that are considered medium according to Cohen (1988). All other significant learning experiences had small effect sizes.

Table 4.3

Comparison Between STEM and non-STEM Students' Perceptions of Learning Experiences

Experience	STEM N	STEM Mean Ranks	Non-STEM N	Non-STEM Mean Ranks	*U*	*z*	*p*	*r*
In-school Experiences								
Lectures	206	170.50	105	127.50	13807.50	4.40	<.001**	.25
Science Demonstrations	206	160.50	105	147.10	11749.00	1.59	.111	.09
Computers	206	161.82	105	144.59	12013.00	1.71	.088	.10
Creating Models	206	163.62	105	141.04	12385.50	2.30	.021*	.13
Projects	206	162.80	105	142.65	12216.50	2.18	.029*	.12
Paper Assignments	206	168.24	105	131.99	13336.00	3.56	<.001**	.20
Lab Exp by Students	206	159.67	105	148.80	11571.00	1.15	.252	.07
Lab Exp Step by Step	206	160.12	105	147.91	11664.50	1.29	.196	.07
Hands-on Activities	206	159.70	105	148.75	11576.50	1.49	.137	.08
Cooperative Learning	206	166.41	105	135.58	12959.00	3.05	.002*	.17
Field Trips	206	158.33	105	151.44	11294.00	0.72	.472	.04
Professional Speakers	206	170.24	105	128.06	13748.50	4.65	<.001**	.26
STEM Careers	206	171.58	105	125.44	14024.00	4.87	<.001**	.28
Science Fair	206	157.43	105	153.19	11110.00	0.45	.650	.03
Relevant Content	206	165.24	105	137.87	12719.00	2.83	.005*	.16
Further Study	206	172.63	105	123.38	14240.50	6.11	<.001**	.35
Memorization	206	162.42	105	143.40	12138.00	1.93	.054	.11
Problem Solving	206	17094	105	126.70	13892.00	4.58	<.001**	.26
Performance	206	173.77	105	121.13	14476.50	5.49	<.001**	.31
Teacher Factors								
Teacher Encouragement	206	157.09	105	153.85	11040.50	0.38	.705	.02
Teacher Comments	206	168.36	105	131.76	13360.50	3.82	<.001**	.22
Teacher Personality	206	157.16	105	153.72	11054.50	0.38	.705	.02
Teacher Style	206	165.03	105	138.28	12676.00	2.82	.005*	.16
Out-of-school Experiences								
Tinkering	206	158.81	105	150.50	11393.00	0.87	.386	.05
Fixing	206	158.81	105	150.50	11393.00	0.84	.400	.05
Models/Legos	206	158.85	105	150.40	11403.00	0.84	.402	.05

Construction/Build	206	157.63	105	152.81	11150.00	0.52	.604	.03
Engines	206	158.28	105	151.53	11284.00	0.88	.380	.05
Video Games	206	150.60	105	166.59	9704.00	-1.58	.115	.09
Computers/Web	206	158.68	105	150.74	11367.00	1.14	.256	.06
Home Science Kits	206	162.72	105	142.82	12199.00	2.19	.028*	.12
Animals	206	157.59	105	152.88	11142.50	0.47	.638	.03
Plants	206	158.13	105	151.83	11253.00	0.63	.531	.04
Stars	206	155.50	105	156.99	10711.00	-0.18	.861	.01
Outdoors	206	157.49	105	153.08	11122.00	0.44	.660	.02
STEM Media	206	163.10	105	142.07	12277.50	2.11	.035*	.12
STEM Books	206	166.99	105	134.44	13079.00	3.41	.001*	.19
Family Talk	206	162.48	105	143.29	12150.00	2.11	.035*	.12
Family Activities	206	160.57	105	147.03	11757.00	2.14	.032*	.12
Family Pressure	206	161.22	105	145.76	11890.50	2.20	.028*	.12
STEM Club	206	164.62	105	139.08	12591.50	3.21	.001*	.18
STEM Camp	206	158.84	105	150.42	11401.00	1.55	.121	.09
Afterschool	206	157.43	105	153.19	11110.50	0.82	.411	.05
Zoo/Aquarium	206	154.91	105	158.14	10590.50	-0.33	.742	.02
Museum	206	253.42	105	161.07	10283.00	-0.78	.436	.04
National Park	206	153.02	105	161.85	10200.50	-0.87	384	.05
Volunteer/Work	206	161.66	105	144.90	11981.00	1.70	.089	.10
Math/Logic	206	170.86	105	126.85	13875.50	4.57	<.001**	.26
Always Interested	206	181.22	105	106.51	16011.00	7.80	<.001**	.44

*p<.05, **p<.001

Research Question 2

The second research question examined the relationship between STEM learning experiences and the SCCT constructs. This analysis began by reduction of the set of forty-nine learning experiences into eleven factors that group those experiences based on their correlations in a principle component analysis. The researcher then used these factors as predictors in a multiple regression analysis to determine whether they could predict the participants' self-efficacies, outcome expectations, and interests in mathematics, science, and engineering.

Dimensionality Reduction

The theory that makes up SCCT provides a model for how decision-making happens, and one of the key inputs into this model is the set of learning experiences that people have throughout their lives. According to SCCT, these learning experiences influence individuals' self-efficacy, outcome expectations, and interests, which in turn influence the goals that drive the actions of career choice. Each of the SCCT constructs should be measured according to the specific subject that is being addressed, and in the case of this study, those subjects are mathematics, science, and engineering.

In this study, these constructs were examined to find correlations between the learning experiences of students and their mathematics, science, and engineering self-efficacy, outcome expectations, and interests. The list of learning experiences contained eighteen in-school experiences, four teacher factors, and twenty-seven out-of-school experiences, for a total of forty-nine experiences and characteristics that may have influenced students' self-efficacy, outcome expectations, or interests in the three STEM subject areas under study. While each individual experience carries some importance on its own, the number of items meant the analysis would be cumbersome and difficult to interpret accurately due to correlations between many of the experiences. To reduce the number of experiences for analysis and to develop groups of common experiences, the researcher conducted a principle component analysis (PCA).

To prepare for the PCA, the learning experiences were coded as ordinal variables according to participants' views of the experience and their value in improving confidence and interest. In this approach, a 0 indicated that the participant had not taken part in that experience, a 1 indicated that the participant had the experience with a negative perception, a 2 indicated having the experience with no perceived effect, and a 3 indicated having the experience with a positive perception of its role in STEM development. This approach had two purposes: it met the PCA assumption of multiple variables measured at the ordinal level, and it allowed for grouping by both participation in and perception of the experience.

A second assumption required for PCA is linear relationship among variables. While the number of total variables was too high to look at each combination individually, a random sample of variables was tested using scatterplots, and the variables met this assumption. The assumption of sampling adequacy was expected based on a sample size of 312 and variable number of 49, which exceeds the general rule of thumb of five participants per variable. This assumption was confirmed by the Kaiser-Meyer-Olkin measure for the analysis, KMO = .84, and KMO values for each item were above .66, greater than the acceptable level of .50 (Field, 2013). To ensure that the variables are correlated properly, Bartlett's test for sphericity was used, χ^2 (1176) = 4956, p < .001, and the correlation values were examined in the correlation table.

The PCA was conducted initially using both varimax and promax rotations, but after analysis, the correlations between some of the factors indicated that they were not independent, so the promax rotation was used for the final results. Eleven factors were retained based on analysis of the scree plot (Figure 4.8) and identifying factors with eigenvalues greater than one. Thirteen factors were in the original model, but two were dropped because they contained single variables. In the end, three variables were dropped from the analysis, and the remaining were retained in the eleven factors. The factors were established initially based on the factor loadings in the rotated pattern matrix (Table 4.4), and then the structure matrix was analyzed to confirm and adjust where necessary. The natural factors in the matrices were used for all variables that were retained except for one. "Taking a class with an emphasis on further study in STEM" loaded similarly in Factor 5 (.60) and Factor 8 (.56). The researcher made the decision to place this variable in Factor

8, which centers on STEM careers and intentional classroom focus on future decisions. The factors are described in greater detail in Table 4.5.

Figure 4.10

Scree Plot for Principle Component Analysis

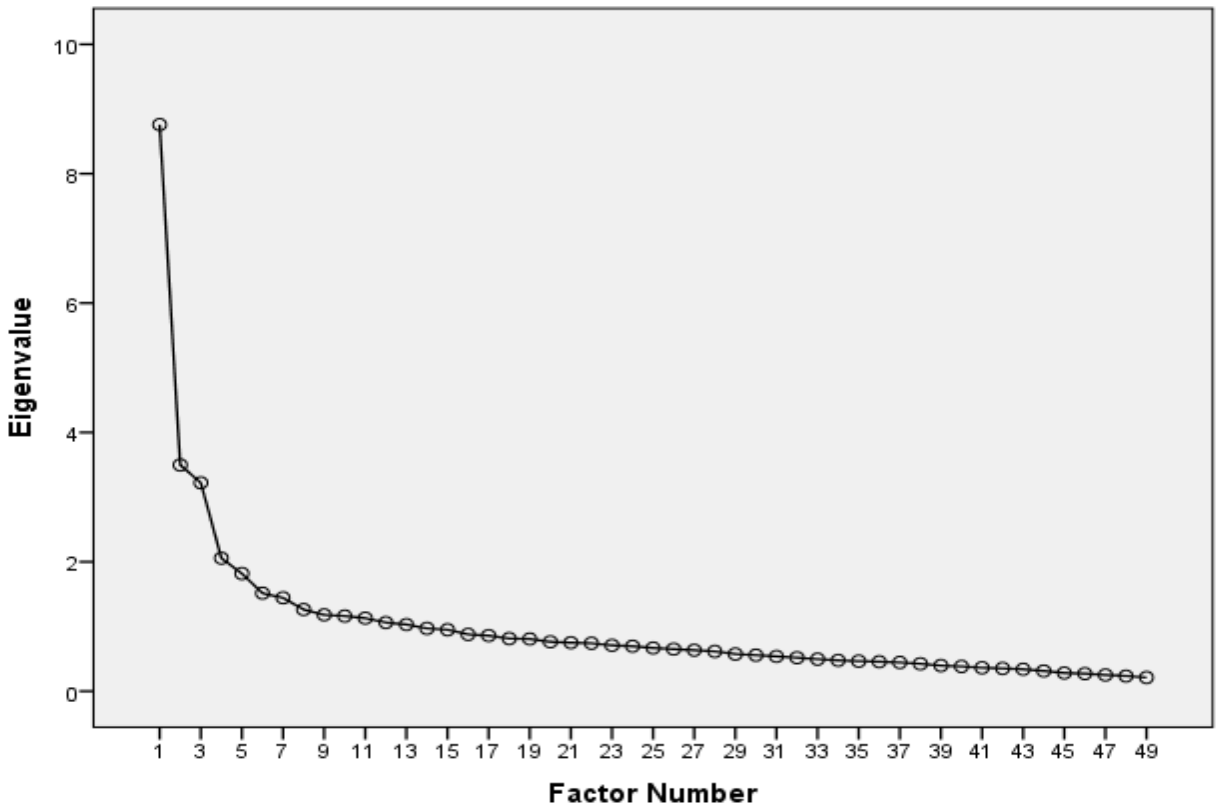


Table 4.4

Factor Loading for Principle Component Analysis

	Factor												
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
HandsOn	.87												
SciDemonst	.71												
LabExpStep	.65												.41
Projects	.58												
Computers	.43												
Cooperative	.43												
FieldTrips	.38												
Models	.34												
ZooAquar		.83											
Museum		.68											
Animals		.56											
NatPark		.54											
Plants		.53											
Outdoors		.51											
VolWork		.46											
Fixing			.86										
Tinker			.66										
ConstBuild			.64										
Engines			.53										
ModelLego			.51										

Table 4.4

Factor Loading for Principle Component Analysis

	Factor												
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
VideoGames			.42						.36				
AfterSchool				.73									
STEMCamp				.50									
STEMClub				.47									
ProblemSolv					.75								
Memorization					.74								
FurtherStudy					.60			.56					
RelevantCont					.53								
ScienceFair					.37								
TEncourage						.66							
TComments						.61							
TPersonality						.58							
TStyle						.41							
AlwaysInt							.78						
MathLogic							.65						
Performance							.39						
ProfSpeakers								.76					
STEMCareers								.71					

Table 4.4

Factor Loading for Principle Component Analysis

	Factor												
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
STEMBooks									.72				
STEMMedia									.63				
Stars									.37				
FamAct				.33						.53			
FamPressure										.53			
FamTalk										.48			
PaperAssign											.55		
Lectures											.47		
LabExpStud													
CompWeb												.55	
HomeSciKit													.35

**Note:* All blank cells have factor loading values less than .30.

Table 4.5

Description of Factors and Lists of Items Contained in Each Factor

Factor	Description	Items
1	Classroom Instruction	• Hands-on activities • Lab experiments directed step-by-step • Science demonstrations by the teacher • Use of computers for class assignments/projects • Creating models by hand or with a 3D printer • Projects • Cooperative learning or group discussions • Field trips or other enrichment activities
2	Nature and Community	• Taking care of or training animals • Planting, taking care of, observing plants • Playing or spending time outdoors • Visit to a zoo or aquarium • Visit to a museum or other learning center • Visit to a state/national park • Volunteer/work related experience
3	Tinkering and Building	• Tinkering with electronics • Taking apart and/or fixing toys • Building models/legos • Construction/measuring/building • Fixing mechanical objects/engines/cars • Playing computer games/video games
4	STEM Extracurriculars	• Participation in STEM clubs or groups • STEM camp • After-school STEM program
5	Class Content	• Class content that was relevant to me • Took a class with an emphasis on problem solving • Took a class with an emphasis on learning/memorizing facts • Science competition/science fair
6	Teacher Influence	• Teacher encouragement • Teacher comments (about ability, future, careers, etc) • Teacher personality • Teacher style of instruction
7	Innate Interest and Ability	• I performed well in a STEM class • Having interest in mathematical problems or logic games • I have always been interested in science, mathematics, and/or engineering
8	Careers and Future	• Speakers from professional STEM fields • Discussion of STEM careers • Took a class with an emphasis on further study in STEM
9	STEM Media	• Watching movies, TV shows, or videos about STEM or science fiction

		• Reading about STEM or science fiction • Observing or studying stars or other astronomical objects
10	Family Influence	• Family member or close friend talking about STEM • STEM was a part of family activities • Pressure from family or peers to pursue STEM
11	Direct Instruction	• Lectures by the teacher • Paper assignments (worksheets, etc)

Learning Experiences and SCCT Constructs

While there are many studies that have looked at the influences of particular experiences on SCCT constructs in STEM, there has been little research done that separates individual subjects to see which learning experiences are more valuable for each. This study examined the learning experiences in relation to self-efficacy, outcome expectations, and interests in the three subjects of mathematics, science, and engineering.

A multiple regression analysis was used to predict the scores on each of the constructs based on participation in learning experiences in each factor generated by the PCA. A standardized score was constructed by averaging the number of experiences each participant had for each factor. For each factor, a participant would receive a score between 0 (did not participate in any of the experiences) and 1 (participated in all experiences). The predictors were added to the multiple regression analysis using forced entry, analyzing all predictors at the same time. The criterion for each test was one of the SCCT constructs for a subject area.

Self-efficacy. The regression data for self-efficacy in mathematics, science, and engineering can be found in Tables 4.6 – 4.8. The model showed that only one factor was significant in increasing mathematics self-efficacy, Factor 7. Science self-efficacy increased with two significant factors, Factor 7 and Factor 8. The model presented three factors significant in increasing engineering self-efficacy, Factors 3, 7, and 10, and one factor significant in decreasing engineering self-efficacy, Factor 2. Factor 7 was significant to self-efficacy in all three subjects, but was most influential to mathematics self-efficacy. Overall, the strongest learning experience factor was Factor 3 to engineering self-efficacy.

Table 4.6

Linear Model of Predictors for Mathematics Self-Efficacy

		95% Confidence Intervals				
Factor	B	Lower Bound	Upper Bound	Standard Error	β	*p*
Constant	3.745	3.227	4.263	0.263		
1	-0.060	-0.567	0.446	0.257	-.017	.814
2	-0.228	-0.592	0.136	0.185	-.070	.219
3	0.245	-0.084	0.574	0.167	.083	.144
4	0.321	-0.115	0.756	0.221	.086	.148
5	-0.010	-0.372	0.353	0.184	-.004	.958
6	-0.292	-0.668	0.084	0.191	-.093	.127
7	1.022	0.715	1.330	0.156	.434	<.001**
8	0.085	-0.231	0.401	0.161	.035	.596
9	-0.297	-0.622	0.028	0.165	-.114	.073
10	0.218	-0.154	0.589	0.189	.071	.250
11	0.139	-0.463	0.741	0.306	.028	.650

Note: R^2 = .219
*$p<.05$, **$p<.001$

Table 4.7

Linear Model of Predictors for Science Self-Efficacy

		95% Confidence Intervals				
Factor	B	Lower Bound	Upper Bound	Standard Error	β	*p*
Constant	3.710	3.239	4.180	0.239		
1	-0.119	-0.574	0.337	0.231	-.037	.608
2	-0.001	-0.327	0.326	0.166	.000	.996
3	0.005	-0.289	0.299	0.149	.002	.973
4	0.051	-0.338	0.440	0.198	.016	.798
5	0.022	-0.302	0.347	0.165	.010	.891
6	0.066	-0.269	0.402	0.171	.024	.697
7	0.478	0.203	0.752	0.140	.233	.001*
8	0.329	0.047	0.611	0.143	.155	.023*
9	0.140	-0.150	0.430	0.147	.061	.344
10	0.242	-0.090	0.573	0.169	.091	.153
11	-0.035	-0.574	0.504	0.274	-.008	.898

Note: $R^2 = .176$
*$p<.05$, **$p<.001$

Table 4.8

Linear Model of Predictors for Engineering Self-Efficacy

Factor	B	95% Confidence Intervals Lower Bound	Upper Bound	Standard Error	β	*p*
Constant	2.949	2.363	3.535	0.298		
1	-0.177	-0.744	0.389	0.288	-0.040	.539
2	-0.682	-1.089	-0.276	0.207	-0.174	.001*
3	1.336	0.970	1.702	0.186	0.379	<.001**
4	0.438	-0.046	0.922	0.246	0.099	.076
5	-0.189	-0.592	0.214	0.205	-0.060	.357
6	0.155	-0.263	0.573	0.212	0.041	.466
7	0.441	0.099	0.783	0.174	0.157	.012*
8	0.285	-0.066	0.636	0.179	0.098	.111
9	-0.081	-0.442	0.281	0.183	-0.026	.661
10	0.687	0.274	1.100	0.210	0.188	.001*
11	-0.092	-0.763	0.578	0.341	-0.015	.786

Note: $R^2 = .322$
*$p<.05$, **$p<.001$

Outcome Expectations. The regression data for outcome expectations in mathematics, science, and engineering can be found in Tables 4.9 – 4.11. The model showed that two factors were significant in increasing mathematics outcome expectations, Factor 3 and Factor 7. Science outcome expectations had only one significant factor, Factor 7. The model presented three factors significant in increasing engineering outcome expectations, Factors 3, 4, and 7, and one factor significant in decreasing engineering outcome expectations, Factor 2. Factor 7 was significant to outcome expectations in all three subjects, but was most influential to mathematics outcome expectations. Overall, the strongest learning experience factor was Factor 3 to engineering outcome expectations.

Table 4.9

Linear Model of Predictors for Mathematics Outcome Expectations

Factor	B	95% Confidence Intervals Lower Bound	95% Confidence Intervals Upper Bound	Standard Error	β	*p*
Constant	3.603	3.126	4.079	0.242		
1	-0.374	-0.839	0.092	0.237	-0.106	.115
2	-0.327	-0.661	0.008	0.170	-0.103	.056
3	0.315	0.013	0.617	0.154	0.110	.041*
4	0.285	-0.115	0.685	0.203	0.079	.162
5	-0.050	-0.383	0.283	0.169	-0.020	.767
6	-0.020	-0.365	0.326	0.176	-0.007	.910
7	1.165	0.882	1.448	0.144	0.511	<.001**
8	-0.006	-0.297	0.285	0.148	-0.003	.968
9	-0.176	-0.474	0.123	0.152	-0.069	.248
10	0.219	-0.123	0.560	0.174	0.074	.209
11	0.196	-0.358	0.750	0.281	0.040	.486

Note: $R^2 = .294$
$*p<.05$, $**p<.001$

Table 4.10

Linear Model of Predictors for Science Outcome Expectations

Factor	B	95% Confidence Intervals Lower Bound	Upper Bound	Standard Error	β	*p*
Constant	3.910	3.429	4.391	0.244		
1	-0.322	-0.792	0.148	0.239	-0.097	.178
2	-0.058	-0.396	0.280	0.172	-0.019	.738
3	-0.245	-0.551	0.060	0.155	-0.091	.115
4	0.050	-0.354	0.454	0.205	0.015	.808
5	-0.165	-0.501	0.172	0.171	-0.069	.336
6	0.047	-0.302	0.395	0.177	0.016	.793
7	0.893	0.608	1.179	0.145	0.415	< .001**
8	0.243	-0.050	0.537	0.149	0.109	.104
9	0.102	-0.200	0.403	0.153	0.043	.508
10	0.037	-0.307	0.382	0.175	0.013	.831
11	0.085	-0.475	0.644	0.284	0.018	.766

Note: $R^2 = .193$
$*p<.05$, $**p<.001$

Table 4.11

Linear Model of Predictors for Engineering Outcome Expectations

Factor	B	95% Confidence Intervals Lower Bound	95% Confidence Intervals Upper Bound	Standard Error	β	*p*
Constant	3.114	2.506	3.723	0.309		
1	-0.222	-0.811	0.367	0.299	-0.050	.459
2	-0.685	-1.107	-0.262	0.215	-0.171	.002*
3	1.284	0.904	1.664	0.193	0.358	<.001**
4	0.551	0.048	1.054	0.256	0.122	.032*
5	-0.335	-0.754	0.084	0.213	-0.105	.117
6	0.152	-0.283	0.586	0.221	0.040	.493
7	0.793	0.438	1.148	0.181	0.277	<.001**
8	0.337	-0.028	0.702	0.186	0.114	.070
9	-0.116	-0.492	0.259	0.191	-0.037	.543
10	0.107	-0.322	0.536	0.218	0.029	.624
11	-0.256	-0.953	0.441	0.354	-0.042	.470

Note: $R^2 = .292$
*$p<.05$, **$p<.001$

Interests. The regression data for interests in mathematics, science, and engineering can be found in Tables 4.12 – 4.14. The model showed that three factors were significant in increasing mathematics interests, Factor 3, Factor 4, and Factor 7. There were also three factors that were significant in decreasing mathematics interests, Factor 1, Factor 2, and Factor 9. Science interests had two significant factors, Factor 7 and Factor 8. The model presented four factors significant in increasing engineering interests, Factor 3, Factor 4, Factor 7, and Factor 8, and one factor significant in decreasing engineering interests, Factor 2. Factor 7 was significant to interests in all three subjects, but was most influential to mathematics interests. Overall, the strongest learning experience factor was Factor 3 to engineering interests.

Table 4.12

Linear Model of Predictors for Mathematics Interests

Factor	B	95% Confidence Intervals		Standard Error	β	*p*
		Lower Bound	Upper Bound			
Constant	3.122	2.511	3.733	0.310		
1	-0.629	-1.226	-0.032	0.303	-0.142	.039*
2	-0.629	-1.059	-0.200	0.218	-0.158	.004*
3	0.789	0.401	1.177	0.197	0.219	<.001**
4	0.550	0.037	1.064	0.261	0.121	.036*
5	-0.202	-0.629	0.226	0.217	-0.063	.353
6	-0.020	-0.463	0.423	0.225	-0.005	.928
7	1.206	0.843	1.569	0.184	0.420	<.001**
8	0.255	-0.118	0.628	0.189	0.086	.179
9	-0.579	-0.962	-0.196	0.195	-0.181	.003*
10	0.206	-0.232	0.644	0.223	0.055	.356
11	0.473	-0.237	1.183	0.361	0.077	.191

Note: $R^2 = .269$
$^*p<.05$, $^{**}p<.001$

Table 4.13

Linear Model of Predictors for Science Interests

Factor	B	95% Confidence Intervals Lower Bound	Upper Bound	Standard Error	β	*p*
Constant	3.773	3.054	4.492	0.365		
1	-0.375	-1.071	0.320	0.353	-0.078	.289
2	-0.064	-0.563	0.435	0.254	-0.015	.800
3	-0.393	-0.842	0.056	0.228	-0.102	.086
4	0.027	-0.567	0.621	0.302	0.006	.928
5	-0.129	-0.624	0.366	0.252	-0.038	.607
6	0.155	-0.358	0.668	0.261	0.038	.552
7	0.960	0.540	1.379	0.213	0.312	<.001**
8	0.545	0.114	0.976	0.219	0.172	.013*
9	0.055	-0.389	0.498	0.225	0.016	.808
10	-0.052	-0.559	0.455	0.258	-0.013	.841
11	-0.090	-0.913	0.733	0.418	-0.014	.830

Note: $R^2 = .144$
*$p<.05$, **$p<.001$

Table 4.14

Linear Model of Predictors for Engineering Interests

Factor	B	95% Confidence Intervals Lower Bound	95% Confidence Intervals Upper Bound	Standard Error	β	*p*
Constant	2.609	1.893	3.325	0.364		
1	-0.431	-1.124	0.262	0.352	-0.082	.222
2	-1.021	-1.519	-0.524	0.253	-0.216	<.001**
3	1.518	1.071	1.965	0.227	0.358	<.001**
4	0.600	0.008	1.191	0.301	0.112	.047*
5	-0.484	-0.977	0.009	0.251	-0.128	.054
6	0.247	-0.265	0.758	0.260	0.055	.343
7	0.946	0.528	1.365	0.213	0.279	<.001**
8	0.557	0.128	0.987	0.218	0.159	.011*
9	-0.228	-0.669	0.214	0.224	-0.060	.311
10	0.059	-0.446	0.564	0.257	0.013	.818
11	0.059	-0.761	0.880	0.417	0.008	.887

Note: $R^2 = .301$
*$p<.05$, **$p<.001$

Overall results. The factor that was positively correlated with all three constructs in all three subject areas was Factor 7. Innate interest and ability are high indicators of increasing self-efficacy, outcome expectations, and interests in STEM subjects in this study. Factor 3 had very strong correlations to all three engineering constructs, indicating that these experiences with tinkering, building, and other hands-on informal experiences are good predictors of engineering self-efficacy, outcome expectations, and interests. There were a few factors that had negative effects, but Factor 2 was the most common. Factor 2 indicated a negative effect in all three engineering constructs along with math interests.

Each multiple regression analysis met the assumption of independence of observations. The Durbin-Watson statistic was between 1.78 – 2.18 for all tests, which is within the acceptable range. The plot of standardized residuals vs. predicted values did not show signs of heteroscedasticity. Additionally, multicollinearity was not detected by the tests for any of the constructs, with all VIF values between 1.0 – 2.0.

Research Question 3

The third research question explored the relationship between the SCCT constructs and participants' STEM goals. The researcher used a logistic regression to predict how self-efficacy, outcome expectation, and interest in mathematics, science, and engineering affected the participants' intent to pursue a STEM career.

SCCT Constructs and STEM Career Goals

The model for SCCT specifies that the constructs self-efficacy, outcome expectations, and interests play a role in career goal decisions. As mentioned before, many studies have examined these connections from a general STEM standpoint, but very little research has been done to determine how the constructs in the context of individual subjects relates to STEM career goals. This study sought to look at those connections and examine the role each subject area for each construct played in the goal of pursuing a STEM career.

One question on the survey asked participants if they intend to pursue a STEM career, and this question was used as an indicator of the participants' career goals. In the question, the options given were yes, no, and unsure. To obtain a dichotomous outcome for the binary logistic regression, the unsure selections were recoded to yes or no based on the participant's current major. Forty-eight participants had unsure plans, but thirty were enrolled in a non-STEM major, while eighteen were enrolled in a STEM major. Those first thirty were marked as not pursuing a

STEM career for this test, and the eighteen in a STEM major were marked as pursuing a STEM career.

A logistic regression was used to examine the relationships between each construct by subject and the participants' goals of pursuing a STEM career. The results of this regression are shown in Table 4.15. These results indicated that there was a significant association between the models for self-efficacy ($\chi^2(3) = 68.48$, $p < .001$), outcome expectations ($\chi^2(3) = 158.55$, $p < .001$), and interests ($\chi^2(3) = 173.56$, $p < .001$) and pursuit of a STEM career. Results indicate that mathematics self-efficacy and engineering interests are significant ($p < .05$) predictors for students' intentions to pursue a STEM career as opposed to a non-STEM career. All three science constructs were highly significant ($p < .001$) predictors of students' intentions to pursue a STEM career. The odds ratio for science self-efficacy (2.956), science outcome expectations (9.555), and science interests (4.778) indicate that if the other subjects were held constant, a one unit increase in the science construct would mean that the odds of a student deciding to pursue a STEM career would be 2.956, 9.555, or 4.778 times higher than not pursuing a STEM career.

Table 4.15

Coefficients of Logistic Regression Models Predicting Whether Participants Intend to Pursue a STEM Career

	B	SE	Wald	Odds Ratio	*p*
Self-efficacy (SE)					
Constant	-5.295	0.900	34.604		
Mathematics SE	0.354	0.176	4.074	1.425	.044*
Science SE	1.084	0.226	22.987	2.956	<.001**
Engineering SE	0.148	0.152	0.945	1.159	.331
Outcome Expectations (OE)					
Constant	-9.852	1.245	62.572		
Mathematics OE	0.172	0.249	0.475	1.187	.491
Science OE	2.257	0.313	51.891	9.555	<.001**
Engineering OE	0.365	0.208	3.089	1.440	.079
Interests (Int)					
Constant	-7.222	1.016	50.497		
Mathematics Int	0.406	0.211	3.712	1.501	.054
Science Int	1.564	0.198	62.151	4.778	<.001**
Engineering Int	0.372	0.187	3.974	1.451	.046*

Note: Self-efficacy model: $R^2 = .29$, $\chi^2(3) = 68.48$, $p < .001$. Outcome expectations model: $R^2 = .58$, $\chi^2(3) = 158.55$, $p < .001$. Interests model: $R^2 = .62$, $\chi^2(3) = 173.56$, $p < .001$.
*p<.05, **p<.001

Qualitative Results

Eight people were selected for the qualitative portion of the study based on their self-efficacy scores in mathematics, science, and engineering. The researcher selected two participants with high self-efficacy in all three subjects, one with median self-efficacy in all three subjects, two with low self-efficacy in all three subjects, and three who had mixed self-efficacies. Interviews were conducted with all eight participants via online videoconferencing platform Zoom, and lasted from 15-25 minutes per interview. The video interviews allowed the researcher to gain insight into the experiences and attitudes of each interviewee. The full interview transcripts are provided in Appendix D.

This section begins with a brief description of each participant. Then, it describes each of the learning experience themes that were developed as a part of this study, detailing features and giving examples from the interviewees for each theme. The section finishes with descriptions of each interviewee's perceptions of how the learning experiences affected their self-efficacy, outcome expectations, and interests.

Participant Profiles

The first section gives a brief profile of each interviewee, including a summary of their backgrounds and key characteristics. The interviewees are grouped according to the selection criteria, starting with high self-efficacy, then median self-efficacy, mixed subject self-efficacy, and low self-efficacy.

High Self-Efficacy

Blake is a freshman studying mechanical engineering. Blake indicated that he has always had an interest in science and engineering, and that for his extended family, "it's almost family tradition at this point to become an engineer". Blake appears confident in his abilities and choices, firmly establishing himself as interested and capable in STEM. He attended a high school with a substantial focus on STEM learning, taking a variety of courses in engineering to supplement advanced mathematics and science courses. He stated that "I don't think there's things other than what I've had in high school that would prepare me better" for further STEM studies.

Nolan is a freshman studying electrical and computer engineering. Nolan is very confident in his ability to pursue STEM tasks, saying that he "enjoys mathematics and physics" and "I like building things and working on projects". Nolan took advanced coursework in high school and was part of STEM-focused clubs and organizations. He clearly sees the pursuit of STEM as difficult and says that you need to be "smart" in order to be successful. Nolan has a strong work ethic and enjoys activities that challenge him mentally.

Median Self-Efficacy

Ashley is a junior in creative writing and English. She had many positive experiences with STEM while growing up and was strongly STEM-oriented in high school and in her first years of college. Her initial major was engineering, but a series of setbacks with advanced mathematics and science courses caused her to switch to her current major. Ashley wants to take her knowledge of STEM into a future career as an author of science fiction and fantasy novels. She describes her family, teachers, and extracurriculars as strong and beneficial STEM influences. Her school experiences in STEM were not negative, but they had very little influence on her. Ashley sees the benefit to STEM careers, but believes that there is a high entrance requirement in terms of mathematics and science ability.

Mixed Self-Efficacy

Annabelle is a freshman majoring in interior design who scored low in science and engineering self-efficacy, but high in math self-efficacy. She has a strong background in mathematics, which she primarily believes is because her father is a mathematics teacher and she has older brothers that are engineers. However, her school had few good courses or teachers in science or engineering and she has very little interest in STEM overall. Annabelle is enthusiastic about education and considered teaching elementary at one point but changed to a major that was more suited to her interests. Annabelle does think that her school failed to promote STEM careers effectively and did not encourage applied learning.

Evan is a freshman studying animal science and is on track to attend veterinary school. He scored low in mathematics self-efficacy, moderate in engineering self-efficacy, and high in science self-efficacy. Evan grew up on a farm and has always shown interest in animals, wildlife, and nature. He has been encouraged to follow his current career path by many influences, including family, teachers, and his environment. Evan seems very comfortable in his decisions and who he is, and cited experiences where he felt very successful in science courses. While school experiences were valuable to him, Evan talked repeatedly about examples of real-world experience and how that was the most important thing to learning.

Neely is a freshman zoology major on track to attend veterinary school who scored low in engineering self-efficacy but high in science and mathematics self-efficacy. She is very organized and structured, both in her communication and her approach to education. Neely worked a variety of internships, job shadows, and volunteer opportunities to gain the skills and experience necessary to do an early enrollment program at the university. She has "always been interested in animals" and has focused most of her coursework and extracurricular activities to meet her goal of becoming a veterinarian. Neely says that STEM careers are valuable because they have meaning, stating that "I need to see some sort of result to be driven" and that "seeing the actual product" brings value to the job.

Low Self-Efficacy

Noah is a sophomore studying secondary education with an emphasis in social studies. He seemed confident in himself and informed about his responses in the interview. The overall impression that he gave was that of an average student, who had some good STEM experiences but nothing that stood out so much that it changed his feelings about STEM. During his interview, Noah often tied interest to STEM to performance in those courses. He said that as the courses got "more complex" that his interest in STEM fell and was replaced with interest in social studies and language arts courses. Noah also expressed his feeling that STEM careers were only for certain people with specific abilities and skills.

Regina is a freshman global studies major. She expressed an interest in traveling and possibly teaching overseas but was uncertain about what subjects she would want to teach. She said that she liked science and it interested her, but she also had mixed experiences with science in high school. She offered positive experiences in biological sciences, but negative experiences in chemistry and mathematics. She also strongly tied her perception of a teacher to how well the teacher was able to explain or break down subject matter in specific steps. Regina's primary interest in STEM revolved around helping young women gain an interest in STEM and see themselves as scientists.

Themes Related to Learning Experiences

The researcher began the process of analyzing the interviews by considering the prior research on learning experiences and SCCT. The researcher decided to make use of provisional coding (Saldaña, 2015) to compile a list of codes from the literature on these topics. These codes are consistent with the lists of learning experiences used to make the initial questionnaire (Burt & Johnson, 2018; Dou et al., 2019; Maltese et al., 2014; Maltese & Tai, 2010, 2011), and the constructs developed from SCCT (Lent et al., 1994). The researcher then read through all the interviews, making notes, placing initial codes, and evaluating whether they would fit within this initial provisional structure. These initial codes were then grouped by types of learning experiences or SCCT construct. The themes that developed from the grouping of codes were consistent with the factors developed during principle component analysis for the quantitative portion of this study. There were two themes that developed from the interviews that were not a part of the initial code list: course offerings and class performance. Because multiple interviewees gave detailed responses related to these themes, they were included in the final list. The full list of initial themes along with the modifications is provided in Table 4.16.

Table 4.16

Themes from Interview Analysis

Theme	
In-school Learning Experiences	Out-of-school Learning Experiences
Classroom Activities	Nature and Community
Types of Class Content	Tinkering and Building
Careers and Future Focus	STEM Extracurriculars
Teacher Influence	Innate Interest and Ability
Course Offerings	STEM Media
Class Performance	Family Influence

Note: initial themes are in plain font, while themes added later are in italics

In-school Learning Experiences

Classroom Activities. The classroom activities learning experience category encompasses all the activities, lessons, and projects that students are involved in within their P-12 school experience. This broad category includes many experiences that are common to students in the classroom, and all eight interviewees mentioned classroom activities during their interviews. The activities that were mentioned included labs and hands-on activities, field trips, science fairs and projects, and engineering activities. While many of these experiences were perceived positively, there were negative experiences as well.

In the survey that was conducted in the initial phase of this study, hands-on activity was the most positively perceived learning experience for the sample. The interviews also indicated that these types of experiences were beneficial to learning and developing interest and confidence in STEM. Evan and Neely, both on a path toward veterinary school, mentioned dissections as a meaningful school experience. Neely said, “I have memories from like fifth and sixth grade of doing, like, dissections and things like that. That was always really cool", while Evan's response was, "In school, doing labs and, like, dissections and stuff. I love that." Many students discussed other activities that were interactive and engaging in nature, and these general themes continued to emerge as positive experiences. Regina, who has low self-efficacy and little interest in a STEM career, still indicated that this engagement was important, saying "it got me hooked because when they can be hands-on and fun, because I'm a hands-on learner, you know, so that's why it was amazing for me." Neely expanded on the value of engagement in laboratory activities, rather than just doing labs for the sake of doing them:

> One of the reasons why I like the class so much too was she gave us a lot of opportunities to do, um, labs. Um, and they were more, I don't know, my prior experience with labs had been once, maybe, a month and they were really extensive and it was more about you know what you wrote out of it than the actual experience. And even though it, you know, do lab reports in our class. She definitely focused more on like the experience than just the grades of it. And so that helps a lot.

One type of hands-on activity that was mentioned by several interviewees was the engineering-focused activity. These activities were often seen as meaningful, fun, and engaging. Nolan and Blake, who are both majoring in engineering, mentioned an engineering activity as one of the most memorable experiences they had participated in. Nolan talked about "a project with a group of people where we had to filter water and overall ours was the most successful of all of them". Blake described a project in his physics class where they had to design a trolley car to run on electrical wires that ran through the classroom, where "you would connect a positive terminal to one wire and negative to the other. You had to use that energy to move a car across, all the way across the classroom on those wires." Annabelle also mentioned an engineering task that involved the use of popsicle sticks to build a bridge. She described the success of her group's project as "so dramatic and awesome".

Projects are activities that extend beyond a single lab or daily experience, and generally involve complex problem-solving and planning strategies that the students design themselves. Nolan was part of an engineering program at a technical school, and one aspect of the program was a senior design project meant to prepare students for similar projects they would encounter in college and their future career. This project incorporated many of the courses and topics that Nolan had encountered up to this point. His perception of this experience was that it was substantially more complex than the types of activities he had done previously:

> Not everything is straightforward like it had been up to then. Because everything else was like, oh worksheets, physics, math. And so you're just taught it and instead of doing it yourself and having everything yourself. It was kind of like a hit in the face, like, oh, this is a lot harder than I thought it was.

Regina spoke of a love for STEM early in high school, and much of her early enjoyment came from involvement in science fair projects. However, her love of STEM faded over time after she changed schools and stopped participating in science fair. She explained:

> So, I was very involved with science fair in the first couple years of high school, and I loved it. My area was microbiology and biochemistry. I am utterly fascinated with microorganisms and things like, it's so much fun. And I actually got second place at state in my category. And I was going to do a different, I was going to do a continuation on it but I ended up moving schools and they didn't offer it.

While field trips happen outside of the classroom, they are generally designed as an extension of the classroom experience. Regina enjoyed an environmental science class because of the activities and the teacher, but she also specifically mentioned the field trips, and how enjoyable they were. Neely remembered when she "did like a water quality field trip and tested water quality of pools…that's also something I need to pay attention to is like actual ecosystems in the habitats, as well as the animals", and remarked how that trip helped her develop confidence as she pursued veterinary medicine.

Some of the classroom activities that came up in the interviews were perceived to have a negative effect on the interviewees. Annabelle, the interviewee with a low self-efficacy in science, felt that a lot of her science classes "focused heavily on, do-it-yourself assignments and even in the labs, it was like you're on your own." This perception of being on your own for science labs was echoed by Ashley, who described a negative experience in "lab-based classes is, when you do something wrong, it sucks. It discourages you". Noah, who is not pursuing a STEM career and had low self-efficacy in all three subjects, named almost solely negative experiences. He spoke respectfully of his teachers, but indicated that his math classes were difficult for him because he was "struggling to maybe remember all the formulas or remember exactly what to do". When the researcher asked about any engineering experiences, Noah recalled a short project in middle school involving Legos, but he was disinterested and considered it just a task to complete before moving on.

Types of Class Content

While the classroom activities category focuses primarily on the activities and methods for learning, the types of class content category concentrates on how teachers set up their overall classroom environment and curriculum. This category includes more generalized ideas about classroom learning and was mentioned fewer times and by fewer interviewees than the specific activities for learning. However, some of these ways to organize and present curriculum were meaningful to particular interviewees.

Neely took a college composition course in high school in which the focus was on research in the students' area of interest. Since she was planning on going to college for veterinary medicine, she spent the course researching and writing about that topic and confirmed that it “really, really helped me know more about what I was getting into”. Annabelle indicated that the focus teachers put on explaining material was valuable, and her favorite classes were those in which the teacher could “explain it multiple different ways”.

Nolan and Blake discussed aspects of their higher-level physics and engineering courses that made a difference to them. Nolan’s physics class was based in problem-solving, and the teacher did not offer much help, forcing the students to figure things out for themselves. While Nolan saw the value in this approach, he also acknowledged that “it made life harder”. Jacob’s robotics teacher spent a lot of time teaching students how to use machinery and tools, so that students would be able to design and machine their parts. Jacob appreciated this focus on the practical applications of the class and felt that it prepared him for future endeavors in engineering.

Careers and Future Focus

The survey indicated that this category was one of the least experienced of all learning experiences, and 40% of participants or fewer selected the three experiences that comprise it. However, it was selected and perceived highly by STEM majors significantly more than non-STEM majors. Interestingly, the two interviewees that were lowest in self-efficacy made no mention of STEM careers in schools, while all other interviewees did.

One method for schools to encourage STEM careers is offering coursework that is specific to particular careers. This can sometimes be accomplished by partnering with local technical schools, as was the case for Nolan and the engineering program that he attended. Blake went to a high school that offered tracks in a variety of career paths, including the engineering track in which he participated. Both interviewees mentioned that they took courses that helped them see their future career paths, but also took courses that confirmed that they did not want to follow a certain path. Nolan described robotics as “not what I want to do with the rest of my life”, and Blake said that “electronics is more of a hobby kind of thing than I would say it as a career thing”.

Another approach for encouraging career choice is to give students the opportunity to interact with STEM professionals. Evan shared that he had a teacher at a technical school who was a licensed nurse, and described her impact:

> Just the real life experience she brought to it. She was at, she actually had been there and done everything that she was teaching us. She was actually, she was able to speak from a place of positivity because she loved the field that she was in and so just, it really rubbed off on you and her enthusiasm and everything about pretty much science and all that.

Ashley and Neely detailed their experiences job shadowing at locations that were related to their career interest. Ashley went to her father’s place of work, and said “that really kick started my interest, I guess. It's just seeing people actually working with mechanics and computers and all this stuff and an actual job field”. Neely shadowed her family’s veterinarian in the eighth grade because she had always loved animals, and that helped spark her desire to follow that career path in earnest.

Two interviewees indicated that they felt their high schools had not done enough to support students in having career options. Ashley said that her high school should have worked to help students become interested in STEM, and that would help increase the number of people who follow STEM career paths. Annabelle suggested that schools should work to raise career awareness, and even hinted that STEM professionals should be a part of the curriculum to help teachers accurately represent the careers:

> I think one major thing for science specifically would just be showing different careers in science, more than just biology and chemistry and because those classrooms, like it really does negatively affect and I know I'm not the only one in my school who experienced

> that there's, there's a lack of like doctors, any, any science related fields coming out of my high school because the teachers just aren't positively reflecting what those careers can be. So I would for sure say showing like real world applications to those classes, rather than just the class.

Teacher Influence

Teachers are an important part of the in-school learning process, and 96% of the sample indicated that teachers had some effect on their confidence or interest in STEM. The vast majority of those responses indicated that teachers were a positive influence, though there were some negative experiences as well. One of the interview questions asked the interviewees to describe a teacher that had an influence on them, positive or negative, and all eight gave responses to this question. Teacher influences can involve teaching styles and expertise, but often also involves a personal relationship between the teacher and their students.

One of the common themes from the interviewees concerning teacher influence was the relationship or support that a teacher would offer. Noah commented that a favorite science teacher had “a positive impact and she was very supportive, no matter what I chose career-wise”. Nolan had a STEM teacher that was supportive in a way that built his interest in studying STEM, indicating that the teacher was “very, very supportive of us. And following your own ideas out even if they failed. And he was honestly one of the best teachers I've ever had. He helped a lot of kids including myself foster interest for STEM.” Ashley described a teacher who acted as a sponsor for the robotics club as someone who “actively took an interest in it” and “was definitely a massive positive experience for us”. Annabelle had the unique situation of having a math teacher for a dad, and the individual attention she got made her “feel very successful in the math department, just because of that relationship”.

Three interviewees indicated that having a teacher who knows how to push students and get the most out of them was a beneficial experience for them. Nolan states that his math teacher in high school “had a tendency to push us hard to get stuff done and be the best we could be.” He also suggested that this teacher helped him and his classmates’ progress, saying that she demonstrated “how to actually improve ourselves, instead of just staying where you’re at”. Regina recalled a math teacher she had in fifth grade that pushed her to correct mistakes, learn where she failed, and “helped me understand the little aspects.” She goes on to say that this teacher “really stuck with me” and “she did not let up”, demonstrating the teacher’s commitment to Regina’s success. Neely talked about an experience where she helped in her math teacher’s classroom as a tutor for younger students, suggesting that the teacher’s role in supporting her and asking her to do things outside of her comfort zone drove her to be better in many aspects. Neely says of the teacher, “she was definitely a mentor within the tutoring role because she helped me with leadership skills and I think that improved my math too, also teaching other people”.

Some of the interviewees talked about the role teachers had in their learning, specifically in the way they taught their subject or gave explanations. Interestingly, in each of these instances, the interviewee was talking about subjects in which they did not see themselves as successful and did not score highly on the self-efficacy scale. Annabelle praised her teachers that could “explain it multiple different ways to get that final, like, the product of understanding”. Regina had a similar take on teacher explanations, suggesting multiple times that the ability to explain clearly was the hallmark of a good teacher to her. She gave an example of an eighth-grade math teacher who “broke it down so we could understand it little by little” and a high school geometry teacher who would give “step by step examples and she would explain things in such great detail that I could actually understand it”. Noah talked about a biology teacher who was “very good at teaching the subject”, and that even though he wasn’t interested in science in general, he “still felt like I wanted to take some classes that pertain to it because of how, like, helpful she was and how she taught the subject that I was able to, um, respond better".

Two interviewees spoke of teachers who worked to show how the subject applied to the workforce and helped the students see these connections. These two students spoke of teachers in subjects in which they were extremely comfortable and are currently pursuing. Evan said that his teacher, who came from the nursing field to teach about medicine, brought "real life experience" and "was a huge influence on me". He suggested throughout the interview that real-world application was more valuable to him than school experiences, and this teacher exemplified that idea. Blake said his most influential teacher taught him how to actually use equipment for engineering and do the things that he would do later in his career.

Three of the interviewees provided examples where teachers did not deliver a positive experience or influence on their confidence and interest in STEM. Annabelle spoke of some of the science teachers she had that "were not as personable" and would "only have the one way of explaining it", and if you struggled in those classes "you were kind of left behind". Regina recalled several science teachers that impacted her negatively, suggesting that they played a role in her declining interest in science. She described one chemistry teacher who would "go really, really fast and there wouldn't really be time to take notes and, you know, she didn't, wouldn't go over the little details, and she wasn't a hands-on teacher". When she changed schools, she encountered another chemistry teacher who "would just, like, write things on the board and she was very monotone". Regina indicated that this teacher wouldn't explain things and that both chemistry teachers were "a negative setback". She also talked about a physical science teacher who showed little interest in teaching, saying that "we mostly watch Myth Busters, and, you know, played games in that class". Finally, Noah said that he didn't have any particular negative experiences with his STEM teachers, but also didn't experience anything positive from them and wondered if that would have made a difference in his interests:

> I don't think there was any one that was, like, negatively impactful at all. I think was just like maybe it was just neutral enough that maybe if there was someone with a positive, it might have gone a different way. But it was just kind of like, here's the class. And that's it.

Course Offerings

One of the categories of learning experiences that emerged from the interviews was the availability and access to advanced or specialized coursework in STEM. Some of the interviewees discussed an array of course options where they could explore anything that they wanted, while others described their wish to have more opportunities for this exploration. In a result consistent with the literature on self-efficacy, the two interviewees who have low STEM self-efficacy did not mention anything about advanced STEM coursework.

One of the ways that many schools offer advanced coursework in STEM is through university partnerships. Neely took part in an upper-level biology course through the local university that offered dual credit. As an up-and-coming veterinary student, Neely appreciated the course because "that made me like, know that that was something that was really interesting to me, because we got to learn a lot about animals". Other schools partner with local technical schools to offer specialized programs. Evan took part in a program in nursing at one of these schools as he prepared for a career in veterinary medicine, and Nolan was involved in an engineering program at his local technical school. Blake's high school had many of these advanced and specialized programs built in. He described options that include STEM and beyond:

> In my high school we had, I'd say this was one of the more STEM-focused high schools out there. We had a STEM. They kind of had different endorsements, if you will. There's like a business path. There was a STEM path. There's like a cultural path. So I chose the STEM path in there and it started all the way back in middle school for me. I believe the

> class was. It was design, was Design and Model and Automation and there's another one about flight. I can't remember the exact name of the class because middle school was a while ago, but then freshman was Introduction to Engineering and Design, sophomore year was Principles of Engineering. And then after that, those were the more basic courses. That's where it kind of branched out and by junior year went into robotics, Robotics 1 and Digital Electronics. Those were definitely, that's where I'd say it really started. I really loved the robotics class and the digital electronics class

When asked about things he might change about his high school experience, Blake stated, “I don't think there's things other than what I've had in high school that would prepare me better”.

On the other side of this situation, there were several students who lamented the lack of options available for them at their schools. Annabelle went to a very small high school, where there were few options for advanced science courses. She indicated that because of the size of the school, “you're kind of like stuck with the one professor that we had, and not the best teachers”, which negatively affected her interests or desires to pursue science. Neely also cited a lack of opportunity for advanced classes, stating that “all of the AP or upper-level classes at my school were like history-based pretty much, or math and there wasn't a lot of science”. This experience for her “was frustrating. Just because like, wanting to go like, to a like, harder class, I guess”, and she felt like she was missing out on opportunities that students at other schools were getting:

> Being able to be more specified, like it was basically just biology or chemistry and nothing more, like specified than that where I know some other schools had like, Medical Explorers ones or different stuff like that. So, I think that would have been something that could have been cool to do.

For Ashley, the issue was partly that her school lacked advanced courses, but more so that the school lacked the resources to make these courses meaningful. She stated that the “technology our school had was extremely outdated and barely worked" and "we barely even had a lab set up to do proper assignments". This led to "book example problems all year long" which are "not exactly fun or educational to say the least".

Class Performance

Class performance was another experience that stood out on its own as an important aspect of interest and self-efficacy development in STEM. This experience was part of Factor 7 in the analysis of survey data, which was the only factor that had a positive effect on the SCCT constructs for all subjects. Additionally, class performance had one of the largest differences between STEM and non-STEM majors. When sharing their experiences, the interviewees often shared times where their performance in a class or subject affected how they thought about their ability in the subject.

The two interviewees that are engineering majors, Nolan and Blake, indicated throughout their interviews that they had a lot of success in their STEM courses. Even when asked to name negative experiences or obstacles, they named instances where they overcame a challenge and succeeded. Evan also talked about an experience in freshman biology, where he "absolutely crushed the course" and "was able to help all my peers…in the class, help them succeed". This class helped him to realize his potential in science, specifically biology, and bolstered his desire to pursue a career centered on it.

Several students had negative experiences in their courses that caused them to reevaluate their involvement with STEM moving forward. Regina stated that she's "terrible at math. I don't understand it", and then pointed toward her low score on the ACT math section as proof of her ability. She also talked about flunking a chemistry course, saying that it "kicked my butt and I had, I ended up dropping it at the semester because I knew that I couldn't survive if I didn't understand". Noah described high school experiences in mathematics that led to his decreased belief in his math ability. Early on, he indicated positive attitudes toward math, stating “when I was a kid, I thought, um math was definitely my subject”, but when he reached high school, that confidence in his ability began to fade. He said of this decline:

> And, so, then you slowly, your skills taper off where you just bomb something so you start to have that negative aspect towards… so eventually, you come to the point where it was. Well, why don't I just switch to something that comes more naturally, I mean that you are almost more passionate about. Because the more, the more you fail at a subject I feel like the less actually you become more, more dreading to go to it and maybe that leads to you failing even more.

Ashley also describes poor course performance as a cause for reevaluation, though it came in college. Ashley started college as an engineering major, but when asked why she switched to creative writing, she said, “physics and calculus two told me engineering was not for me”. She went on to talk about struggles with chemistry pre-college, but it was clear that being unsuccessful in those two college courses caused her to deviate from the engineering field to one that does not involve any mathematics or physics.

Both Neely and Evan shared experiences where they struggled in mathematics. However, because they felt they could continue to pursue their career path, they saw these struggles as minor issues and not reason to reevaluate their choices. When discussing struggles in STEM, Neely even states “this wouldn’t really be integral to my degree now, but my calculus class”. Evan shared his struggles with math as an aside within a description of the successes he feels in other areas of STEM. These comments indicate that each understands which areas of study are most vital to their field and that lack of confidence in other subjects will not deter them from their current path.

Out-of-school

Nature and Community

The nature and community category contains activities such as visits to a zoo or museum, being outdoor in nature, and volunteer work in the community. These activities were only discussed in three interviews, but the two interviewees that are on a veterinary track talked extensively about them.

The primary thing that each of these veterinary-track interviewees indicated was that they had an interest in animals since they were young. Neely said, "I think I've always loved animals" and "I've wanted to be a vet for as long as I can remember". Evan spoke freely about his experiences on a farm as a child, and how those experiences manifested in his desire to be a veterinarian:

> As far as where it originally rooted from, I've always been super interested in wildlife. Going out to creeks and stuff by the house and just flipping over rocks and seeing what I could find…just growing up and really being able to explore the world around me just really ignited that passion. And I mean so it's given me confidence to kind of push myself further and further and seeing how high I can take it and how successful I can be. It really has driven me to go that extra mile, that some other people haven't been able to do.

Another activity common to both interviewees was the on-the-job experience that they got while job shadowing different veterinarians. Neely started with a job shadow of her dog's veterinarian, but then moved on to shadow another veterinarian and began volunteering at animal shelters. She detailed that one of the veterinarians "was helping me learn things a lot more hands on", and that she was able to do a lot of the things that would be done on the job. She said that "starting to be able to do that was really cool". Evan shadowed at a small animal day-care facility and then spent time at a 24 hours emergency care facility, and indicated that both of these experiences were beneficial in the pursuit of his career path.

The only other interviewee that discussed this category of activities was Noah. He talked about visiting a local aquarium and a science museum. He said that the interest sparked by these may have helped him succeed in the lone science class that he did well in, anatomy. However, while these experiences stood out to him, their effect was largely superficial. He felt that if he had had more experiences, “maybe they could have fueled more of a passion for it”, though he did not indicate any desire to pursue those experiences further.

Tinkering and Building

Tinkering and building is one of the categories of learning experiences that demonstrated predictive value toward engineering self-efficacy, outcome expectations, and interests. Therefore, it makes sense that the only two interviewees that mentioned these activities are those that are majoring in engineering. Blake described some of his childhood hobbies as building Legos and playing Minecraft. Nolan said that he likes “building things and working on projects”, along with saying that he enjoys “coding and programming”. Neither of these interviewees spent much time discussing these activities, but they did speak of them as early interest developers.

STEM Extracurriculars

The category for STEM extracurriculars includes after-school programs, clubs, groups, and summer camps that have a focus in some area of STEM. While few participants in the survey said that they had participated in these activities (less than 10% for camps and after-school activities and less than 25% for clubs), they generally carried a positive response, and clubs were selected significantly more by STEM majors than non-STEM majors. During the interviews, the two interviewees with low STEM self-efficacy did not mention any experiences with STEM extracurriculars, while all other interviewees did. In fact, Regina said that because she came from a small town, the number of STEM activities outside of school was limited.

Clubs and groups were the most common form of STEM extracurricular activity mentioned by the interviewees. Annabelle said that her school did offer several clubs and she was aware of them, though she never participated. Neely did participate in her school's science club and said it "was really fun". Three interviewees talked extensively about their experiences with a robotics club. Blake and Ashley both indicated that robotics competitions were the STEM activities that made them feel the most successful and confident in STEM. Ashley spoke of the challenges that her team faced, but said "our team was actually really successful and I was sort of the big, like I pretty much did all the hard building tasks. And so that was probably my most successful moment in STEM". Blake was proud of his and his team's accomplishment with a robotics competition, saying "I was the team leader and we took it home, we won that competition". Nolan also participated in a successful robotics team, but while he had a good experience he did not desire to continue. He stated, "It was something that I'm like, okay I can do this. It's just not what I want to be for the rest of my life".

Three interviewees talked about their experiences with summer camps, though none of them said that it had a large influence on their STEM decisions. Blake attended a summer camp for programming in Python when he was young, but did not remember much about it. Neely also recalls a STEM summer camp that she enjoyed, saying it "was really interesting". However, the camp was focused on technology and did not pertain much to her eventual zoology track, so though "it was cool to see all these people, this entire research on [their models]", it did not have a long-term effect on her STEM decision-making. Nolan had a positive experience as a helper at a STEM camp for younger students, saying "it was just nice to see other people taking an interest in trying to foster an interest in it. That just really stuck out to me for, it was like helping the next generation".

Innate Interest and Ability

Innate interest and ability was one of the strongest predictors of self-efficacy, outcome expectations, and interests in all three subject areas. This often reveals itself as a self-proclaimed love for a subject, or an unnamed source for the initial interest in a subject. This topic was only discussed by half of the interviewees, though because it is not a specific experience, it is often more difficult for people to express.

Evan, when discussing the spark that drove him to go to college for veterinary medicine, gave a list of influences, but most notably stated, "I've just always loved it. I can't see myself doing anything else, to be honest". Neely followed suit by stating that she has "wanted to be a vet for as long as I can remember". Blake and Nolan both talked about how they had always felt like they were successful in STEM courses, and that engineering felt like a natural path. When asked about whether his engineering courses made him choose his career path or if he took the courses because he was already on that path, he said, "I would say it was I was already somewhat heading down that path. These classes and experiences more just reaffirmed my path choice…just made my decision stronger".

Noah was successful in mathematics in early grades, but as he got into high school, his interest and confidence waned. He tried to make sense of this concept of innate ability in relation to mathematics:

> Stuff like, you know Sudoku, logic puzzles, all those, you see a correlation at least. Because like the Sudoku is very mathematic based. And those, you know, you do those and you're like, okay, you know, either you have an interest for them or you don't really like them.

While he saw his interest decline, Noah felt like he could sense who he deemed a math person or not based on the criteria he described. While this does not comprise every aspect of innate ability, it is an interesting insight into students' views of this quality.

STEM Media

The category for STEM media can include science periodicals, science fiction books and movies, science biographies or biopics, and any other form of media that portrays STEM topics. Three of the interviewees spoke about reading some form of STEM media, and how that affected their STEM career goals, though only one of the three is actively pursuing a STEM career.

Evan recalled "growing up, I always, my grandma, she always had the Nat Geo little magazines weekly subscription". He said that these magazines helped him see more of the animals he was interested in, and that they "super piqued my interest", and when he got to read them he "was always excited about that". Regina discussed that, even though she is not pursuing a STEM career, she would really like to help encourage women to pursue STEM. One of the highlights she shared related to this was her love for "books, a lot of it was books like Hidden Figures". Ashley shared that science fiction books were a large part of her interest in STEM, and that after dropping her engineering major that she is pursuing creative writing to become a science fiction author.

Family Influence

This category contains any means by which the immediate or extended family has influence over students. This could include family activities or discussions of STEM careers. However, if often manifests itself when seeing a family member who has a STEM career and what they demonstrate to the student. All interviewees were asked about their family influences.

Some interviewees shared influences from their immediate family. Blake was the most pointed about his family's influence in his choice to pursue an engineering career, saying "it's almost family tradition at this point to become an engineer" and that all but one of his cousins have studied to become engineers. Annabelle's father is a math teacher and has two brothers that are engineers. Though she is not pursuing a STEM career currently, she has high self-efficacy in mathematics and says "we're a big math family". Ashley's father worked a mechanical job in the Air Force and would often take her to his job with him. Nolan didn't have any particular family influences in a STEM career, but he said his mother "wanted me to have a good foundation for wherever I want to do. And kept throwing math books at me". He stated that she was supportive of whatever he did but prepared him and helped guide him to his current career path.

Other interviewees had experiences with extended family. Evan had an uncle that was a veterinarian and stated that "he's definitely been a huge part of my interest in STEM just seeing how successful he was how much he loved it". Additionally, he had a grandmother that was a nurse who received several honors, and he expressed pride in that family accomplishment. Ashley mentioned a host of extended influences, including her grandfather who worked with mechanical objects, a family friend who volunteered with the robotics club, and an uncle who was a physics and calculus teacher. Regina became especially interested in her biology classes in high school after her cousin died from cystic fibrosis, and that "that's what really, really opened my eyes to science and you know it being so fascinating and so amazing and it explains everything".

Two of the interviewees claimed no family influence to their interest or confidence in STEM. However, both Neely and Noah tied this question to whether their parents worked in STEM, which neither did. In this case, they either experienced no further involvement with their family in STEM or attribute family influence only to parent careers. Noah said, "like if your parents were like a scientist or something, maybe you would be naturally pursuing down that line more".

Social Cognitive Career Theory Constructs

The collection of learning experiences from the interviews that were described above give insight into the experiences that the interviewees viewed as important or meaningful. The previous section explored the individual learning experiences, while this section focuses on the specific ways that these learning experiences were perceived to affect the interviewees' self-efficacy, outcome expectations, and interests. Each section explores the broad viewpoints of each interviewee, with specific examples from each when possible.

Self-Efficacy

Self-efficacy is a belief that distinguishes what people think about their ability to perform a particular task in the future. This belief plays a part in how people perceive themselves and their abilities, and also in what they will choose to undertake in their classes and career paths. The experiences of the most efficacious are described first, followed by the median, mixed-efficacy, and the low-efficacy interviewees.

Blake displayed his confidence and ability in STEM throughout the interview, beginning with his clear knowledge of internet protocols when he said, "hold on, let me turn off the VPN, that slows the connection down sometimes" and continuing with his grasp of the engineering pathway he was on and how he got there successfully. He spoke of his considerable number of engineering courses in high school as something that "just made my decision stronger". When asked to describe a time where he did not feel successful in STEM, he reinforced his strong self-efficacy in STEM by describing events where he overcame challenges. He first described a time in robotics where his team faced a problem with the robot's performance, but eventually worked through the issue and ended up winning the competition. Then he talked about a complex physics lab where he was asked to design a trolley car to run on electric wires. After a series of failures, he was able to build a car that worked very well.

Nolan also demonstrated a clear confidence in his ability in STEM during the interview. He talked first about his enjoyment of difficult math and science courses. He described a project in his engineering program where his team is designing a visual computer program to help dementia patients, saying that “it’s extremely difficult, but I also enjoy doing it”. He also describes STEM careers as “time consuming and extremely difficult”, and that you must be “smart enough”, “creative enough”, and “work hard enough” to be successful, suggesting that while not everyone is capable, he believes he is. Nolan also says that “everything has been for the most part, difficult”, but that “I just have to persevere through it” and that it is “just hard”. Upon being asked to describe challenges he has faced, Nolan details events in which he felt unsuccessful, but the primary reason was because he took on a project that was far above the level he was currently. In telling the story, he described his abilities and noted that they were quite high, further reinforcing his interest and belief about himself in STEM. Nolan provided all of these statements with confidence that he would be able to fight through and accomplish his goals in spite of the challenges.

Ashley had particular experiences throughout her time in high school and college that affected her self-efficacy in STEM. In high school, she participated in a robotics club, and when her “team was actually really successful” and she was one of the leaders, she felt capable in STEM. In part, that led to her beginning college with an engineering major, saying that the robotics competitions “definitely boosted my, especially my confidence and what little I know about engineering”. However, once Ashley got to college, experience in advanced science and math courses changed how she viewed her ability to succeed in engineering. When asked about her biggest obstacles in STEM, she responded “well of course there is me utterly failing physics and calculus 2”, and going on to say that was the semester she dropped out of engineering because she did not feel like she could succeed in it anymore.

Annabelle attributed little of her decisions to her beliefs in her abilities, but she did affirm her high self-efficacy in mathematics. She talked about logic puzzles such as Sudokus that require mathematical skills, and said "yes, I can do those. I feel very intelligent when I do them". Her mathematics self-efficacy is demonstrated through her talk of being part of a "math family" and feeling of success in mathematics. However, she did not talk about engineering at all and spoke negatively about her abilities in science several times, supporting her low self-efficacy scores in those two areas.

Evan started by talking a lot about his upbringing and being able to explore the natural world and discover wildlife on his own. These opportunities have "given me confidence to kind of push myself further and further", and that being an explorer "has really driven me to go that extra mile, that some other people haven't been able to do". He talks of another source of his science self-efficacy as a biology course that he "absolutely crushed", and the fact that he was able to help other students succeed made him "realize that this might be a good opportunity for me". Evan further demonstrates his belief that he can be successful in the path before him by describing his perseverance through the difficulties ahead, saying "this is what I'm doing, no matter what. Make it happen, just go out there and do it".

Neely used a field trip to springboard her confidence in her ability to pursue veterinary medicine, mentioning that she felt confident that she could understand the role of animals in their ecosystem afterward. Her job shadowing at the local veterinary office was a very important experience in helping Neely believe that she was capable of being a veterinarian and be successful in the future. She describes that the veterinarian would ask her to fill a prescription, and she would say "I know exactly what that is. And I know exactly what drug it is. And I can go get it. I know where it is and I can fill the needle, I can fill the vaccine". She described that event as "really cool". Neely also feels strongly about her ability to problem solve and challenge herself in science endeavors in the future, stating:

> I think one of the biggest things that I, like, has drawn me to it is that there's continual problem solving and there's continual um, I feel like personally for me. I need to see some sort of result to be driven. And, so, I think that's big and seeing the actual product or healing process or something like that.

Regina expressed some sources of self-efficacy, however very little of it related directly to STEM. She did say that researching about STEM independently and reading books, especially about women in STEM, helped her gain confidence that she could be successful in her STEM classes, but did not mention anything else. She also talks about the fact that she "really pushed myself for all of this" and "I haven't really had any outside help". However, these experiences are largely non-STEM related and speak only to her general self-efficacy rather than STEM specific self-efficacy.

Noah openly spoke of experiences that diminished his self-efficacy in STEM. He started really believing in his mathematical abilities as an elementary school student, but as he got into higher grades, the courses he took got harder and he became discouraged about his ability to be successful in them. As he continued to struggle, he stated "the more you fail at a subject I feel like the less actually you become, more, more dreading to go to it and maybe that leads to you failing even more". Noah believed that his failures were indicative of his future ability in mathematics, so he moved onto coursework that required less mathematics. He also talked about being in an introductory STEM course where the grade was competitive, and that those who were already performing well in the class thrived on this competition while those that were struggling continued to feel worse about their abilities. He said that he thought this format was detrimental for an introductory course because "it would turn away too many people" from pursuing STEM.

Outcome Expectations

Outcome expectations are what a person believes to be the end result of a particular behavior. These expectations describe a person's views about how actions and experiences will result in particular outcomes, but do not necessarily reflect the individual's assessment of their ability to accomplish these outcomes (Bandura, 1977). The experiences of the interviewees and their relationships to outcome expectations are described in the same order as the self-efficacy section.

Blake sees the results of doing engineering as rewarding and enjoyable. He sees value in participating in a STEM career, though he does not necessarily view a STEM career as being different from other fields, saying "you can get a very good job in plenty of other industries". However, he thinks that following an engineering path can be rewarding for him personally, because "it's just a field that I enjoy" and he likes "the process of design". Blake notes that STEM jobs take a lot of work, and that they put in "very long hours". Blake's participation in a STEM-focused program at his high school helped him see that there are many opportunities in STEM and engineering in particular, and that his experience could lead to obtaining those opportunities.

Nolan noted that an engineering job would result in good pay and job availability "because you always need somebody who can innovate and invent". For him specifically, however, he thinks that the opportunity to design, invent, and create new things presents a valuable opportunity that he would enjoy. He has gained experience with projects in his life, and he enjoys doing things that involve this development. He cites his current computer engineering project for its value to society and knows that even though it is hard, he is glad he is doing it. He says he hopes that participating in an engineering career will lead to him making "something that hasn't been made before".

Ashley views experiences with STEM as being incredibly beneficial for future endeavors and careers. Her own experiences with science fiction media and STEM studies have directed her to become an author. In this line of work, she believes she can put her experiences to use and create stories that people love. Even though Ashley is no longer pursuing a STEM career, she believes that experience with STEM can lead to a promising career. She says that "most jobs [will] become technology related in some way", and that many opportunities await those with "a STEM degree of really any kind".

Annabelle has mixed views about the outcomes of pursuing a STEM field. She thinks that those following a STEM path have a "lack of social life" and "lack of communication with people and community". However, she also says that those with STEM degrees have a "higher salary" and are "well-educated and intelligent". Annabelle says that her family background in mathematics has had an effect on how she views mathematics-related tasks, and though she sees application and teaching mathematics as important she does not view herself as following in those footsteps. She also mentions that a lack of school focus on STEM careers, especially in science and technology, limits the likelihood that students will pursue those paths.

Evan sees the pursuit of a STEM career to be a very safe and secure place to be. He believes that "job security is literally always going to be there", and that having a STEM degree gives a person a variety of options. He specifies that most of his thought is in his area of veterinary medicine, but that the same applies for "technology, engineering, for sure" and that "there's just been a huge boom". Evan states that STEM careers are "just a great place to be", however he also concedes that engaging in a STEM career could mean a lot of time spent in school. He has weighed the outcomes of completing this long process or not but has decided that "this is what I'm doing, no matter what".

Neely views engagement with STEM learning experiences as a process rather than a final outcome. When asked about STEM careers, she talks about “continual problem solving” and describes her need to “see some result”. She also describes the outcomes as “seeing the actual product or healing process”. Neely’s experience working in job shadowing and volunteering helped her to develop a picture about what working as a vet would be like. She also talks about those in STEM needing “to stay on top of new findings and constantly learning”. These outcomes demonstrate her process-oriented viewpoint on the outcomes of STEM activities.

Regina had very positive feelings about what a person pursuing STEM could accomplish. She first focused on the role of females in STEM, and that they could provide the influence that drives young girls to think about pursuing STEM themselves. She then laid out a series of positive outcomes from engaging in STEM, including making “great connections” and “you get to learn new things every day”. She also considered people who work in STEM as teachers who “learn as your students learn” or researchers who “get to new breakthroughs every day”.

Noah does not see himself in any future engagements with STEM, so he shares his views of STEM outcomes as he sees them from the outside. He starts by stating “when you think about STEM careers, you think of people making more money”. He goes on to say that people often see people who are involved in STEM as “more successful” and “more educated than those without it”. However, he also sees negatives to engaging in STEM, saying that a person may have to “skip out on having a family” because of the time commitment. Noah’s experiences in STEM preclude him from seeing opportunities for himself in this field.

Interests

The construct of interest describes the attitudes a person has about whether involvement with certain activities would be enjoyable to be a part of or learn more about. Even if someone is capable in a certain area, interest may be a factor that helps control whether a person chooses to continue engaging in those activities. The experiences of the interviewees and their relationships to interests are described in the same order as the above two sections.

Blake suggested that he had always had an interest in engineering. He talked about very few early experiences other than building and computer games, but he did have a strong family connection to STEM fields that played a role in his interest development. He stated that his high school experiences did not convince him to pursue STEM, they “reaffirmed my path choice”. These experiences also helped Blake to decide which fields he was interested in pursuing. Taking robotics and digital electronics were enjoyable, but he said “electronics is more of a hobby kind of thing than I would say it as a career thing. And I think that class helped me realize that”. One of the key aspects to Blake’s interest in engineering is that “it’s just a field that I enjoy…I like the process of design”.

Nolan gave comments repeatedly throughout his interview that suggested that he had developed an interest in engineering from a young age. He described certain types of engineering as “hobbies” and stated that he liked “building things and working on projects”. Nolan attributed many of the experiences that he had in high school to orienting him in his current direction. He spoke of a teacher who “helped a lot of kids including myself foster interest for STEM” and his mother who “kept throwing math books at me”. He also worked as a leader at a STEM summer camp where he enjoyed teaching students and would “help them along in their projects”. This experience was valuable because “it was just nice to see other people taking an interest”. His experiences also shifted him away from mechanical engineering to electrical engineering, because “I guess you would say because I enjoy coding and programming, and circuits was a fun class that I took in high school”.

Ashley developed an early interest in STEM from her family members who had STEM-related jobs and from STEM media. She said, “I’ve really liked science fiction, fantasy books”, and while this drove an initial interest to pursue engineering it eventually led to spark her "interest in becoming an author…to write science fiction and fantasy". Ashley's interest grew in high school through participation in robotics club and competitions, which she still attends when she can. She said, "that definitely boosted my, especially my confidence and what little I know about engineering, definitely my interest". While Ashley's interest never diminished, she chose to change careers because of math and science class performance, though she still intends to pursue a career writing about science.

Annabelle had very little interest in STEM. The one activity that she described as an interest booster was Sudoku and logic puzzles. However, she also said that the lack of good science instruction and opportunities in her school decreased her interest in science dramatically, saying "I'm very, very drawn back from the idea of science".

Evan developed an interest in animal science and veterinary medicine very young while exploring on the farm he grew up on and taking care of the animals. He said that "growing up and really being able to explore the world around me just really ignited that passion". In addition, spoke of family influences that encouraged his interest in STEM. His uncle is a veterinarian and seeing him have success in that field made Evan more interested in pursuing that career path. He also recalled experiences at his grandmother's house, where "she always had the Nat Geo little magazines" and he was "going through reading these books" which "piqued my interest". In terms of interest development, Evan did not speak about much beyond middle school, as his interest was firmly developed at that point.

Neely said that she has "always loved animals" and "wanted to be a vet as long as I can remember". The experiences that she recalled being most influential to her interest were job shadowing and volunteer activities with veterinarians and animal shelters. Her first job shadow was at her family vet in eighth grade, and after that she "kind of decided that I liked it". She also had experiences with classes where she went on field trips which she said improved her interest in wildlife and ecosystems. Neely also talked about advanced courses that she took that helped to cement her interest in veterinary medicine. An upper-level biology course “was really interesting in that it made me like, know that that was something that was really interesting to me, because we got to learn a lot about animals”, and a research-focused course “really helped me to know more about what I was getting into. And what I was more interested in”.

Regina shared a variety of early high school experiences which increased her interest in STEM. One was the science fair, where she worked on projects in microbiology. She explains, “I am utterly fascinated with microorganisms and things like, it's so much fun”. Concerning her science fair experience, Regina said, “that’s what's one of the reasons I'm so fascinated in science was because of science fair. It's so much fun.” A biology course was also a driver for her interest because of the topics that the teacher covered, specifically “genotyping, it's like that's what really, really opened my eyes to science and you know it being so fascinating and so amazing”. Later in high school, Regina had several experiences that began to diminish her interest in science, particularly her chemistry courses. She explained that the teachers were boring and did not explain the material well. Her failure in that class, along with moving schools where there was no science fair, played a role in decreasing her interest in continued pursuit of STEM.

Noah demonstrated very little interest in STEM. He had early interest in mathematics because he was successful in it, but that interest went away as his successes in the courses diminished. Noah directly tied his interest in STEM to his performance in his courses. When discussing the complexity of STEM courses compared to English and social studies courses that he could understand, Noah said “your interest [in science and mathematics] just, like almost switch places with [English and social studies]”. He consistently expressed that how well he performed in a particular course had a direct effect on his interest in that subject.

Conclusion

This study used an explanatory sequential mixed-methods design to explore the learning experiences that had an effect on undergraduates' STEM self-efficacy, outcome expectations, and interests, and the effects of those constructs on their STEM goals. The quantitative portion of the study surveyed 312 undergraduate students at a large Midwestern land-grant university to explore their perceptions of learning experiences prior to college and the SCCT constructs that may guide their career decisions. The qualitative portion of the study involved interviews with eight students from the initial survey, who were selected based on their self-efficacies in mathematics, science, and engineering. These interviews provided depth to the exploration of the research questions by adding narrative descriptions of the learning experiences the interviewees had and how they perceived the effects of those experiences.

The first research question explored the types of learning experiences that students felt were meaningful to their own self-efficacy, outcome expectations, and interests in STEM. Analysis of the survey results indicated that typical classroom features such as teacher lectures and projects were the most commonly selected in-school activities, while teacher characteristics also played an important role. Outside of school activities were less common for participants than the in-school activities. The most commonly selected out-of-school experiences included things that may or may not be linked directly to STEM learning, such as spending time outdoors or visiting a zoo. The least common experiences were some that were most specifically and intentionally geared toward STEM learning, such as after-school programs, camps, and family pressure to pursue STEM.

Comparing these experiences between STEM and non-STEM majors reveals that some of the experiences were selected more often by those students who are majoring in STEM. In general, the in-school experiences were focused on future study in STEM or career-specific STEM experiences. The out-of-school activities were not as closely clustered, but STEM majors more often selected experiences such as reading about STEM, having family influence in STEM, or having natural interests in STEM or logic-based activities. Analysis of the differences in perceptions between STEM and non-STEM students revealed that many of the experiences that were selected more often by STEM students were also viewed more positively by STEM students. Two experiences that were not selected more often, but were viewed as positive experiences by STEM students were paper assignments and teacher lectures, which are experiences commonly associated with direct instruction methods.

The interviewees' description of their learning experiences and how they were affected by them often ran parallel to the findings in the quantitative study. Themes that were very influential to these students included innate abilities, teacher influence, meaningful classroom activities, and memorable experiences outside of school. One notable theme that the interviewees indicated was very influential to their beliefs about STEM, both positively and negatively, was their performance in STEM classes. Several interviewees said that their performance had a large effect on their belief that they could continue taking STEM courses successfully. The out-of-school experiences that interviewees talked about often revolved around specific areas of interest. The veterinary students talked a lot about working with animals on their own or with others, and the engineering students discussed building with toys and working with robots or programming projects. All of the interviewees had fairly clear ideas about what types of activities, people, and experiences had affected them and how those things affected them. Each interviewee described experiences that related to their self-efficacies, outcome expectations, and interests in STEM.

The second research question examined the relationship between the participants' learning experiences and their reported self-efficacies, outcome expectations, and interests in mathematics, science, and engineering. Analysis of the regression models indicated that several factors played a role in these constructs, but each subject often had its own set of influencers. Innate interest and ability was the factor that was a significant predictor of all three constructs in all three subjects. However, tinkering and building yielded the strongest predictive value, toward the three engineering constructs. Engineering interests had the largest number of significant positive predictors, adding STEM extracurriculars and careers and future to the two previously mentioned. Mathematics interests had the largest number of negative predictors: classroom instruction, nature and community, and STEM media.

The third research question examined the relationship between students' self-efficacies, outcome expectations, and interests in mathematics, science, and engineering and their intent to pursue a career in STEM. The results indicated that self-efficacy, outcome expectations, and interests in science were all predictive of a student pursuing a STEM career. In addition, mathematics self-efficacy and engineering interests were significant predictors of the students' intent to pursue a STEM career.

In Chapter V I will discuss the meanings and implications of these results, along with limitations of the study and future directions for this research.

CHAPTER V

DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

This study is grounded in the idea that the decisions involved in choosing a career path are complex and involve many sources and experiences. The choices people ultimately make in the pursuit of a career can be affected by personal characteristics, the behaviors that they exhibit, and a host of external factors (Bandura, 1986). The theoretical framework for this study, social cognitive career theory (SCCT) uses these foundational principles of Bandura's social cognitive theory to construct a model for how these decisions are made. According to SCCT, personal background factors and characteristics influence the learning experiences people have, which in turn influence the development of their self-efficacy, outcome expectations, and interest. These factors then have an impact on the career goals people set, and ultimately those that they act on (Lent et al., 1994).

While this study acknowledges all these factors, the primary focus is on the STEM learning experiences that students have in and out of school, and how those learning experiences influence students' self-efficacies, outcome expectations, interests, and goals. Several studies have demonstrated the positive effects of learning experiences on STEM career choice or the

SCCT constructs that act as intermediaries to these choices (Dou et al., 2019; Ferry et al., 2000; Mohd Shahali et al., 2019). For many students, it was particular in-school experiences that made a difference in their STEM beliefs and goals (Thiry, 2019), for others there are out-of-school experiences that had a lasting effect (Allen & Peterman, 2019), and many developed their STEM attitudes through a combination of the two (Halim et al., 2018; Maltese et al., 2014). These studies, among others, have provided a substantial foundation for understanding how learning experiences can play a role in not only developing knowledge, but also the self-efficacies, outcome expectations, and interests that lead to career choice.

The purpose of the study was to gather information about undergraduates' STEM learning experiences prior to college, how they perceived those experiences, the effect of those experiences on the SCCT constructs, and how those constructs affect students' intent to pursue a STEM career. This study employed an explanatory sequential mixed-methods design (Creswell & Plano Clark, 2017) with an initial survey that examined the participants' prior learning experiences, how they perceived those experiences, and their beliefs about STEM. Follow-up interviews sought to dig deeper into each of these questions and reveal the story behind these perceptions and beliefs. As such, this study allowed for the following research questions to be addressed:

1. What learning experiences do students perceive to affect their self-efficacy, outcome expectations, interests, and goals in STEM?
    a. How do these learning experiences differ between students in STEM and non-STEM majors?
2. What learning experiences affect students' self-efficacies, outcome expectations, and interests in mathematics, science, and engineering?
3. How do self-efficacies, outcome expectations, and interests in mathematics, science, and engineering affect students' intent to pursue a career in STEM?

The first, quantitative phase of the study included an online questionnaire sent to all first- and second-year students at a large midwestern land-grant university; 312 participants completed the entire questionnaire. The racial and ethnic demographics of this sample were very similar to those of the university, but substantially more females responded than males.

The questionnaire asked participants to identify learning experiences they had experienced prior to college, and then how each experience affected their confidence and interests in STEM. The researcher analyzed this portion of the survey by first examining the percentage of participants that selected each learning experience as a part of their in-school or out-of-school experience. Then, the perceptions of those learning experiences were examined by comparing the percentage of participants that had positive, neutral, and negative perceptions of each experience. These experiences and perceptions were also compared between STEM and non-STEM groups.

The questionnaire also asked questions about participants' mathematics, science, and engineering self-efficacies, outcome expectations, and interests. These SCCT constructs were compared to the learning experiences to examine whether certain sets of experiences could predict the construct values in mathematics, science, and engineering. Finally, each of these subject-specific constructs was examined to determine whether each predicted the participants' self-reported intention to pursue a STEM career. The next section will present a discussion over the quantitative and qualitative findings as they relate to each research question. The section will conclude with implications for practice, policy, and research, limitations of the study, and conclusions.

Discussion

The first research question sought to identify the learning experiences that students identified and perceived to influence their self-efficacies, outcome expectations, interests, and goals. To examine this question, the researcher first focused on the experiences identified by the participants, both through the survey and interviews. Then, the researcher examined participants' perceptions of these experiences and their resulting confidence or interest in STEM subjects and careers. Both the identified experiences and the perceptions of those experiences were also compared between STEM and non-STEM students.

Perceptions of Learning Experiences

In-School Learning Experiences

All survey participants were first asked which learning experiences they had participated in prior to college. The most common in-school experiences included lectures from the teacher, paper assignments, projects, hands-on activities, science demonstrations by the teacher, step-by-step laboratory experiments, and use of computers for class assignments. This list of experiences included a mixture of teacher-centered and student-centered approaches, many of which are used as part of direct instruction methods. These activities can all be completed inside the classroom with little need for outside resources, and are likely to be used by many teachers because of the ease of implementation. Many teachers use direct instruction techniques if they do not have the confidence or content knowledge to teach using innovative methods or talk about their subject in a meaningful way (Appleton, 2013; Sanders et al., 1993; Yoon et al., 2011).

The survey participants were also asked to indicate whether the activities they had experienced had a positive, negative, or no effect on their confidence and interest in STEM. Two of the direct instructional techniques, paper assignments and classes focused on facts and memorization, were perceived as negative experiences more often than they were perceived as positive. Only two of the eight interviewees named these types of experiences as memorable at all, though both were perceived negatively and as ubiquitous but unimportant parts of their STEM learning environment. An interesting note is that while direct instruction techniques were perceived negatively as a whole, two of these techniques were perceived more positively by STEM students than non-STEM students. Lectures by the teacher and paper assignments had significantly higher perception scores for STEM students. There was not an explicit explanation for these results based on the data gathered for this study. However, participants in this study who are majoring in a STEM subject were 30% more likely to have indicated that they performed well in STEM classes. Other studies have found similar results (Dawes et al., 2015), and these students are likely to excel in traditional school settings. It is interesting that while standards are calling for a hands-on, inquiry-based approach to learning science and mathematics (National Council for Teachers of Mathematics, 2016; NGSS Lead States, 2013), and hands-on activities have been found to be effective at increasing STEM interest (Mohd Shahali et al., 2019), many STEM students still enjoy and see benefits in direct instruction techniques.

The in-school learning experiences that were selected the least by survey participants include taking a class with an emphasis on further study in STEM, speakers from professional STEM fields, discussion of STEM careers in school, and taking a class with an emphasis on problem solving. These four experiences are also among the experiences selected significantly more by STEM students than non-STEM students. Furthermore, all four interviewees who are interested in pursuing a STEM career talked about STEM career-focused activities directed by their schools or classes that were focused on specific STEM careers. Two of the interviewees who were median and mixed self-efficacies indicated that they did not see an emphasis on STEM careers at their schools and wished that their schools would have done more to focus on this aspect.

These STEM-focused experiences can be a crucial part of developing STEM interest in students. Collaboration with peers and engagement with STEM professionals (Mohd Shahali et al., 2019; Struyf et al., 2019; Thiry, 2019), and authentic problem-solving and projects (Beier et al., 2018; Guzey et al., 2016) are valuable for the development of STEM career interest. These findings, along with the results from this study, indicate the need to infuse specific STEM career-centered activities and experiences into the curriculum to provide students more opportunities to understand and perhaps pursue STEM careers. Jahn and Myers (2015) even suggest that engaging activities must be accompanied by explicit discussion of their application to STEM careers to have an impact on interest.

Analysis of the perceptions of STEM learning experiences revealed six experiences with more than 80% positive responses and less than 3% negative responses. These experiences were hands-on activities, high performance in a STEM class, field trips, classes with relevant content, emphasis on further study in STEM, and science demonstrations by the teacher. Several interviewees recalled specific hands-on activities, field trips, and science demonstrations that were meaningful to them. The interviewees identified these particular experiences as influencing their confidence and interest in STEM, and the activities were often situated in the field that the student was studying. Mohd-Shahali et al. (2019) found that hands-on activities and solving relevant and meaningful problems are important drivers to STEM motivation. Other studies that echo the results in this study include Struyf et al.'s (2019) findings that relevant content in the classroom increased student engagement and Dawes et al.'s (2015) findings that students tend to gravitate towards fields in which they excel during school. Students perceive the activities in this list to be meaningful, and STEM teachers can expect that it will be worthwhile to spend the time and effort to make these experiences a part of their classes.

The survey data did not provide information about coursework, but the interviews revealed that the students who were pursuing STEM valued advanced or career-specific coursework. Those students who had access to many course options were grateful for those opportunities and felt that they were well-prepared for their courses in college. Students who were interested in STEM but did not have the same array of course options suggested feeling as though they missed out. Research indicates that taking advanced math and science coursework in high school is associated with STEM career interest (Sadler et al., 2014), success in college STEM courses (Redmond-Sanogo et al., 2016), and STEM degree completion (Maltese & Tai, 2011; Sasson, 2020). Gottfried and Bozick (2016) also found that taking courses that were focused on the application and integration of STEM was a predictor for choosing a STEM major in college. The interviewees who had the lowest STEM self-efficacies did not mention anything about advanced STEM coursework. Zeldin and Pajares (2000) suggested that students with low self-efficacy in mathematics and science will not take advanced courses in those subjects. Annabelle stated that her school lacked quality science teachers and that it did not produce very many people who were pursuing science careers. This finding is similar to that of a study by Hampden-Thompson and Bennett (2013), who suggested that students from schools with few science teachers were less likely to pursue STEM careers.

Survey and interview data revealed that students' perceived performance in STEM classes as very important to their confidence and interest in STEM. This experience was selected by nearly 70% of STEM students and only 40% of non-STEM students, and was perceived more positively by STEM students than non-STEM students. Interviews revealed that STEM students often talked about how well they performed in a course, while the non-STEM majors all spoke of times in which their poor classroom performance caused them to feel less confident or interested in STEM. In the cases of Noah and Ashley, this poor performance caused them to change from a STEM path to a non-STEM path. Successes and failures in STEM can cause students to increase or decrease their self-efficacy in those subjects (Bandura, 1977, 1997). Studies by Byars-Winston et al. (2017) and Zientek et al. (2019) suggest that these mastery experiences are more important to the development of self-efficacy than any other factor, and this is consistent with the findings regarding students' perceptions in this study.

Teacher Characteristics and Experiences

Analysis of the survey data regarding teacher characteristics and experiences revealed that teachers were often selected as having an influence on students' STEM confidence and interests, and that influence was overwhelmingly positive. All four teacher factors received a high number of positive responses, and only teacher style of instruction (8.2%) had more than 5% negative responses. Studies of people in STEM careers by Banerjee et al. (2018) and Maltese and Tai (2010) also found that teachers were regularly cited as influential. Teacher encouragement was the characteristic most selected by all participants, and was also the most positively perceived. Teacher comments and teacher style were the lowest categories overall, but both were significantly higher for STEM students. There was not an opportunity during the survey for students to communicate why these characteristics were important, but it is possible that STEM students were influenced more by teachers in general. While nearly 80% of STEM and non-STEM students felt that encouragement and personality were influential, the STEM group stayed above 70% for style of instruction and teacher comments though the non-STEM group dropped to 66% and 48%, respectively. These results are consistent with research indicating that students are most influenced when teachers are caring, encouraging, and challenging (King, 2017; Petersen, 2014; Struyf et al., 2019).

All eight interviewees talked about the positive influence teachers had on them in STEM. Their remarks focused on the encouragement and relationships they had built with their teachers, how teachers challenged them to be their best, the teaching styles that were effective for them, and how teachers applied their subject. Studies by Burt and Johnson (2018) and Banerjee et al. (2018) support the findings from the interviews that teachers' ability to explain material affected the enjoyment of the course. While all the STEM students shared only positive impacts from teachers even when prompted to share positive or negative experiences, three of the four non-STEM students shared at least one negative teacher experience. These primarily involved the way the teacher explained material or their style of instruction. This study presents little data to inform the reasons for these experiences, but it is important to keep in mind that teachers can have an impact in both positive and negative ways.

Out-of-School Learning Experiences

The participants in the survey selected out-of-school experiences less often than in-school experiences. This makes sense as all students have taken STEM classes and have experience with various learning opportunities in the school, while out-of-school experiences generally require initiative and desire to pursue. However, out-of-school experiences in STEM can be valuable for students and often lead to an increase in interest and career goals in STEM (Bonnette et al., 2019; Goff et al., 2019; Steenbergen-Hu & Olszewski-Kubilius, 2017).

The experiences that were selected most often by participants in the survey included visits to a museum, spending time outdoors, and visits to a zoo. These are common experiences for families and children, and it is not surprising that many students in the survey would have participated in these. However, the participants did not generally view any of these activities as particularly meaningful toward their development in STEM. In the interviews, only Evan talked positively about one of these experiences, saying that spending time outside exploring nature and wildlife was a positive influence on his STEM views. Noah also mentioned visits to museums and an aquarium, but they did little to impact him and he is currently following a non-STEM career path.

The experiences that were selected least often by participants involved activities that were much more focused on STEM specifically. They included activities like STEM extracurriculars, family-based activities, and technical activities like programming or working with engines. These experiences often must be initiated by families or influential adults, and may come with a monetary cost which can be a barrier to access for some.

Examination of the experiences of STEM and non-STEM students revealed several differences in the choices made by both groups. Only playing video or computer games was chosen more often by non-STEM students than STEM students. One experience that was selected more by STEM students than non-STEM involves watching or reading media related to STEM and science fiction. Dou et al. (2019) found that consuming STEM media in early life was a significant predictor toward students' STEM identity later in life. However, their study grouped watching STEM shows and movies and reading STEM books together, whereas this study found that STEM students were significantly more likely to say they read STEM books but not that they watched STEM movies or shows. Additionally, three interviewees discussed the influence of reading STEM books or periodicals on their interest in pursuing STEM further though none mentioned watching STEM media.

Students in STEM also selected participation in STEM clubs more often than non-STEM students. The two interviewees who are currently engineering students and the one who started college as an engineering student all talked about participation in robotics club as a major influence on their interest in STEM. While Nolan said that he enjoyed it but did not desire to pursue robotics further, both Ashley and Blake had great experiences with their robotics clubs and said that the clubs were major influences in their decisions to pursue engineering as a career. STEM clubs have demonstrated effectiveness in increasing students' interest in STEM careers (Campbell et al., 2012; Mohd Shahali et al., 2016), whose results are supported by the results of this study. In particular, the qualitative results show the effect that robotics clubs had on some interviewees, matching studies that show the effectiveness of robotics clubs in influencing STEM career interest (Nugent et al., 2010; Ziaeefard et al., 2017). Another form of STEM extracurricular that has extensive support in the literature is the positive effect of STEM camps on STEM self-efficacy (Heiselt, 2014) and career interest (Hammack et al., 2015; Kong et al., 2013; Mohr-Schroeder et al., 2014). This study indicated that camps were among the experiences that were selected least by both the overall sample and STEM students. However, they were viewed positively by 79% of the students who did participate in them. Three interviewees talked about

STEM camps, but none indicated that the camps were very influential in their STEM confidence or interests.

The final two categories of experiences that were selected more by STEM students than non-STEM students involve more general descriptions of students' environments while growing up. The first is students' innate interest in STEM or activities like logic puzzles or mathematics-based games. Each of the interviewees who are pursuing STEM careers explained some form of feeling that they had always been interested in their subject. They all explained that many of their choices in activities began from this initial interest, and that many of the activities served to bolster their interest or help them find their specific areas of interest. The other category deals with family connections to STEM, as STEM students were more likely to say that STEM was a part of family activities and that they felt pressure from family and friends to pursue STEM. Several of the interviewees indicated that family who were in STEM careers were influential to developing their interest. This interest came from watching the family members have success or getting to see them in their place of work. Analysis of the perceptions of learning experiences reveals that there were two experiences that were not selected more but were perceived to be more beneficial by STEM students: talking with family about STEM and doing home science kits. While the science kits are not directly related to family, it is likely that they are often done in homes where the family supports STEM learning. These findings are consistent with other studies which suggest that people with families who demonstrate or discuss their STEM career (Dou et al., 2019; Steenbergen-Hu & Olszewski-Kubilius, 2017; VanMeter-Adams et al., 2014) or lead their children in STEM-related activities (Morris et al., 2019) are more likely to develop interest in STEM careers.

Analysis of the perceptions revealed that while the out-of-school learning experiences were selected less often, they were perceived quite positively. At least 50% of the participants who selected each out-of-school experience except one, playing video games, indicated that the experience improved their confidence or interest in STEM. Likely the most notable statistic from this portion of the survey is the lack of negative perceptions of out-of-school experiences. Of the 312 participants, not a single person indicated that an out-of-school experience had a negative impact on their confidence or interest in STEM. This is likely because students who participate in these experiences have an investment in the activity and have chosen to participate. A study by Allen and Peterman (2019) suggested that students select and enjoy out-of-school STEM experiences because the experiences involve their own individual choice to participate and don't involve pressure to get a grade. While this choice component should be considered, it is still striking that zero negative experiences were recalled. The interviews supported this finding, as no interviewees mentioned negative experiences with out-of-school activities.

SCCT Model

Participants' selection and self-perceptions of the learning experiences provide some insight into how these experiences affect students and their choices. However, the SCCT model posits a more defined pathway between these learning experiences—which provide mastery experiences, vicarious experiences, verbal persuasion, and physiological conditions (Bandura, 1997)—and the constructs that lead to career choices and actions. Lent et al. (1994) state that these learning experiences have an effect on self-efficacy, outcome expectations, and interest, all of which influence students' career goals and actions. In this study, the forty-nine learning experiences listed on the questionnaire were condensed into eleven factors via principal component analysis (PCA). These factors, described in detail in the previous chapter, were then used in a multiple regression analysis as predictors of the participants' self-efficacy, outcome expectations, and interest in mathematics, science, and engineering. Then each of these constructs were used in a logistic regression to predict participants' intent to pursue a STEM career.

Effect of Learning Factors on STEM Self-Efficacy, Outcome Expectations, and Interest

Analysis of the effect of the learning experience factors on the SCCT constructs revealed five factors that were significant positive predictors of self-efficacy, outcome expectations, or interest in mathematics, science, or engineering. Additionally, there were three factors that were significant negative predictors. These factors are discussed beginning with the most positive outcomes, moving toward those with negative outcomes.

Factor 7: Innate Interest and Ability was the most influential predictor of the SCCT constructs. Factor 7 was a significant positive predictor for all three constructs in all three subject areas. This factor had the strongest positive effect on mathematics interest, indicating that full participation in the experiences that are a part of this factor—which would increase the factor by a unit of 1—would increase mathematics interest by 1.20 points on a scale from 1.00 – 5.00 if all other experiences were held constant. This same increase in the predictor would also increase science and engineering interest by 0.96 and 0.95, respectively. Full experience with all of Factor 7 would lead to outcome expectation increases of 1.16 in mathematics, 0.89 in science, and 0.79 in engineering and self-efficacy increases of 1.02 in mathematics, 0.48 in science, and 0.44 in engineering.

These increases align with work by Maltese and Tai (2010) and Maltese et al. (2014), which indicate that an unspecified innate interest or ability is the strongest indicator of STEM career choices. Also, these studies indicate that this innate interest or ability develops early in life, before many students begin making choices about their hobbies, activities, and classes. Schlegel et al. (2019) suggested that early positive feelings and experiences with STEM can help students see STEM careers as a future option. If students' innate interest does affect self-efficacy as indicated in these results, then their increased self-efficacy in the STEM fields will likely cause them to choose tasks related to STEM and see them as challenges that they can master (Pajares & Schunk, 2005). This sets the stage for students to make course selections that are difficult and

STEM-related (Banerjee et al., 2018) and begin the process of STEM career selection (Lent et al., 1986; van Aalderen-Smeets et al., 2019).

Factor 3: Tinkering and Building was a positive predictor for all three constructs in engineering along with mathematics outcome expectations and interest. While factor 7 influenced the largest number of constructs, factor 3 was the strongest predictor in any individual categories, with full participation in all experiences increasing engineering interest by 1.52, self-efficacy by 1.34, and outcome expectations by 1.28. Analysis of the interviews also revealed that only the two engineering students mentioned participation in activities in this category. Burt and Johnson (2018) gave examples in their study of students who attributed some of their ability and belief in STEM abilities to early experiences like building with LEGOs. It also matches the results of Maltese et al. (2014) who suggested that tinkering and building were significant for STEM career choices. These types of building, tinkering, and construction experiences are strongly correlated with engineering self-efficacy specifically, and may provide a gateway to the development of the types of thinking and problem-solving associated with engineering. Often, one of the major steps in getting students interested in engineering is helping them see the connections between their abilities and the careers themselves (Baran et al., 2019). Since this factor is strongly associated with the constructs in the engineering domain, it is possible that many engineering-oriented students responded positively to the questions regarding mathematics in their future careers and lives as well.

Factor 4: STEM Extracurriculars was a positive predictor for engineering outcome expectations and interest and mathematics interest. Participation in these activities represented a 0.55 increase in engineering outcome expectations, a 0.60 increase in engineering interest, and a 0.55 increase in mathematics interest. Many camps and after school programs focus not only on STEM activities, but on career opportunities as well (Roberts et al., 2018). Students who attend these experiences may have a clearer idea of the types of career opportunities available and what types of skills might be necessary to be successful in those careers, which may describe why these experiences affect interest and outcome expectations but not self-efficacy.

Factor 8: Careers and Future was a positive predictor of science self-efficacy and interest and engineering interest. Participation in all these activities represented a 0.56 increase in engineering interest, 0.55 increase in science interest, and 0.33 increase in science self-efficacy. This factor included discussion of STEM careers, interactions with STEM professionals, and emphasis on future STEM studies. The two interviewees who are pursuing careers in life science fields indicated that experience with STEM professionals and in job shadowing experiences were extremely valuable in developing both their confidence and interests in continuing a science track. A study by Mohd Shahali et al. (2019) emphasized the value of interactions with STEM professionals for understanding the tools of scientists, which could explain an increase in a student's belief about their ability to do science.

Factor 10: Family Influence was a positive predictor for only one construct, engineering self-efficacy. Earlier results from this study also demonstrated that students perceived family influence to have a positive influence on their confidence and interests in STEM. While several studies indicate that family influence can have a positive effect on how students view themselves in STEM (Dabney et al., 2013; Dou et al., 2019; Morris et al., 2019), it is interesting that this factor was a predictor of only engineering self-efficacy in this study and not mathematics or science. These findings merit more research into the role of family influence in all of the STEM subjects.

Both Factor 1: Classroom Instruction and Factor 9: STEM Media were small negative predictors for mathematics interest. Factor 2: Nature and Community was a negative predictor for engineering outcome expectations and interest and mathematics interest. All these factors were very small predictors except for factor 2 on engineering interest, which indicated that participation in the nature and community activities would lower engineering interest by 1.02. While the researcher may speculate on the causes of these negative effects, the study and literature provided no indications for why these factors had negative effects.

The findings here are interesting because the literature provides examples of how measures of the STEM constructs are increased with tinkering and building (Maltese et al., 2014), STEM camps and programs (Anderson & Gilbride, 2003), interaction with STEM professionals (Struyf et al., 2019), classroom instruction (Petersen, 2014), nature and outdoors (Allen & Peterman, 2019; VanMeter-Adams et al., 2014), and STEM media (Dou et al., 2019). However, all these studies look at interest in STEM generally, without breaking it down into the subjects that make up STEM. This study has similar results to other studies of STEM interest, but by breaking it down into parts, allows for individual sets of activities and experiences to come through more clearly. For example, tinkering and building are associated strongly with all three of the SCCT constructs in engineering, and with mathematics somewhat, but not with any of the constructs related to science. Nature and community experiences were negatively predictive of engineering and mathematics interests, but not so with science. STEM media, also a good predictor of STEM interest according to Dou et al. (2019), was a negative predictor of mathematics interest in this study. These findings suggest that more work needs to be done when looking at the types of experiences that are valuable in developing a future STEM workforce, and ensuring that activities are not overly promoted or dismissed because they are not differentiated for people who may pursue a variety of STEM career paths.

Construct Effect on Goals

Social cognitive career theory states that self-efficacy, outcome expectations, and interest all have an impact on the goals and decisions that students make regarding their future careers. Lent and Brown (2006) emphasize that measurements of these constructs should be domain-specific, and since mathematics, science, and engineering beliefs may be different for different people, this study examines each of these subjects for all constructs rather than one STEM instrument.

The first model examined whether intent to pursue a STEM degree, which this study used as an indicator of STEM career goals, could be predicted by mathematics, science, or engineering self-efficacy. The results found that mathematics self-efficacy was a positive predictor of STEM career intent, which is consistent with studies by Betz and Hackett (1983) and Hackett and Betz (1989). Science self-efficacy was an even stronger positive predictor of STEM career intent. Luzzo et al. (1999) demonstrated that math and science self-efficacy had an effect on STEM career aspirations, though the math and science scales were combined rather than separate as in this study.

The second model examined whether intent to pursue a STEM degree could be predicted by mathematics, science, or engineering outcome expectations. Only the science outcome expectations scale was a positive predictor of STEM career intent, though with an odds ratio of 9.56, it was the construct that had the greatest effect on this intent. Hazari et al. (2010) suggest that discussions of future careers and their benefits can help students make sense of what being a mathematician, scientist, or engineer might be like and dispel stereotypes. While engineering outcome expectations had a lower predictive value and mathematics outcome expectations had a very low predictive value, the high odds of science outcome expectations on STEM career intent suggest that discussions of science careers were likely happening more often or more effectively than discussions of other types of STEM careers. Mathematics is often promoted as important for everyday life and known to play a role in many STEM careers, but is not always pointed to as a valuable outcome for study. Engineering is becoming more ubiquitous over time as engineering standards are implemented in P-12 classrooms, but many of the current students have not had a long history of engineering career discussions. Science careers and the benefits of being a scientist, while not an integral part of many curricular plans, are likely discussed more often in classrooms explicitly.

The third model examined whether intent to pursue a STEM degree could be predicted by mathematics, science, or engineering interest. Science and engineering interests were both significant predictors of intent to pursue a STEM degree. Science interest again held the highest odds ratio of the subjects in this study. Mathematics interest did not meet the significance threshold at $p < .05$, but did have a value of $p = .054$, and its odds ratio of 1.50 is slightly higher than the engineering interest odds ratio of 1.45. The idea that interest is closely related to STEM career intent is not surprising, as many studies have examined this effect (Halim et al., 2018; Maltese et al., 2014; Maltese & Tai, 2010; Petersen, 2014). Interest in one or more of these subject areas can provide the skills and experiences that are necessary to enjoy and be successful in a STEM career.

The combination of models provides insight into how students develop a goal to pursue a career in STEM. All three science constructs were significant predictors of STEM career intent. The breakdown of majors for participants shows that science majors make up the largest category of responses, though engineering majors are very close behind.

On reflection of the results the researcher identified several patterns. First, mathematics and science self-efficacy describe what participants believe they can be successful at in future tasks. While belief in engineering abilities may be important for success in the engineering field, mathematics and science are generally believed to be important in a large portion of STEM fields. This is consistent with multiple studies that point to math self-efficacy (Betz & Hackett, 1986; Hackett & Betz, 1989; Hall & Ponton, 2005; Lent et al., 1991; Watt, 2006) and science self-efficacy (Maltese & Tai, 2011; Sadler et al., 2014) as having an effect on STEM career choice.

Furthermore, several of these studies point to math and science self-efficacy being a driver for pursuit of challenging classes and viewing STEM careers as challenging and rewarding.

Another finding is that science and engineering interests, and to a lesser extent mathematics interests, are vital components in the selection of a STEM career. STEM interests are well-studied in the literature as exhibited in this paper thus far, but few studies look at the subject areas separately. This study examines each subject area, and finds that science interest is paramount, but engineering interest can also play a role in the decision to pursue a STEM career. These findings suggest that intent to pursue a STEM career is most strongly predicted by students' beliefs about their ability to succeed in science and mathematics, their expectations about the outcome of using science in their career and life, and their interest in science and engineering.

Implications

Implications for Practice

The results of this study suggest several implications for STEM teachers as they work to prepare students to succeed in their subjects and be prepared for the STEM workforce. First, the results suggest that many teachers are still using a variety of direct-instruction approaches to STEM education. These methods can be useful, but alone they fail to meet the requirements for teaching practices set forth by standards such as the *Next Generation Science Standards* (NGSS Lead States, 2013) and the *Principles and Standards for School Mathematics* (National Council for Teachers of Mathematics, 2016). Many students also do not see these methods as beneficial in the development of their STEM self-efficacy. The results of this study indicate that techniques such as the use of worksheets and rote memorization are more harmful than beneficial. Teachers should consider how these instructional techniques are used in their classrooms, not only for students' understanding of concepts in class but also for their effects on students' self-efficacy in STEM.

The results also indicate that hands-on activities, projects, field trips, and active demonstrations are valuable to students and are perceived as useful to the development of STEM self-efficacy and interests. Memorable experiences elicited in the interviews were often hands-on activities and projects that the students found interesting, and the activities mentioned were almost always in the fields of the interviewees' interests. Teachers should incorporate activities in these areas when possible to help students build their confidence and interests in the subject area. However, students in any primary or secondary STEM classroom will likely be headed to a variety of fields of study. Therefore, teachers should provide experiences for a range of interests or collaborate with others in their school to ensure that students with different interests are exposed to activities in their field.

A third implication for teachers is the revelation that STEM students were exposed to experiences that were focused on STEM careers or future study in STEM more often than non-STEM students. Mohd-Shahali et al (2019) found that experience with STEM professionals was important for increasing students' awareness of and identity in STEM careers. This study indicated that these experiences were among the least utilized, but also among the most important for those students who did choose a STEM career path. Schools and teachers should make a focus on careers and an emphasis on the benefits of further study a priority to help students have access to the information and skills they need to pursue a career in STEM.

Results from the survey indicate that good classroom performance is effective in improving students' self-efficacy and encouraging them to pursue STEM further. The interviews corroborate this finding, and studies of undergraduates considering STEM majors find similar results (Bonous-Hammarth, 2000; Dawes et al., 2015). However, analysis of the interviews also reveals that poor performance in a STEM class may be the reason some students stop considering STEM study or careers. Teachers and schools should examine how to encourage those students who are doing well, while keeping those who are performing poorly engaged and interested as they make improvements academically.

Implications for Policy

This study indicates that there are several areas where community leaders and school administrators can make improvements to encourage students to continue study in STEM, build their confidence, or gain an interest in pursuing a STEM career. First, schools can provide access to the types of coursework that helps students succeed in STEM. Survey and interview data suggest that access to advanced or specialized courses in secondary schools can provide students the opportunity to explore their abilities and interests in STEM. Interviewees who had access to this type of coursework in their schools were grateful for it and students who did not have this access wanted the opportunity. One option for schools is a partnership with local universities and technical schools to provide advanced and specialized courses and encourage their students to utilize those resources. Rural schools may find resources such as these difficult to access (Lavalley, 2018), so it will be important to develop ways to help these schools meet the needs of their students.

A second implication for schools and communities is the need to plan for family involvement. This study revealed that students who had close family contribution to their STEM experience were more likely to feel confident in their abilities and pursue a STEM career. The desire and knowledge to incorporate STEM into family talk and activities may not be available to all families, so efforts could be made to support families in this endeavor. Furthermore, participation in out-of-school activities often happens with the encouragement and support of the family. This study revealed that STEM out-of-school experiences are not as common as those that happen in school, but that they are perceived positively and have little to no negative effect. Efforts should be made to provide more students with the opportunity to participate in these types of learning experiences by making the experiences known and providing access monetarily or with transportation. Furthermore, students should be encouraged to participate in STEM clubs and groups. School administrators may be able to provide these opportunities by making those groups part of the school day instead of outside of school or providing transportation to those meetings.

Implications for Research

This study adds to the literature on SCCT and learning experiences in STEM, but also points to opportunities for future research possibilities. First, this study provides a basis for looking at SCCT through the lens of mathematics, science, and engineering rather than a more general definition of STEM. There are many studies that look at constructs such as STEM self-efficacy or science interests, but this study examines how learning experiences affect the constructs in different subjects, and in turn how those constructs affect STEM career intentions. The study also compiled learning experiences from the results of multiple studies as a starting point for collecting quantitative data (Burt & Johnson, 2018; Dou et al., 2019; Maltese et al., 2014; Maltese & Tai, 2010, 2011). The combination of quantitative and qualitative data provides an updated, larger set of learning experiences that are useful in the development of self-efficacy, outcome expectations, and interest.

There is more work that needs to be done with STEM learning experiences and SCCT. The results of this study suggest several recommendations for future research:

- Not all STEM subjects are alike, and students in engineering, life sciences, and mathematics may produce different results in SCCT constructs. Work needs to be done to separate the STEM fields and examine their differences.
- Learning experiences should be examined for each of these STEM categories and compared to determine which experiences are important for each group, what sparks interest, and what encourages students to continue studying that subject.

- STEM career intentions and goals appear to be affected differently by the constructs in different subjects. More research needs to be done looking at how these constructs affect STEM goals.
- Studies should examine whether certain learning experiences are helping students pursue more STEM classes or if they are turning them away.
- Research should be done to understand the role of STEM coursework in high school, and whether students are making the choice to pursue these courses because of prior interest and self-efficacy, or if these courses are the source of the interest and self-efficacy.

Limitations

This survey portion of this study was conducted with a sample of 312 students from a large university with over 20,000 students. When soliciting emails from the university, the Institutional Research and Analytics department only allowed the researcher access to 5,000 emails, limiting the number of students available for sampling. The sample demographics were similar to the population in terms of racial makeup. However, considerably more females participated than males and the percentage of STEM students in the sample was about 20% higher than that of the university. Thus, the sample may not have provided data that is representative of the university and should not be generalized to all students.

The questionnaire was designed based off previous research on learning experiences in STEM, and care was taken to avoid bias whenever possible. However, the questions were all specific to learning experiences in STEM. Because of this, STEM students were more likely to complete the questionnaire and the participants' responses may have been skewed based on their initial views about STEM. Furthermore, the results are dependent on the participants recalling experiences accurately and responding to questions truthfully.

The questions on the questionnaire asked participants to choose learning experiences from a list, and while the list was compiled from a series of other studies, it was not exhaustive. Even though there was an option to input additional experiences, most participants did not choose to add anything to the list. Responses about the participants' perceptions were limited to a single positive, neutral, or negative response. However, participants may have had a positive learning experience in one STEM class but a negative experience in another and had to choose which perception to indicate. This possible discrepancy in their choice may have changed the results on these perceptions.

Finally, this research project was conducted in the midst of the COVID-19 pandemic when many students were attending classes partially or wholly online. Many students were not on campus to see the flyers that were posted and those that were solicited via email may have been less willing to participate due to online fatigue. This may have decreased the total number of students who chose to participate in the survey.

Conclusion

The STEM workforce of the future will need qualified people who are interested in developing new technologies and solving new problems. As schools strive to nurture students who have the skills and knowledge necessary to succeed in an ever-changing environment, there is a need to understand which experiences drive this development. This study found in- and out-of-school experiences that are important for preparing people who are capable and interested in STEM careers. Students perceived hands-on, relevant activities to be valuable to the growth of their interests and confidence in STEM. Moreover, students who are pursuing a STEM career indicated they had more opportunities to work with STEM professionals and take part in career-focused activities in school. Teachers should strive to incorporate these meaningful learning experiences and explicitly integrate career-focused activities into the STEM classroom. Findings from this study also suggest the educational community should strive to make out-of-school

STEM experiences more prevalent and accessible to students. By understanding how these various experiences impact students' attitudes toward STEM and their desire to pursue a STEM career, educators and policymakers can effectively implement strategies that prepare students for a greater impact on their world.

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APPENDICES

APPENDIX A

Institutional Review Board Approval

Approval of Exempt IRB Application IRB-20-385

IRB Office <irb@okstate.edu>

Tue 9/1/2020 2:52 PM

To: Gossen, Drew <drew.gossen@okstate.edu>; Gossen, Drew <drew.gossen@okstate.edu>; Ivey, Toni <toni.ivey@okstate.edu>

Dear Drew Gossen,

The Oklahoma State University Institutional Review Board (IRB) has approved the following application:

Application Number: IRB-20-385
PI: Drew Gossen
Title: The Effect of STEM Learning Experiences on Undergraduates' Self-Efficacy, Outcome Expectations, Interests, and Goals: A Mixed-Methods Study
Review Level: Exempt

You will find a copy of your Approval Letter in IRBManager. Click IRB - Initial Submission to go directly to the event page. Please click attachments in the upper left of the screen. The approval letter is under "Generated Docs." Stamped recruitment and consent documents can also be found in this location under "Attachments". Only the approved versions of these documents may be used during the conduct of your research.

As Principal Investigator, it is your responsibility to do the following:

- Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted for IRB approval before implementation.
- Submit a request for continuation if the study extends beyond the approval period.
- Report any adverse events to the IRB Chair within 5 days. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
- Notify the IRB office when your research project is complete by submitting a closure form via IRBManager.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB office at 405-744-3377 or irb@okstate.edu.

Best of luck with your research,

Sincerely,

Dawnett Watkins, CIP

Oklahoma State University
Institutional Review Board
Office of University Research Compliance
223 Scott Hall, Stillwater, OK 74078
Website: https://irb.okstate.edu/
Ph: 405-744-3377 | Fax: 405-744-4335| irb@okstate.edu

APPENDIX B

Online Questionnaire

Effect of STEM Learning Experiences on Undergraduates' Self-Efficacy, Outcome Expectations, Interests, and Goals

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Start of Block: Demographic Information

Q3 CWID

____

Q4 Classification

- ◯ Freshman
- ◯ Sophomore
- ◯ Junior
- ◯ Senior

Q5 Gender

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ Prefer not to respond

Q6 Race

- ○ American Indian or Alaska Native
- ○ Asian
- ○ Black or African American
- ○ Hispanic or Latino
- ○ Native Hawaiian or Other Pacific Islander
- ○ White
- ○ Other ____
- ○ Prefer not to respond

Q7 Ethnicity

- ○ Hispanic or Latino
- ○ Not Hispanic or Latino
- ○ Prefer not to respond

Q8 Highest education attained by father

- Less than 8th grade
- Completed 8th grade
- Completed high school
- Some college
- Completed associate's degree
- Completed bachelor's degree
- Completed graduate/professional degree
- Prefer not to respond

Q9 Highest education attained by mother

- Less than 8th grade
- Completed 8th grade
- Completed high school
- Some college
- Completed associate's degree
- Completed bachelor's degree
- Completed graduate/professional degree
- Prefer not to respond

Q10 Your major (on a computer, use Ctrl (PC) or Command (Mac) to select multiple options):

- ▢ Accounting
- ▢ Aerospace Administration and Operations
- ▢ Aerospace Engineering
- ▢ Agribusiness
- ▢ Agricultural Communications
- ▢ Agricultural Economics
- ▢ Agricultural Education
- ▢ Agricultural Leadership
- ▢ American Studies
- ▢ Animal Science
- ▢ Apparel Design and Production
- ▢ Applied Exercise Science
- ▢ Architectural Engineering
- ▢ Architecture
- ▢ Art History
- ▢ Arts Administration

- [ ] Biochemistry
- [ ] Biochemistry and Molecular Biology
- [ ] Biology
- [ ] Biosystems Engineering
- [ ] Chemical Engineering
- [ ] Chemistry
- [ ] Child and Family Services
- [ ] Civil Engineering
- [ ] Communication Sciences and Disorders
- [ ] Computer Engineering
- [ ] Computer Science
- [ ] Construction Engineering Technology
- [ ] Early Childhood Education
- [ ] Economics
- [ ] Electrical Engineering
- [ ] Elementary Education

☐ English

☐ Entomology

☐ Entrepreneurship

☐ Environmental Science

☐ Family and Consumer Sciences Education

☐ Finance

☐ Fire Protection and Safety Engineering Technology

☐ Food Science

☐ French

☐ General Business

☐ Geography

☐ Geology

☐ Geospatial Information Science

☐ German

☐ Global Studies

☐ Graphic Design

- [ ] Health Education and Promotion
- [ ] History
- [ ] Horticulture
- [ ] Hospitality and Tourism Management
- [ ] Industrial Engineering and Management
- [ ] Interior Design
- [ ] International Business
- [ ] Landscape Architecture
- [ ] Landscape Management
- [ ] Management
- [ ] Management Information Systems
- [ ] Marketing
- [ ] Mathematics
- [ ] Mechanical Engineering
- [ ] Mechanical Engineering Technology
- [ ] Medicinal and Biophysical Chemistry

- [ ] Merchandising
- [ ] Microbiology and Molecular Genetics
- [ ] Multidisciplinary Studies
- [ ] Multimedia Journalism
- [ ] Music
- [ ] Music Education
- [ ] Music Industry
- [ ] Natural Resource Ecology and Management
- [ ] Nutritional Sciences
- [ ] Philosophy
- [ ] Physical Education
- [ ] Physics
- [ ] Physiology
- [ ] Plant Biology
- [ ] Plant and Soil Sciences
- [ ] Political Science

- [ ] Psychology
- [ ] Recreation Management and Recreational Therapy
- [ ] Secondary Education
- [ ] Sociology
- [ ] Spanish
- [ ] Sports Media
- [ ] Statistics
- [ ] Strategic Communication
- [ ] Studio Art
- [ ] Theatre
- [ ] Zoology
- [ ] Undeclared

Q11 Do you intend to pursue a career in a field related to science, technology, engineering, or mathematics?

- ○ Yes
- ○ No
- ○ Unsure

End of Block: Demographic Information

Start of Block: High School Course List

Q12 **Please check all of the courses that you took in high school or junior high.**

Q13 **Mathematics**

- ☐ Algebra 1
- ☐ Algebra 2
- ☐ Algebra 3
- ☐ Other algebra course (other than college algebra)
- ☐ Geometry
- ☐ Trigonometry
- ☐ Pre-Calculus
- ☐ Calculus (not AP)
- ☐ AP Calculus AB
- ☐ AP Calculus BC
- ☐ Statistics and Probability (not AP)
- ☐ AP Statistics
- ☐ Mathematics of Finance
- ☐ Consumer Mathematics
- ☐ Applied Math
- ☐ College Algebra

- [ ] Other ____

Q14 **Computer Science and Technology**

- [ ] Computer Science
- [ ] Computer Applications
- [ ] Web Design
- [ ] Publishing
- [ ] Any programming course
- [ ] Any auto mechanics or engines course
- [ ] Any wood or metal course
- [ ] Any construction, materials, or manufacturing course
- [ ] Communications
- [ ] Drafting
- [ ] Electronics
- [ ] Technology education
- [ ] Photography
- [ ] Other ____

Q15 **Science**

- ☐ Physical Science
- ☐ Biology 1
- ☐ Honors biology 1
- ☐ General biology 2 (not AP)
- ☐ Other biology (not AP)
- ☐ AP Biology
- ☐ Chemistry 1
- ☐ Chemistry 2 (not AP)
- ☐ AP Chemistry
- ☐ Physics 1 (not AP)
- ☐ Physics 2 (not AP)
- ☐ AP Physics 1
- ☐ AP Physics 2
- ☐ AP Physics C
- ☐ Earth science
- ☐ Environmental science

- [ ] AP Environmental science
- [ ] Anatomy
- [ ] Physiology
- [ ] Zoology
- [ ] Botany
- [ ] Ecology
- [ ] Forensic science
- [ ] Life science
- [ ] Astronomy
- [ ] Geology
- [ ] Meteorology
- [ ] Other ____

Q16 **Engineering and Integrated STEM**

- ▢ Engineering design
- ▢ Principles of engineering
- ▢ Any applied engineering course (aerospace, civil, architecture, etc).
- ▢ STEM or integrated STEM
- ▢ Other ____

Display This Question:

If Engineering and Integrated STEM = Any applied engineering course (aerospace, civil, architecture, etc).

Q16b How many applied engineering courses (aerospace, civil, architecture, etc) did you take?

____

Display This Question:

If Engineering and Integrated STEM = STEM or integrated STEM

Q16c How many STEM and/or integrated STEM courses did you take?

____

Carry Forward Unselected Choices from "Mathematics"

X→

Q13b Select all **mathematics** courses (if any) that you would have taken, but your school did not offer.

- ☐ Algebra 1
- ☐ Algebra 2
- ☐ Algebra 3
- ☐ Other algebra course (other than college algebra)
- ☐ Geometry
- ☐ Trigonometry
- ☐ Pre-Calculus
- ☐ Calculus (not AP)
- ☐ AP Calculus AB
- ☐ AP Calculus BC
- ☐ Statistics and Probability (not AP)
- ☐ AP Statistics
- ☐ Mathematics of Finance
- ☐ Consumer Mathematics
- ☐ Applied Math
- ☐ College Algebra

☐ Other ____

Carry Forward Unselected Choices from "Computer Science and Technology"

Q14b Select all **computer science/technology** courses (if any) that you would have taken, but your school did not offer.

- ☐ Computer Science
- ☐ Computer Applications
- ☐ Web Design
- ☐ Publishing
- ☐ Any programming course
- ☐ Any auto mechanics or engines course
- ☐ Any wood or metal course
- ☐ Any construction, materials, or manufacturing course
- ☐ Communications
- ☐ Drafting
- ☐ Electronics
- ☐ Technology education
- ☐ Photography
- ☐ Other ____

Carry Forward Unselected Choices from "Science"

Q15b Select all **science** courses (if any) that you would have taken, but your school did not offer.

- ☐ Physical Science
- ☐ Biology 1
- ☐ Honors biology 1
- ☐ General biology 2 (not AP)
- ☐ Other biology (not AP)
- ☐ AP Biology
- ☐ Chemistry 1
- ☐ Chemistry 2 (not AP)
- ☐ AP Chemistry
- ☐ Physics 1 (not AP)
- ☐ Physics 2 (not AP)
- ☐ AP Physics 1
- ☐ AP Physics 2
- ☐ AP Physics C
- ☐ Earth science
- ☐ Environmental science

- ☐ AP Environmental science
- ☐ Anatomy
- ☐ Physiology
- ☐ Zoology
- ☐ Botany
- ☐ Ecology
- ☐ Forensic science
- ☐ Life science
- ☐ Astronomy
- ☐ Geology
- ☐ Meteorology
- ☐ Other ____

Carry Forward Unselected Choices from "Engineering and Integrated STEM"

Q16b Select all **engineering/STEM** courses (if any) that you would have taken, but your school did not offer.

- ☐ Engineering design
- ☐ Principles of engineering
- ☐ Any applied engineering course (aerospace, civil, architecture, etc).
- ☐ STEM or integrated STEM
- ☐ Other ____

End of Block: High School Course List

Start of Block: Learning Experiences

Q18 This list contains **learning experiences that you may have had while in a STEM course** in grades K-12. Indicate which of the items you experienced in these courses.

- ☐ Lectures by the teacher
- ☐ Science demonstrations by the teacher
- ☐ Use of computers for class assignments/projects (other than word processing)
- ☐ Creating models by hand or with a 3D printer
- ☐ Projects
- ☐ Paper assignments (worksheets, etc)
- ☐ Lab experiments designed by the student
- ☐ Lab experiments directed step-by-step
- ☐ Hands-on activities
- ☐ Cooperative learning or group discussions
- ☐ Field trips or other enrichment experiences
- ☐ Speakers from professional STEM fields
- ☐ Discussion of STEM careers
- ☐ Science competition/science fair
- ☐ Class content that was relevant to me
- ☐ Took a class with an emphasis on further study in STEM

- [ ] Took a class with an emphasis on learning/memorizing facts
- [ ] Took a class with an emphasis on problem solving
- [ ] I performed well in a STEM class
- [ ] Other ____

Q19 Think about the **most influential teachers** you had in STEM courses (good or bad) and indicate whether these characteristics affected your confidence in your ability to succeed in STEM.

- [ ] Teacher encouragement
- [ ] Teacher comments (about ability, future, careers, etc)
- [ ] Teacher personality
- [ ] Teacher style of instruction
- [ ] Other ____

Q20 This list contains **learning experiences you may have had outside of school** throughout your life. Indicate which of the items you experienced or participated in.

- ☐ Tinkering with electronics
- ☐ Taking apart and/or fixing toys
- ☐ Building models/legos
- ☐ Construction/measuring/building
- ☐ Fixing mechanical objects/engines/cars
- ☐ Playing computer games/video games
- ☐ Writing computer programs or designing web pages
- ☐ Conducting experiments at home/chemsitry sets/science kits
- ☐ Taking care of or training animals
- ☐ Planting, taking care of, observing plants
- ☐ Observing or studying stars or other astronomical objects
- ☐ Playing or spending time outdoors
- ☐ Watching movies, TV shows, or videos about STEM or science fiction
- ☐ Reading about STEM or science fiction
- ☐ Family member or close friend talking about STEM
- ☐ STEM was a part of family activities

- [ ] Pressure from family or peers to pursue STEM
- [ ] Participation in STEM clubs or groups
- [ ] STEM camp
- [ ] After-school STEM program
- [ ] Visit to a zoo or aquarium
- [ ] Visit to a museum or other learning center
- [ ] Visit to a state/national park
- [ ] Volunteer/work related experience
- [ ] Having interest in mathematical problems or logic games
- [ ] I have always been interested in science, math, and/or engineering
- [ ] Other ____

Carry Forward Selected Choices from "This list contains learning experiences that you may have had while in a STEM course in grades K-12. Indicate which of the items you experienced in these courses."

X→

18b Select whether each experience or factor made you: **More interested and/or confident in your ability to succeed in STEM Had no effect on your STEM interests or confidence Less interested and/or confident in your ability to succeed in STEM**	More interested/confident	No effect	Less interested/confident
Lectures by the teacher	○	○	○
Science demonstrations by the teacher	○	○	○
Use of computers for class assignments/projects (other than word processing)	○	○	○
Creating models by hand or with a 3D printer	○	○	○
Projects	○	○	○
Paper assignments (worksheets, etc)	○	○	○
Lab experiments designed by the student	○	○	○
Lab experiments directed step-by-step	○	○	○
Hands-on activities	○	○	○

Cooperative learning or group discussions	○	○	○
Field trips or other enrichment experiences	○	○	○
Speakers from professional STEM fields	○	○	○
Discussion of STEM careers	○	○	○
Science competition/science fair	○	○	○
Class content that was relevant to me	○	○	○
Took a class with an emphasis on further study in STEM	○	○	○
Took a class with an emphasis on learning/memorizing facts	○	○	○
Took a class with an emphasis on problem solving	○	○	○
I performed well in a STEM class	○	○	○
Other	○	○	○

Carry Forward Selected Choices from "Think about the most influential teachers you had in STEM courses (good or bad) and indicate whether these characteristics affected your confidence in your ability to succeed in STEM."

X→

Q19b Teacher Factors

	More interested/confident	No effect	Less interested/confident
Teacher encouragement	○	○	○
Teacher comments (about ability, future, careers, etc)	○	○	○
Teacher personality	○	○	○
Teacher style of instruction	○	○	○
Other	○	○	○

Carry Forward Selected Choices from "This list contains learning experiences you may have had outside of school throughout your life. Indicate which of the items you experienced or participated in."

X→

Q20b Out of School Factors	More interested/confident	No effect	Less interested/confident
Tinkering with electronics	○	○	○
Taking apart and/or fixing toys	○	○	○
Building models/legos	○	○	○
Construction/measuring/building	○	○	○
Fixing mechanical objects/engines/cars	○	○	○
Playing computer games/video games	○	○	○
Writing computer programs or designing web pages	○	○	○
Conducting experiments at home/chemsitry sets/science kits	○	○	○
Taking care of or training animals	○	○	○
Planting, taking care of, observing plants	○	○	○
Observing or studying stars or other astronomical objects	○	○	○
Playing or spending time outdoors	○	○	○
Watching movies, TV shows, or videos about STEM or science fiction	○	○	○
Reading about STEM or science fiction	○	○	○
Family member or close friend talking about STEM	○	○	○

STEM was a part of family activities	○	○	○
Pressure from family or peers to pursue STEM	○	○	○
Participation in STEM clubs or groups	○	○	○
STEM camp	○	○	○
After-school STEM program	○	○	○
Visit to a zoo or aquarium	○	○	○
Visit to a museum or other learning center	○	○	○
Visit to a state/national park	○	○	○
Volunteer/work related experience	○	○	○
Having interest in mathematical problems or logic games	○	○	○
I have always been interested in science, math, and/or engineering	○	○	○
Other	○	○	○

End of Block: Learning Experiences

Start of Block: Interests and Attitudes

Q58 Answer each of the following questions, responding about mathematics, science, *and* engineering.

Q21 I'm certain I can master the skills taught in ________ classes.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q22 I'll need ___________ for my future work.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q23 I study __________ because I know how useful it is.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

!24 I major in an area needed for a career that uses ___________.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q25 I'm certain I can figure out how to do the most difficult class work in ____________.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q26 Knowing ____________ will help me earn a living.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q27 ____________ is a worthwhile and necessary subject.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q28 I will graduate with a college degree in a major area needed for a career that uses ____________.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q29 I can do almost all the work in ____________ class if I don't give up.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q30 I will need a firm mastery of ____________ for my future work.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q31 I will use ____________ in many ways as an adult.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q32 I will have a successful professional career and make substantial ____________ contributions.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q33 Even if the work is hard in ____________, I can learn it.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q34 ____________ is of no relevance to my life.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q35 ____________ will not be important to me in my life's work.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q36 I see ____________ as a subject I will rarely use in daily life as an adult.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q37 I will get a job in a ____________-related area.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q38 I can do even the hardest work in a ____________ class if I try.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q39 Taking ____________ is a waste of time.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q40 In terms of my adult life it is not important for me to do well in ____________.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q41 I expect to have little use of ____________ when I get out of school.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

Q42 Some day when I tell others about my career, they will respect me for doing ____________ work.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
mathematics	○	○	○	○	○
science	○	○	○	○	○
engineering	○	○	○	○	○

End of Block: Interests and Attitudes

Start of Block: Block 7

Q43 Would you be interested in participating in a follow-up interview, which will be completed via online meeting platform Zoom? Nine participants will be selected for the interview and each person who completes the interview process will receive a $10 Amazon gift card. You will be asked to enter your contact information.

○ Yes

○ No

Q44 Thank you for your participation in this research study. If you would like to be entered in the drawing for a $50 Visa gift card please click yes below. You will be asked to enter your contact information.

○ Yes

○ No

Display This Question:

If Would you be interested in participating in a follow-up interview, which will be completed via on... = Yes

Or Thank you for your participation in this research study. If you would like to be entered in the d... = Yes

Q45 Name

____

Display This Question:

If Would you be interested in participating in a follow-up interview, which will be completed via on... = Yes

Or Thank you for your participation in this research study. If you would like to be entered in the d... = Yes

Q46 Email address

____

APPENDIX C

Interview Protocol

1. When did you first become interested in (your current major)?
2. Why are you still interested in (your current major)?
3. Tell me about a time where you felt successful in STEM.
4. Tell me about a time where you did not feel successful in STEM?
5. What are some benefits of having a STEM career?
6. What are some drawbacks to having a STEM career?
7. What activities did you do prior to college that affected your interests and/or confidence in your abilities in STEM?
    a. What activities did you do in school?
    b. What activities did you do outside of school?
8. Think about a STEM teacher or teachers that influenced you (positively or negatively). What made them influential to you?
9. Tell me about your family and their influence on your interests and/or confidence in your abilities in STEM.
10. Have you experienced any obstacles to your STEM plans?

APPENDIX D

Interview Transcripts

Regina

Interviewer: Hello.

Regina: Hello.

How are you, I'm good, how are you

Interviewer: Doing well thank you so much for agreeing to do this interview today.

For being a part of this.Okay, well then let's go ahead and get started. So what I want to know, first of all, and So I know you fill out some information in the questionnaire, but the way I select things lead to some anonymity. So I actually don't have any data, you know, directly on you. So tell me a little bit about just what your current Year is what we are. You are in college and what your major is

Regina: Okay, so I'm a freshman. This year, and I'm taking I'm a major and global studies, I'm eventually going to double major with education. Because I want to do international teaching And

Interviewer: You have any like field of teaching you want to do like grade level or subject area.

Regina: I'd rather do some sort of, um, I like science. And I like history. I'd rather do a science or history.

And high school

Interviewer: Cool. Very good. So I was a high school science teacher for a long time and in my book I like teaching is one of the greatest job in the world.

Regina: love science, like I would love to teach environmental science.

Interviewer: Very cool. That's awesome. Well, I'm glad to hear that. So a lot of what I want to do is just kind of talk to you about Some of like the things that kind of led you to this point in your life. Right. So my first question is, what, what made you first interested in pursuing kind of that map.

Regina: Well, I've always loved kids and everything and I worked with kids. Basically my entire high school career and I worked at Rejoice Christian schools and also In the aftercare department with the little kids and I love little kids. I just, I don't want to do it every day to where I have to constantly entertain them with because at least with high school kids, they can entertain themselves.

But I've wanted to help. I want to help kids who can't usually get the help that they need on their own. So that's where why I am where I am and I love everything globally. I've always wanted to travel and with international teaching, I could take contracts like year long contracts and go teach English or something else in a different place. And, you know, always come back.

Interviewer: Um, so is there anything in particular that happened that's helped you kind of maintain that interest as you made the transition to college or or any any you know things activities you participate, other than, you know, the job you haven at Rejoice

Regina: Well, A lot of it is to. I'm the eldest cousin, out of all of it. So, you know, I'm 20 all my siblings and cousins are younger than me. So I've always, you know, had to be that second parent, you know, things like that.

Regina: And my mom's been a single mom, even when she was married to my step dad. She was basically a single mom, so that's a lot of it to, you know, I had to grow up fast but I Love being that Nurturing figure, per se, and I get involved a lot I volunteer at the American Red Cross I volunteer at St. John's will also and with Phil breath Art Museum And I always help when we have them things with kids going on, but I just I love being able to help I love being able to give assistance, where it's needed, or even when it's not needed. That's part of me wanting to be a teacher to thing I just want to help anyone. I can

Interviewer: Very cool. Um, okay. So thinking about since this is focused really on your experiences in science, technology, engineering, And math. Tell me about a time where times where you felt successful in them.

Regina: So I was very involved with science fair and the first couple years of high school, and I loved, My area was microbiology and biochemistry, I am utterly fascinated with my with microorganisms and things like it's so much fun. And I actually got second place at state and In my category and I was going to do a different I was going to do a continuation on it but I ended up moving schools and they didn't offer it. But that's why I felt so successful because I Did this project and I worked on it.

And it ended up paying off and it was just so much fun, giving the presentation. And, you know, speaking to the judges and it's that's what's one of the reasons I'm so fascinated in science was because of science fair. It's so much fun. And that's like my most successful Area of science.

Interviewer: Awesome. Okay, well on the, on the flip side of that, then, is there a time that you can tell me about where you did not feel successful in STEM.

Regina: Um, chemistry, I actually ended up flunking out of chemistry. I only did a semester. I'm terrible at math. I am terrible at math.

I don't understand it. It's like sometimes I think I know there's not a dyslexia for math, but some, That's how I see it. Sometimes, because I don't understand what's happening. People have tried to help me understand and everything is like I made like a 16 on my ACT in math. And it's just chemistry it, and I don't like to fail, it's, it's something I don't take in stride at all like I become a big baby when I fail it

Because I work so hard, but chemistry kicked my butt and I had, I ended up dropping it at the semester because I knew that I couldn't survive if I didn't understand. I was going to happen in the first semester I most definitely would understand the second semester.

Interviewer: Cool, thank you for sharing that. Um, what do you think when you think about maybe. If you were to take the science teaching route or something along the lines that those lines or you could think even outside of just yourself. You think about having a STEM career, either you or someone else. What do you think are some of the benefit of a STEM career.

Regina: Well, for one, if you're a woman in stem that helps a lot, especially with younger females having someone to look up to, because there's not a lot of females in STEM. And also you get. There's a lot of knowledge that comes with it, and a lot of opportunity and you can make a lot of great connections and stem and you get to learn new things every day. And that's amazing. You learn something new every day you learn as your students learn or, you know, if you're a researcher, you get to new breakthroughs every day, which is it's fascinating and it's amazing.

Interviewer: I get the sense just from listening to you talk that that this idea of influence and making a difference for like the young generation that's something that's really important to you.

Regina: It is. It's really, I had a really tough childhood and it's really important that I help the kids that you know went through the same things. I went through and they don't have what I did. They have what I didn't have available to them. And that's what that's what driving me really

Interviewer: That's awesome. That's fantastic. And I love that. That's something that's important to

Um, okay. So thinking back to the idea of STEM career. Again, I'm going to kind of take that reverse aspect, you think of any drawbacks to having a STEM career.

Regina: Well, going back to being so few women in the STEM careers that it's very hard for a woman to become successful. She'll have to work twice as hard as a man and get twice as many recommendations and twice as many connections and sometimes STEM careers can be isolating and long, long hours and well like a big time commitment.

That's some of the drawbacks. I can think of, I don't know. I'm just so fascinated by STEM that I can't think of a lot of negative

Interviewer: And that's totally fine. I just wanted to get some perspective. Now I really want to focus on some of the specific experiences that You've had in school, out of school. Anything that you can think of. And you could be science, math, it could be Technology like. What are some *activities that you did prior to coming to college that affected your interest And/or confidence in your abilities in STEM?*

Regina: So my freshman year I took biology, instead of physical science. I was always an overachiever but I remember I my teacher was also my science fair advisor, she's crazy as hell crazy as Hell. But I love them her so much

We were doing, um genotyping. She was teaching us about, you genotyping and you know how different diseases can carry on and families and stuff. And that's like one of the big things like I fell in love with that. It's so fascinating about how the gene can be in one parent, but not the other, or it could be dormant in both parents and the child can have it because

Cystic Fibrosis runs in my family and my cousin died from it. When she was nine.

So that's really why it just, genotyping, it's like that's what really really opened my eyes to science and you know it being so fascinating and so amazing and it explains everything, and I'm a religious person and I like to think that science and God goes hand in hand.

So, um, and that's why it's even more fascinating to me because, you know, it explains so much and I can't, you know, just pick one side

Interviewer: Thank you. That's really helpful. I'm. Is there anything that you participate in outside of school or activities that you did outside of school that may be changed your interest in STEM in any way.

Regina: I come from a really small town. So, not really. I mostly participated in school. And so it was mostly in school experiences for me.

Interviewer: Okay, awesome. Thank you. I know you mentioned the teacher already. And that's something I want to highlight neck so you can you can kind of, Just, you know, use what you've already said and say that's that's kind of the extent to that. But I want to talk about teachers, a little bit. Can you think of some teachers that influenced you, it could be the one you already mentioned, or others, and it could be positive or negative influences you what made them influential to you.

Regina: Well, my AP Environmental teacher, she that was when I went to a school for about a year, but she was so amazing, you know, she was crazy as hell too, seems like the science teachers are the crazy ones, but she made it so fun and interactive and we because it was AP, So we did field trips and things like that.

And it was always really fun. And that's, you know, it got me hooked because when they can be hands on and fun because I'm a hands on learner, you know, So that's why it was amazing for me, and she made it fun. She made it easy to learn and she made it interesting. It wasn't dull, you know, read a textbook fill out this piece of paper kind of class. It was, Hey, let's do, let's make an explosion in the classroom. Things like that. And I did ok so

The semester I was taking chemistry. I actually switched schools in about October. So my first chemistry teacher was crazy, she actually did set it off an explosion in the classroom. On the first day of School and

Okay, I'm both chemistry teachers were negative because the first chemistry teacher, we would go through about three or four chapters, a week and she'd go really, really fast and there wouldn't really be time to take notes and you know she Didn't wouldn't go over the little details and she wasn't a hands on teacher. And then the second teacher was kind of old. Well, they're both on the older side. But she didn't really explain things in great detail, either. She would just like write things on the board and she was very monotone so that didn't help at all.

So that both chemistry teachers were kind of a negative set back and my physical science teacher was a coach, actually. So I didn't really learn anything in that class.

I mean, I don't understand, making coaches, like a core curriculum teachers in some aspects but um we mostly watch Myth Busters. And, you know, played games in that class.

Interviewer: Um, well, and that's really good feedback because. Because oftentimes this is the case, we have lots of positive experiences as well as negative experiences and so that Tells me, you know, tells me a little bit. You mentioned this idea of math being something that you had Some challenges with

What were your, what were your experiences like in math classes. Did you ever have any either teachers or particular classes or activities that were influential to you.

Regina: I have a teacher. This is like far back like okay so I will start. They started putting me in math tutoring in first grade. So I did first grade through 12th grade math tutoring. But my fifth grade teacher. She really, This is she's the most influential when it comes to math because

I might hate it, or at the time for it, but she would make me go through and every answer I'd missed. I'd have to write it out the correct way five times, you know, she really stuck with me and you know, helped me understand the little aspects. Funnily enough, she was my math tutor for sixth grade. She did not let up.

But those are the ones they they helped me the most, and my eighth grade math teacher. He was a soccer coach, but he was really cool. And he really helped. He broke it down to where we could understand it little by little. And other than my fifth grade teacher. My most influential teacher was my tenth grade geometry teacher because she would record every session and put it on our classroom.

Google Classroom, but she would write it out. Step by step by step examples and she would explain things in such great detail that I could actually understand it and then she would give us reference YouTube videos and things like that. I still did horrible in that class. But that was my fault, not hers.

But she Really really helped. And that's what I needed it with someone who, you know, who was patient enough to help

Interviewer: Okay, my last main question is just, I'm kind of looking to see if there any other influences On you particularly in STEM and your confidence or abilities. So maybe it comes from family. Maybe it comes from outside the school in some aspect, was there anyone else in your life who had some sort of positive or negative input in influence on your thoughts on them.

Regina: Not really. I come from, a lot of my family is, Okay, so one side is really, really conservative so they don't really believe in that. And then the other side is druggies and burnouts

Really and like bikers. So I really pushed myself for all of this. I'm the only one who really likes this in my family and, you know, Because of what happened to me as a child. I've always wanted to be successful and be more than the rest of my family is and not in a bad way. But just, you know, I wanted, I wanted a different life. I want a different life.

So it's just me pushing myself. I haven't really had any outside. My mom's always been supportive of it, but she's not interested in this kind of thing at all.

Interviewer: Well, I first of all, I'm proud of you for pushing yourself so hard in that aspect. That's not easy. And I also find it interesting is you mentioned this idea of you've got one side of your family that's very conservative and how they have a negative attitudes, I guess towards this idea of sciences, but also how you kind of have this opposite feeling of, Like you can blend the two, Like it's okay to be coinciding

Regina: Right. It's like I'm liberal and they're very, very conservative and I like I like, you know, the idea of it all mixes in this perfect. You know, it's Like perfectly and mixes and they don't really believe that it's, like Thanksgiving is very hostile situation. Because they like to pick fights and I like to defend my views and my mom ends up running from the children up from the table and run

Interviewer: Yeah, how do you think you got to that Point where you got maybe away from that idea of like your, you still have some of those maybe pieces of that religious background but, But now you're kind of in this spot, and I'm not worried about maybe the political parties. That's if that's part of it. That's fine. But how did you get to a Point where you felt this way?

Regina: I feel always, I've always loved to read. It's one of my big things and I can knock out two or three books in a week. If I, you know, really just do it.

But, um, I've always not agreed with what my conservative family says it's always been like, why would you say that that's so hateful, you know, it doesn't make sense. And, you know, then I started getting teachers who are fascinating and amazing. And you know, I started Researching more into it and reading books that I found fascinating, especially women in STEM and you know stuff to build my confidence and that's where a lot of that came from was me doing my own research. And things like that. So yes, books, a lot of it were books like Hidden Figures really boosted my, I loved it. I was in a women's for STEM book club in high school.

Because, for the longest time I wanted to be a doctor, but I don't think I could deal with all that emotional trauma with all my emotional trauma. And so that's one of the reasons I've decided to be a teacher.

Interviewer: Very good. Well, do you have anything else you'd like to share in terms of of your influences and stem particularly or or what sets you on your path at this point.

Regina: Not particularly. I can't think of it at the top of my head.

Interviewer: That's okay. I just wanted to give you an opportunity to share anything. I didn't ask about so well that's pretty much it. I appreciate the time that you've spent and and for taking part in this.

Noah

Interviewer: Afternoon. How about you doing? Thank you for joining me today. I appreciate you taking the time out to talk with me a little bit.

Noah: Yeah no problem.

Interviewer: So, um, let me just explain a little bit of what you know kind of what I'm doing and what this is about. And then we'll, we'll get into, you know, got some questions for you and. With this study, I'm just looking for your experiences. Right. There's no right or wrong answers or anything like that. It's truly just, you know, what, what do you think about some of these different aspects of what we're looking at.

So the first thing that I want to know. Just like introductory information is what is your, what's your major and your year in school.

Noah: I am a secondary education, social studies major and I am a sophomore.

Interviewer: Okay, so you are looking into teching. I am a teacher, so I think it's literally the greatest job that you can have so I'm excited for you. What I want to know is what got you interested in your major?

Noah: Um, mainly my senior of high school, I moved high schools my senior year. Right. And so a lot teachers were very helpful in subjects that, Not only that I didn't know. But like sometimes I was already comfortable in enough and I realized that maybe the education system itself wasn't as good as it should, it can it can be and that even if I can help like 40 kids a year, um, like, learn and prepare them for after high school. That was good enough for me. So

Interviewer: That's awesome. So, so I know that your, your, you know you your career path and all that isn't embedded in STEM, but that's okay. Part of what I'm trying to do is I'm trying to get all different viewpoints. So I've interviewed engineers, I've interviewed teachers, I've interviewed you know, all types of people. So, so keep that in mind as I go through that's part of the deal. So what I want you to do is think about a time. Can you tell me a time that you felt successful in STEM?

Noah: Um, yeah, my junior year of high school, I took an anatomy class that I thoroughly enjoyed. Um, and it felt easier than most math and science classes that I took before even to the point where like I was getting like hundreds on tests that before I'd get, like, you know, in math classes or science would be like an 80 or like a C to a B range, so.

Interviewer: What was it about that class that you, that made you successful. Was it the content. The teacher. The, what was it do you think?

Noah: I think it was both. I did very, I took that teacher before for physical science my freshman year, and I did very well in that class, more so than usual. And then on top of that, it felt like a lot of the stuff we learned in class to sort of other classes.

Interviewer: So can you tell me about a time that maybe you did not feel successful in STEM.

Noah: Um sophomore year of high school, I took algebra two. Um, and I went from ninth, freshmen year thinking geometry. Comparatively, it was a lot worse. I didn't do as well. Um, it was a lot of times I'd get like C's on tests. D's or C's. And I had to retake it again my junior high school

Interviewer: So again, just kind of thinking about that. Is there anything in particular about algebra two that I gave you trouble?

Noah: I think it's the subject as well. I took college algebra here. OSU as well and I struggled heavily with it. Um, and it was essentially the same class like a lot of stuff I remember learning in Algebra 2 I had in college algebra, but it was still the same Struggling to maybe remember all the formulas or remember exactly what to do. Mathematically.

Interviewer: So, I'm going to shift focus a little bit, For momentarily from from your, you know, success. And since then, I want you to think about think STEM career. I want you to think about what comes to mind and What I want to think want to know is if you think of someone having a STEM career. What are some of the benefits to that?

Noah: I'm usually one thing that comes to mind is monetary value, usually when you think about STEM careers. You think of people making a lot more money. Like doctors, engineers, Physicists. Also, it feels almost like it's more more popular, like when people if you say you have a career in STEM people think you're more successful more, for lack of better words more educated than those without it.

Interviewer: So then what are maybe some drawbacks to those STEM careers?

Noah: Um a lot of hours. I'd say when I think about, like, they will they do. Um, I have an uncle, who's a biochemist, and he doesn't, he skipped out on having a family because of how much time he spends into a career, um, doctors who see a lot of, the at least ones that work in like big hospitals and in big cities, usually. Some of them. Sometimes they skip out on some of the home aspects, because they focus on the career a lot

Interviewer: Yeah, sure. All right. So kind of refocusing back on your experiences in, particularly, you know, like I said before college and that it can truly be anytime before college. What are some, unless you think about some maybe activities that you did part of college that affected your interest or competence to participate in STEM. Right. So you gave me a couple ideas on these classes, but what else, maybe some specific things that happened that you feel like really affected your interest or confidence in STEM?

Noah: Um, when I was a kid, I thought, um math was definitely my subject, I was very I was ahead of my grades in math at the time and then, But then high school here and it went downhill. But, um, But stuff like you know Sudoku, logic puzzles all those you see a correlation at least. Because like the Sudoku sorry mathematic based. And those you know you do those and you do them. And you're like, Okay, you know, either you haven't interest for them or you don't really like them. And I mean, yeah, I'm very, it was very promising as a kid, like that's what you thought. And then you hit the classes and then it all went like, well, maybe now I should change.

Interviewer: Is there anything that happened like what, what was the change that happened that made it go from felt like this is my thing to all of a sudden, now it's not?

Noah: I think it was definitely just the switch to a higher education towards education level of high school where you went from, You got more involved in these other ones like English and history where I felt like it made more sense now and um, more of a, math got more complex and more reliant on each other. It felt like I just kind of. Like your interest or your, your level and sort of just like almost switch places with the other ones.

Interviewer: Yeah, I gotcha. Was there ever a point as you were, you know, you think about. Maybe early high school, was ever a point where you felt like okay, like this is not like, I'm not interested in doing this beyond what I have to. Was there ever a point where that switch flipped. And do you think that maybe that affected your feelings about Math and Science or is it the other way around. That your Your success or, you know, in math and science cause you to Lose that interest.

Noah: I think it was me both um, because like you start off with the success. And so when you feel like it's all naturally so you don't have that time where like, I don't really need to study. And so then you slowly. Your skills taper off where you just bomb something so you start to have that negative aspect towards because the whole. So eventually, you come to the point where it was. Well, why don't I just switch to something that comes more naturally mean that you are almost more passionate about, because the more the more you fail at a subject I feel like the less actually you become more more dreading to go to it and maybe that leads to you failing even

Interviewer: Were there any activities you did that are outside of school. Think about places that you know, maybe you visited, camps, other programs, anything like that that may have affected your confidence or interest in STEM.

Noah: Um, There was a not really often, so I thought it was kind of there was some stuff I thought was cool. But eventually, I'm like I went I remember going to an aquarium with my family and stuff. And then also, which sparked more of an interest in like That like zoology kind of base that's probably led to the success of the earlier like anatomy class and um then there was like science museums. We went to sometimes that’s kind of cool. There's like on the Science Museum, which was kind of cool, but it felt like Those like objects were you're drawn a little more to like the Anatomy. That was more focused and they like LG and geography and stuff. I don't Like towards like the like the math and like the Physics and stuff. I just felt like I didn't have any activities. Maybe they could have fueled more of a passion for it. Then, like others.

Interviewer: Okay, so what I want you to think about now is kind of along the same lines on what you think about teachers. And mentioned teachers briefly earlier. I want to think about maybe a STEM teacher or teachers that influenced you in some way. And I say that I really, really mean. Could have influenced you positively or negatively. And any teachers that you had that had an influence on you and what made them influential?

Noah: Um, I had a like the one I took anatomy and physical science with. She was. It was a positive impact on she was very supportive. No matter what I chose career wise, right. And so even though I said like afterwards. I want to pursue like a career and like teaching, more history based than these STEM areas, she was still very supportive and wasn't like oh well you know they're sort of have a lesser subject that some would. And then, I'm trying to think if there's a negative impact. I don't, I don't think there was any one that was like negatively impact at all. I think was just like maybe it was just neutral enough that maybe if there was someone with a positive, it might have gone a different way. But it was just kind of like, here's the class. And that's it, really.

Interviewer: Gotcha. Um, okay, I want you to think about outside of teachers outside of school. Is there anyone else who. And again, I'm kind of focused here on STEM, but take it however you like anyone outside of school that had an influence on you in any way you know I'm saying family members family friends, just people you knew, peers. Who had an influence on you, particularly in STEM positively or negatively?

Noah: Um, I remember I did I was a camp counselor my junior high school and it was northwest outdoor science. So it's very heavily on the science and my job, my when I was when I volunteered was teach kids about plants right, and I had to have a supervisor who were, who taught us that stuff and then would watch us as we talked the students and she was very. amazing. um, she's very good at teaching subject you know as part like even after that I was more interested in taking selfies like plant biology classes. Even though I wasn't like this point I was already shifting towards the non-STEM areas. I still felt like I wanted to take some classes that pertain to it because of how like helpful she was and how she taught the subject that I was able to um respond better, I should say.

Interviewer: Um, have you experienced any, And you've kind of weaved in throughout, but just anything you want to add in terms of like, Any obstacles ,particularly in STEM that you've come across, anything that you haven't already mentioned.

Noah: Um, maybe one obstacle is the competitiveness of it. I'm, like you get in these classes and it's, it seems like sometimes up at college level or, like, I took physical geography last year. And there was a curve where like if you. That like so many students can only get an A, so many students can only get a B, like that. And I felt like it was a too much of a negative environment to keep going because like if you're going to need help on assignment, there's no, if you reach out to a classmate. They have no. They have a better incentive to deny your help, because they they want a better grade for their GPA. And I understand, like, I'm not saying curves itself or bad because I understand like at a higher level of like a like a med school or law school, you want the best of the best, but like these intro level STEM classes Introduction, to get people to feel that they want to have a competitive base like that. I feel like it would turn away too many students.

Interviewer: Yeah, that's a great point. Um thinking back toward your experiences. Is there anything that you wish. You know, you could have changed it, and not necessarily just for yourself but like if you are, you know, all powerful and you could go back and, and is there anything you could have changed about your experiences that maybe would have affected you differently, put you down a different path or even just even if it didn't end up or put you in a different place in the end, maybe would have changed your journey.

Noah: In regards to system. Um, I probably work on myself to study and better and have better work ethic as a mid, late middle schooler too early high schooler because I feel like that's when you really establish how you study and how you do your homework and all that stuff. I feel like maybe I think that's where it all went I don't want to say wrong because I like where I'm at now, but like it could've all changed. I could have maybe done way better in those science classes and wanted to keep going down a science field or maybe I would still do well and still in all my classes and still enjoy where I'm at now, but I feel like definitely just studying habits and like being able to enforce a better work ethic as, As an early teen.

Interviewer: Okay. I've asked kind of from a variety of viewpoints. Right. On activities and places. Is there anything that I haven't mentioned that you feel like maybe had some effect on you. In your, you know, progress in particularly in STEM?

Noah: Um, maybe a family factor as a big one. Um,*my* family can't I come from a lot of family that aren't in STEM like my main family like my mom, my dad, and um but like you look at, like, aunts and uncles, they all do STEM work. Like I said earlier, my uncle was a biochemist. I think maybe having a bigger family influence. Like if your parents was like a scientist or something. Maybe you're you would be naturally pursuing down that line more. Like my dad was a, went to college for a history degree and he got that. And so as I almost pursue and it's almost like maybe if he had a different degree. It could have, like in STEM maybe, would have gone down the line of also going after.

Interviewer: Did you have any experiences with engineering at all in high school or elementary school?

Noah: Um, In middle school. Um, we did. I remember we had a Lego robotics class. Which I think counts engineering as far as I know. Um, and our whole thing was we programmed. We built this robot with Legos to do variety of tasks and that's about it. I mean, it was a couple. It wasn't going through a full semester it was maybe like eight weeks. And after that every science class I took was like either biology or it was it was almost a life science, like there wasn't anything more engineering. Down the engineering path.

Interviewer: Awesome. All right. That being said, that is pretty much the end in terms of interview. Have a great day.

Noah: You too.

Evan

Interviewer: Good afternoon.

Evan: Good afternoon. I'm so sorry I'm late. I had been a bit busy day well

Interviewer: I understand. I appreciate you just carving out some time. Thanks for being a part. So my name is Interviewer and as you kind of gathered I'm sure I'm doing a research study on just some of the things that, Some of the experiences people have in school, specifically regarding science, technology, engineering and mathematics, which I'll shorten to just STEM. So if I ever say STEM just know it's talking about any of them. So it could be a math class, science class, you know, something involving engineering or whatever. Right, so I just want to ask you a few questions. So first thing first thing I want to know is, tell me a little bit about like what year are you and what's your major.

Evan: I'm a freshman, I major in Animal Science with pre-vet option as my major.

Interviewer: Okay, so is your plan then vet school

Evan: Yes, sir. Graduate, graduate school after thi

Interviewer: Very good. Alright, so tell me this, what, when did you first become interested in following that career path.

Evan: Um, I mean, honestly. Ever since I was a little kid, you know, my uncle, he he's a veterinarian. He always has been, since I was growing up, he went to college. From like 2001 to 2008 and so he was he was graduating from college, whenever I was growing up and stuff, you know, since I was born in 2002 so just seeing him go through school, be extremely successful with it and now he's he's doing great things in the veterinary field so he's just been a big inspiration for me. And so I've just always loved it. I've done a couple internships now. And so I've been. I can't see myself doing anything else, to be honest.

Interviewer: Absolutely. So did you do you have anything that tied you to animals? Like did you grow up on a farm or did you or anything like that. Or, or, or is it just that relationship and and and seeing, you know, your uncle's success?

Evan: Um, no. We grew up. I grew up in a very rural environment. So a lot of farmland, stuff like that. Um, my family were Native American. And so we lived on tribal land and my entire family lived on probably this probably three square miles worth of land we had cattle horse horses and stuff like that. And so I mean like just growing up I was always either messing around with wildlife or livestock, you know, so

Interviewer: Absolutely. Cool. So is there anything as you've made the transition from, you know, from high school and all that into college. Now is there anything additional that's happened other than kind of what you've already told me about that initial interest that's really helped you maintain that interest in and following that path. Or is it just a continuation of the stuff you've already mentioned?

Evan: I mean, it is a big continuation. I mean, I'd have done those internships so that really piqued my interest. Just doing the tours here at OSU, meeting some of the faculty and stuff like that has really helped me make the decision. It's like, just where I want to be, to be honest, you know,

Interviewer: This is a great place for following that, yeah. Well, what kind of internships, you talked about that a couple times.

Evan: I did one at a regular day care facility for small animals, and then I did that one for a little while. And I've also done I did one for about a week. And I was, I did. I think like 110 hours total in that week span actually with my uncle. I pretty much just shadowed him and worked in the clinic at a 24 hour emergency care facility. So a lot of hours there.

Interviewer: Absolutely, yeah. Very cool. So I'm going to shift a little bit just in talking again talking about STEM in general. So anything related to science, technology, engineering, or math. Tell me about a time where you felt successful in STEM.

Evan: Um, I mean all throughout high school I excelled in STEM courses and stuff like that, except for math, math, not really my thing. But sciences. Technology is a big one that I've really tried to come around on in really improved in I've taken. There's this like free course or this course thing called Udemy online. I've been taken icon of like programming, software, like Excel courses through that. That's that's really been something that's allowed me to develop my skills and stuff like that a little bit better.

Interviewer: Very cool. Okay. So is there a time continuing on the flip side of that, is there a time where you felt like you were not successful in STEM?

Evan: Yeah, absolutely, actually, right now I'm kind of struggling in biology. It's just hit me upside the head pretty fast. It's quite the transition from high school level courses to one where it's just a huge class and you're pretty much just expected to show up to the lecture and just go on and struggle or not struggle but like. Just putting in the work and study in and reaching out and finding that material. So, I mean, it's also been a growing process for me I've really been able to develop my study habits and myself as a student. So it's kind of both sides of that [inaudible]

Interviewer: Sure. Okay. And it's not uncommon. There's a lot of people who make that switch into the Intro Bio class is it's, It's a shock to a lot of people. So anyway, you're not alone in that just the, um, okay. So thinking about you know yourself as possibly going, you know, going into this veterinary track or just in general, if you prefer to answer that way. What are some benefits to having a STEM career?

Evan: Um, you're always going to have a job. It's like that job security is literally always going to be there. It's so versatile what you can do with the career and I mean I can. Off the top of my head I can name like 20 jobs that I can do with a veterinary degree, to be honest, you know. It's just you're always going to have a place in STEM. I mean, that goes for technology, engineering, for sure. Right now, there's just been a huge boom. In like bio engineering stuff like that. So it really is just that job security, knowing that there's always going to be a place for you well.

Interviewer: So, on the flip side of that, do you think there any drawbacks to a STEM career?

Evan: Um, I, to be honest. I really haven't had that much experience where I can speak to any drawbacks. You know, I'm on. I mean, just thinking about it. Not really. I mean, it's just a great place to be, you know,

Interviewer: Good. Awesome. OK. So now I want you to think about the experiences you had prior to school. So you've spoken to a few of these. But when I say prior prior to college. So thinking about you're in high school or junior high or elementary school, or even outside of school. What are some activities that you did? And like I said you could think about, you know, specific in class activities or or something like I said you did outside school. What are some activities you did prior to college that affected your interest or confidence to pursue STEM.

Evan: Okay, so, um, outside of school growing up, I always my grandma, she always had the Nat Geo little magazines weekly subscription from those. Yeah, I probably have thousands, though, so I'm going through reading those books about sharks and I, growing up. I was split on what I wanted to do. I either wanted to be a marine biologist, or a veterinarian and both those were just super piqued my interest and stuff like that. I was always excited about that. I mean in school doing labs and like dissect and stuff. I love that. I went to actually I'm actually registered registered nurses aide and so I have a certification in that already, and so I mean I did a lot. I had a lot of exposure to STEM growing up and stuff like that.

Interviewer: Okay, that's good. What about, was there anything that happened in school, particularly that you remember that really made you feel like I could I could be successful in STEM?

Evan: Um, yeah, my freshman year in biology. I just absolutely crushed the course and I had high marks from my teacher, I was able to help all my peers, and stuff like that in the class, help them succeed. And so it was just really that bring in other people up around me and allowed me to kind of realize that this might be a good opportunity for me.

Interviewer: So I want you to think about a teacher that you've had or teachers. And I want you to think about someone who's influenced you in STEM and that could be positive or negative. Right. So someone who is a positive or negative influence on you. What, what was it that made them influential?

Evan: Um, so going back to a course I took from a Vo-Tech. The certification degree or certification I got as a registered Nurse aide. I had the greatest teacher I'll probably ever have in my life um barring I meet anyone here in college that's better. But, um, she was a huge influence on me. First year teaching. She came straight from the nursing field. She was actually a LPN. And she just the real life experience she brought to it. She was at she actually had been there and done. Everything that she was teaching us she was actually she was able to speak from a place of positivity because she loved the field that she was in and so just, it really rubbed off on you and her enthusiasm and everything about pretty much science and all that so

Interviewer: Good. So I want to ask also anyone else in your life, maybe outside of your teachers, who's had an influence on, you know you've already talked about your uncle, a little bit so you *can expand on him, add or just add anything else you know in your family or other people, friends that have had an influence on your interest or confidence in your abilities and STEM.*

Evan: Yeah. Um, yeah, my uncle. He's definitely been a huge part of my interest in STEM just seeing how successful he was how much he loved it. Um, and my grandma on my mom's side she, which is his mother, but she always really pushed it. She was a registered nurse as well. So she coming from a certain background. She was actually the first Native American registered nurse in the state of Oklahoma. So that was really cool seeing her being extremely successful and a pioneer in the field, to be honest.

Interviewer: That's amazing. Very cool. Were there any other influences this where I can. I'm gonna let you kind of you know, I'm not going to be a specific here, but just thinking about just you know your life leading up to this point. Is there anything else that outside of the specific things that I've asked that really led to your either being, you know, feeling like you wanted to go into Vet, you know, to Vet Med or just in general you feeling like, hey, I can do this and in your math classes, your science classes, things like that.

Evan: Yeah, I mean, it really is. It's kind of gave or given me confidence. But let me back up on. So, I mean, it really has been kind of a passion, um, as far as where it originally rooted from I've always been super interested in wildlife. Going out to creeks and stuff by the house and just flipping over rocks and and seeing what I could find, you know, and a lot of it came or. Sorry, I'm kind of losing track where I'm going. But like just growing up and really being able to explore the world around me just really ignited that passion and mean so it's given me confidence to kind of push myself further and further and seeing how high I can take it and how successful I can be. It really has driven me to go that extra mile, that some other people haven't been able to do so. Yeah.

Interviewer: So just hearing you talk, it's obvious that this is like a lifelong thing. This has been around since you are since we were young, so one thing I'm curious about is, is there anything that you've encountered, maybe, particularly in school but but you can answer, however you want. Is there anything you encounter this become like an obstacle or something where, at some point in your life you felt like, oh, maybe this isn't what I meant to do, because, you know X, whatever that might be, the obstacles that you feel like you've overcome to get to this point.

Evan: Yeah, definitely. Um, the time requirement has been a huge debate for me to be honest, just the schooling is so extensive you know, eight years is a long time, and it's a big part of your life, especially this early just I've over the past couple months I've gotten really interested in personal finance and investing and stuff like that. And so just a lot of the most successful people in the world um first, they hate debt. And second, they hate wasting time and so school obviously, isn’t a waste of time. It's one of the greatest investments, you can make is education for yourself but like just that time lost and spent on something. It really has become almost the obstacle. I've had issues, trying to kind of justify the means of going to school for so long, so I think I have gotten into the point to where I kind of figured out that hey I this is what I'm doing, no matter what. Make it happen just go out there and do it so hopefully I keep on with that mindset.

Interviewer: Well, that's great. Well, I think, then that's the end. That's, that's all I have for you today. So, um, I really appreciate the time you spent and and this is really beneficial for me because as I I'm a science teacher and and my goal is to make science education, math educational as, the best that it can possibly be. And so what I'm hoping is to find you know people like you who who have seen good and bad and and who have had all these different influences in your life and see what makes you successful. And so that's what this is about. So with that being said, that's really all I have. I appreciate the time you spent with me.

Evan: Yeah, absolutely. I hope I was able to help you a little bit of

Interviewer: You, you definitely were. I appreciate it.

Evan: Yeah, absolutely. You have a great one.

Interviewer: You too. Bye.

Annabelle

Interviewer: Good afternoon.

Annabelle: Hi, how are you. I'm good, how are you good

Interviewer: Good. Thank you for joining me today. I really appreciate it.

Annabelle: Yeah, for sure.

Interviewer: So my name is Interviewer and as I've, you know, you've seen an email correspondence and everything, we're conducting a study looking a little bit at some of the things that people have experienced in prior to coming to college, specifically in classes related to like science and technology, engineering and math. And then how those things have affected have affected people. And so that's what we're going to talk about today. Alright, so like I said I'm going to ask some questions specifically related to Science, Technology, Engineering, or math. I'm going to use the abbreviation STEM for that. Not sure if you've heard of us that abbreviation before but When I if I say STEM. I just, it could mean any of those things. So it could refer to that as math class or science whatever comes to your mind Is fine. I just want your thoughts on it. Alright, so first thing that I want to know. What year are you in your major.

Annabelle: I'm a freshman and I'm an interior design.

Interviewer: Okay, so my first question is how or when did you become first became interested in and your major.

Annabelle: Actually this semester. So I've switched my major twice this year, but this this semester, I realized that I actually really enjoyed mapping out plans for housing and just creating, creating homes.

Interviewer: Cool. So, what, what were you before. What were your thoughts before you switch to this.

Annabelle: I started out in elementary education because my dad was a teacher and I liked the idea of being around two kids and then I switched to social work, because I have a heart for those kids who don't have homes and then now I'm like, Well, maybe I should actually use the things I'm good at and do interior design.

Interviewer: Awesome. Fantastic. What, there's no reason why you still can do those things. This is off the record for the interview, but I am a teacher for my job but I am also foster parent. So I have a lot of interest in those things also. This doesn't relate to the interview, but I just think those are really Cool things. Um, okay. So with that in mind. Um, so, so I'm going to ask you, even though your major and the things you've done aren't directly related to STEM that's actually good. That's part of why you're a part of this because I want to know all different aspects of viewpoints from a variety of different people. So tell me about a time where you felt successful in STEM.

Annabelle: Um, I would say in, I want to say like eighth grade we we had a program that was specifically centered around STEM. So we would throughout the year, we would try out like different aspects of it. And I know we did this one project where we had to like build this bridge made out of popsicle sticks that had to hold up textbooks and it was this really cool thing, and my group had like 15 textbooks on top of these like popsicle sticks and it was like so dramatic and awesome

Interviewer: Okay, so on the other side of that. Tell me about a time where you did not feel successful

Annabelle: Um, I would say like coding. I have tried coding before and that is just not something I am good I not in my wheelhouse of skills.

Interviewer: Okay, fair enough. So what do you think, if you think about someone maybe having a career in STEM. What, what do you think are some benefits to that.

Annabelle: Um, when I think of careers in STEM. I think higher salary. I don't know how accurate that is but in my head. That's that seems to be the case. And then I also just picture very like well-educated and intelligent people so I feel like maybe just experience money and

Interviewer: So what do you think, or maybe some drawbacks for someone having a STEM career.

Annabelle: I think when I picture STEM careers, I picture a lack of social social life. I'm not sure. And maybe I just have this idea of people in computer labs only working on computers all day. But I just, I just picture lack of communication with people and community, I guess. Okay.

Interviewer: Thank you very much. I so this is this next part is kind of one I really want to focus on. And that is, think back to your, say prior to college. So it could be high school. It could be middle school. Wherever anytime. I want you to think about what are some activities That you did that affected your interest or confidence in STEM, but both good or bad, like what are some things. I know you mentioned a couple things already about like when you felt successful and all that, but what are some maybe specific activities or times, Things that influenced you, in your confidence.

Annabelle: Yeah, for sure. So my dad is a math Teacher actually and I know just working with him individually and having that one on one relationship. I feel very successful in the math department. Just because of that relationship. Also, problem solving, I don't know if you like those like Sudokus, reflexors, those types of things. I'm like, yes, I can do those I feel very intelligent when I do them.

What else technology where you just asking for good moments. I'm sorry, I forgot the

Interviewer: Either, Anything that affected you

Annabelle: Yeah, so I would say for sure benefits with math and then with the idea of science and technology. I have a lot of negative experiences. My small school did not offer very many opportunities as far as science goes. You're kind of like stuck with the one professor that we had, and not the best teachers. So, I, I'm very, very drawn back from the idea of science, I would say.

Interviewer: Um, what about things like I don't you mentioned your dad and then being a teacher, but what are some things maybe outside of school that you did. Any activities that you did that influence you in any way.

Annabelle: Um, I know I did. It's still kind of connected to school. I, I have a hard time differentiating it because small town everything you do is through school. But I did like scholars bowl and those types of things. There were a lot of activities outside of school in regards to after school programs looking more atlike, The engineering aspects and the math things, there are a lot of activities that pertained around those after school hours I guess.

Interviewer: Cool. I'm very good. So here's what I want you to think about. So you've obviously got one very influential teacher in your life. So think about like maybe him or any other teachers that you've had.

What are some things that made certain teachers influential to you and I'll say, and I know you mentioned the science teacher, too. So like, good or bad, like what are some characteristics or things about specific teachers that influenced you

Annabelle: I would say, as far as most influential teachers I had better relationships with my English teachers. I'm not sure if that's because I understand English easier, it's easier for me to understand that. But a lot of the teaching that they did was more hands on and it made sense. And they had the ability to explain it multiple different ways to get that final like the product of understanding it

And then negatively. I definitely science teachers. I they were not as personable, And they focused heavily on, do-it-yourself assignments and even in the labs, It was like you're on your own. You got to figure it out. And there was just not a lot of help that way. And then when they would help. They only have the one way of explaining it. So if you didn't understand it, you were kind of left behind.

Interviewer: Yeah okay yeah that that is that's super helpful and that that is really interesting when you see it broken down like that.

Alright, so, um, other outside influences. Right, so like oftentimes I asked you about family you've obviously got family influence. What are some outside influences that may have contributed to, you know, the way you feel about STEM so specifically family or friends.

Annabelle: Yeah, I would say family is definitely a big part of that. I know two of my brothers are engineers. So I'm very familiar with the math were a big math family. I guess I never thought of that. But as far as like the technology aspects, I have a few friends who are very technologically savvy. It's definitely not a skill I have but I admire the fact that they're very technologically savvy. Um, but other than that. I'm I really can't think. But just math and my family. And then I definitely see the technology aspect of my friends more. Yeah.

Interviewer: Um, is there anything that you can think of when you think about like your own learning experiences. Is there anything you can think of that. Might have changed your outlook on stem like, is there anything that teachers could have done differently that or your school could have your classrooms could have done differently that would change your outlook.

Annabelle: I think one major thing for science specifically would just be showing different careers and science more than just biology and chemistry and because those classrooms, like it really does negatively affects and I know I'm not the only one in my School who experienced that there's there's a lack of like doctors, any, any science related fields coming out of my high school because the teachers just Aren't positively reflecting what those careers can be so I would for sure say showing like real world applications to those classes, rather than just the class.

Interviewer: That's awesome. Um, okay. You're giving me lots of great stuff. So I appreciate it. Okay, so thinking about, just in general. Now is there anything we're getting close to being done so. Is there anything that you. Can think of that maybe I haven't asked anything in terms of of your influence on on in STEM, you know, leading up to college. So anything else that affected you in any way that I haven't asked you about

Annabelle: Not sure that it affected me, but I know I've kind of landed heavily on math and science, but I think Something that we should think about looking forward to, like, educating students is the lack of like technology that's being taught because we as a young generation, kind of just figure it out on our own, but looking at Careers I feel like there's not an outreach for students to like learn about those groups, I think, I think there just needs to be an openness about careers that aren't just doctors and nurses are teachers, if that's if that makes sense.

Interviewer: Yeah, absolutely, hugely emerging workforce need is technology. Okay. Well, like I said, I've reached the end of my question. Okay, so hopefully that was pretty easy and painless and I really appreciate the time you spent with me.

Neely

Interviewer: Hello. How are you?

Neely: I'm good, how are you

Interviewer: Doing well.

My name is Interviewer. And first of all, I appreciate you being here and being a part of this interview process.

Okay, so I'm just gonna ask you a few questions a little bit about kind of your background I'm, what I'm primarily looking at is the types of variances that people had before they came to college. And I'm particularly looking at things that happen in Science, Technology, Engineering, or Mathematics. So I'll use the acronym STEM some, just going to shorten up those four subjects. But if I say STEM, It can be anything in those subjects and science or technology or engineering or math that you've had, at some point.

Neely: Good. Yes, thank you.

Interviewer: So what I, what I want to do first is just get some basic information from you. I know you may have entered in some things before but I everything is anonymous. So if you just give me you know your grade or your, your year of study and then also your major.

Neely: I'm a freshman and I'm zoology prevet major

Interviewer: Alright, so obviously you being in zoology and prevet you've got some experience in STEM classes and all those different things that kind of led you into this spot. So my first question for you is, what was what first made you interested in pursuing this as a major

Neely: Um, I think I've always loved animals. So I know that's like the typical answer. Um, but, like, I've wanted to be a vet for as long as I can remember, and I just loved animals in general. And I think, more specifically, the reason I wanted to go down the Zoology pathway, was I had a career shadow day that we were, We had to do in my eighth grade. And so I chose the vet that my family took my dogs to, um, and it was a small animal that and kind of decided that I liked it but it wasn't what I had expected.

And so that's when I went from I didn't really know about the animal science versus a zoology major at that point. But that's when I was like kind of having a crisis because I didn't know what I wanted to major in because I thought I wanted to be a vet. And so that's when I kind of did research and thought maybe I wanted to do marine biology and then kind of stumbled upon zoology. And that's kind of how I started looking up schools was what schools would have a zoology major, and that's why I chose this university because they were one of the few that had a zoology track for the vet program.

And so, and then that kind of progressed because I started shadowing at another vet. And I go to do, I started helping at animal shelters and then one of the classes that really helped was my junior year I took a biology class that was like an upper level. It was through a local university, and it was dual credit so. that was really interesting in that made me like, know that that was something that was really interesting to me, because we got to learn a lot about animals. And then in my senior year, we had a College Composition class. And that was basically all research in our like chosen field. It also really, really helped me to know more about what I was getting into. And what I was more interested in.

Interviewer: Wow, so you had a lot of opportunities for experiences when you've mentioned that career shadow day in eighth grade. Is that something that you did through your school?

Neely: Yes, they, I mean, it was really loose parameters. It was just whatever career you wanted to shadow, but um so it was, but it was required that you do it, like you had to turn in a form for it afterwards.

Interviewer: Well, that's a really neat experience. I think. Tell me more about this research class through or research focus class your senior year.

Neely: Um, I think my teacher made it research focus, but I'm not sure if It was. I mean, it was dual credit through the university. So it was taking the place of Comp 101 and Comp 102, I believe, or whatever the first one. So, but um pretty much everything was either controversies or like people in the field, or just it was really wide of just any research topic in our field.

Interviewer: That's really interesting. Well, very cool. So you've got a lot of things that kind of fed into this, um, this process for you. So what I want to ask is just kind of backtrack to you and how you felt through this process. Tell me about a time where you felt confident in STEM?

Neely: Um, I think this is. But does it have to be in school or can it be outside of

Interviewer: Nope. It could be anything. Yeah.

Neely: I think the first time I like I shadowed at a vet in my hometown from January through when I left to come here. So August ish

And maybe sometime during the summer it got to the point where she was kind of letting me um go in and take histories, and, obviously it was not doing everything because she's the vet, I was helping, it was a lot more hands on and she was helping me learn things a lot more hands on. So actually being able to say, oh, they need this prescription. I know exactly what that is. And I know exactly what that drug is And I can go get it. I know where it is and I can fill the needle I can fill the vaccine. Starting to be able to do that was really cool.

Interviewer: That's awesome. Um, is there a time you can talk about that. Maybe you didn't feel confident in STEM?

Neely: Trying to think, sorry. Okay, I think it could be the opposite of that. When I started out, it was like, I feel like I know nothing. And I thought I knew more about animals than I did, um, we're I think In high school, as you get into your senior year, everyone's kind of talking about their plans and it's easy to compare to other people or compare yourself to other people. So sometimes feeling like, oh, I'm behind because I'm not researching like they are. I'm not doing something like that so. Trying to think, probably a lot of things with technology. I don't feel super confident, but that's all.

Interviewer: Okay, so thinking about your, you know, I'm thinking for you specifically in veterinary medicine, but you could maybe generalize this to all STEM careers. What are some benefits to having a STEM career?

Neely: I think one of the biggest things that I liked has drawn me to it is that there's continual problem solving and there's continual um I feel like personally for me. I need to see some sort of result to be driven. And so I think that's big and seeing the actual product or healing process or something like that, I think, is a big benefit. And I think the benefit of, I mean I guess this could be for really any career, but the need to stay on top of new findings and constantly learning. I think It could be a benefit or or a loss. But I think for people that are like really um. If you're driven and you want to keep learning. I think that that's a benefit.

Interviewer: Cool. Are there any drawbacks to a STEM career?

Neely: Yes, I think so. I'm trying to think. I think I'm. A big one could also be sometimes, especially in research your hinging it all on something. And if that doesn't work out, and it can be really difficult. Um, I'm Sorry.

Interviewer: No, that's absolutely fine. I just want your thoughts, whatever they are. So no worries. You know, something you can think of. It's not a big deal. Alright, so one thing I really want to want you to think about is the experiences you had prior to school. Now you've named several things already so In terms of like things that you've done, that your school did classes, is that so I want you to think back to, are there any particular learning experiences: activities, projects, classes in general, that really affected your interest or confidence in STEM?

Neely: I think definitely the biology class. And I think of maybe earlier on classes I think anytime we got to do things I have memories from like fifth and sixth grade of doing like dissections and things like that that was always really cool. Um, We had a Science Club at my school. And so that was really fun because I was a part of that. And we did field trips and so that got me more interested and we did like a water quality field trip and tested water quality of pools of that was, um, I think that helped me gain confidence of like that's also something I need to pay attention to is like actual ecosystems in the habitats, as well as the animals and kind of helped gain confidence in that part.

Interviewer: What about, think about outside of school. Is there anything that you that you did outside of school, whether organized like a camp or a program or just on your own, that that affected your confidence or desire to pursue STEM?

Neely: I mean, definitely helping at the animal shelter. That was a big thing and shadowing, and I did go to a camp that I think back on a lot, it was in sixth grade. I think that was like a STEM camp. There wasn't like an overnight thing or anything, but it was at a college in my town, and that was really interesting, I think it was more probably focused on technology more than anything. But it was cool to see because they had a lot of just kind of not finished models of things that they were testing out. And so it was cool to see all these people this entire research on this, and created this, so.

Interviewer: Cool. So what I want to think about now is is think about your teachers that you've had. And I want you to consider like think about any STEM teacher or teachers that you've had that have had an impact on you and I'm say that I really mean positively or negatively. What are some things that the about them about those teachers that made them influential to you.

Neely: I think the first one that comes to my mind is, I had this same teacher for my sophomore and junior year of math. So I had her for Algebra 2 and pre-calculus and I also had her for my homeroom and so. Our home was like kind of weird, but we would do as a national honor society, and they would have us do tutoring during our like home period. And so I was her math tutor for hers and she, So she not only helped like she was just an incredible teacher, influential in that way. And was very like understanding, but she also was very like organized which is helpful for me. Um, but then also like helping me with. I mean, she was definitely a mentor within the tutoring role because she helped me with leadership skills and I think that improved my math too also teaching other people.

And then I think also my biology teacher and which I think is one of the reasons why I like the class so much too was she gave us a lot of opportunities to do, um, labs. Um, and they were more. I don't know my prior experience with labs had been once, maybe a month and they were really extensive and it was more about you know what you wrote out of it than the actual experience. And even though it you know do lab reports in our class. She definitely focused more on like the experience than just the grades of it. And so that helps a lot.

Interviewer: Cool. Um, What about. Is there anyone. Any other outside influences. I'm thinking maybe family members, friends. You know, friends of the family, whoever, people around you that had any influence on you?

Neely: Neither of my parents are in STEM so. Let me think. (pause) I don't think so.

Interviewer: That's great. And that's fine. It's one of those things interesting. Some people, you know, do have those situations where their families really involved in for you. It sounds like this kind of Interest and love for animals and those types of things just kind of came about naturally as you as you grew. I think that's really interesting. Do you think you, have you experienced any obstacles along the way as far as trying to approach this career that you want to pursue

Neely: Um, yeah, I think early on, like in high school. I don't think I did it my sophomore, junior year was kind of when I started trying to seek out internships and and I applied to several of them like I applied to one at our zoo. And that's by where I live. And an aquarium and then several vet offices and it was kind of all of them were dead ends. And so it was kind of like, I don't know if I was more worried because of the early admission program here. I really wanted. I really wanted experience and so that was definitely like oh gosh, I don't know if I'm going to be able to get this experience in. And I don't know, I must be going about it the wrong way or something. I didn't know what I was doing wrong. And so, um, but then I think just keep trying. I, My senior year when I tried to find a vet to shadow. I went around to several, several and only got called back by one. And so it was really lucky, but that for sure and as far as classes go

I don't know, my, this wouldn't really be integral to my degree now, but my calculus class. That's what I needed to be able to get credit here for math and AP credit. And so, and that was really hard for me. So that was one thing

Interviewer: Cool. Um, alright, so two more questions I have for you. So the first one is, is there anything that you can think back of that you wish maybe could have been done differently or that might have that might have, you know, improved your experience in any of those classes in school.

Neely: Yeah, I think. As far as like classes go, I personally wish we could have had more like we didn't have. All of the AP or upper level classes at my school were like history based pretty much or math and there wasn't a lot of science. We didn't really have any AP science. And so that was frustrating. Just because like, wanting to go, like to a like harder class, I guess, I don't know, or just being able to be more specified like it was basically just biology or chemistry and nothing more like specified than that where I know some other schools had like medical explorers ones or different stuff like that. So I think that would have been something that could have been cool to do. Um, trying to think of what else

Interviewer: So that's, that's good. I think that's that'll work. Um, alright, so just thinking about all this I came from a lot of angles, like what has affected you know your desire to pursue what you're doing now, or maybe your confidence along the way. Is there anything else you can think of that I haven't asked about that might have had an impact on you in some way.

Neely: I don't think so.

Interviewer: All right, that's good. Well, that's it, then that's all my questions for you today. So thank you so much for being willing to share and give me some insights into your experiences like that's really hopeful and meaningful. So So I appreciate it.

And that's everything. So thank you so much and have a great day.

Neely: Thank you, you too. Nice to meet

Interviewer: You too. Bye.

Ashley

Interviewer: Good morning.

Ashley: Morning. Can you hear me all right.

Interviewer: I can, how are you

Ashley: Doing well.

Interviewer: Awesome. Well, thank you for joining me today. So I, my name is Interviewer and I am working on, you've already kind of seen some of the stuff that I've sent you, but I'm working on this little study on looking at the learning experiences that people have prior to coming to college. So with that in mind, then what I want to do is just talk to you about some some experiences that you've had kind of leading up to this. Now I'm specifically focused in on the experiences that happen in science, technology, engineering, or math fields. And sometimes we use the word STEM to shorten those subjects. And so with that in mind, just know that if I say STEM at any point I just mean in general, any of those fields of study

Okay, so first thing I want to do is just kind of get a very brief background. What is your year and what's your major.

Ashley: I'm a third year students, so, Junior. And currently, I am a creative writing English major.

Interviewer: Fantastic. So tell me a little bit. Just what got you, what was your initial interest in creative writing and English? What sparked your interest in that major?

Ashley: I'm really it was I've really liked science fiction, fantasy books and at that sort of sparked my interest in becoming an author, which is why I'm working towards specifically to write science fiction and fantasy.

Interviewer: Okay, so why, like, is there anything particular about that genre that Interests you or anything in particular that that why that genre is your favorite

Ashley: For fantasy. I've just always been interested in fantasy, but uh for science fiction. Part of it was. I used to be an engineering major, So I kind of know roughly some of the stuff that talks about and that helped boost my interest

Interviewer: Gotcha. So why the switch from engineering to creative writing?

Ashley: Physics and calculus two told me engineering was not for me.

Interviewer: I understand that. Okay, very cool. So, so then here's what I want to do is spend some time thinking back to specifically I'm looking at times prior to college. Right. So it could be high school, middle school, elementary school if there's something that pops in your mind that is related to a college experience, feel free to say that too. But my focus is on those times before college. So I want you to tell me. So you were an engineering major at one point. So I think *coming into college, you had some of those experiences. So tell me about a time where you felt successful in STEM.*

Ashley: Um, biggest moment would probably be in high school I was a member of the robotics club there. And we partook in a competition called FIRST Robotics, which was essentially we had, we were given a prompt essentially for a robot we had to build in January and then six week at. We had six weeks to build said robot. And our team was actually really successful and I was sort of the big, like I pretty much did all the hard building tasks. And so that was probably my most successful moment in STEM

Interviewer: Okay, so then conversely, and you You hinted at one instance of this, but can you tell me about a time where you did not feel successful

Ashley: Oh, God. Well of course there is me utterly failing physics and calculus 2. But before college I always struggled with chemistry. I ended up trying to take that AP exam twice and failed horribly both times so that's definitely up there. I've never really been good with circuitry. I've ended up nearly burning down a warehouse because of mismatching some wires. That's very much up there, then uh. Yeah, that's the big thing is I've never been good with circuits ever

Interviewer: Alright, so thinking about, you know, as you started considering yourself, particularly in the engineering career as you start thinking about that, you know, at one point in your life. Or just maybe as a general rule, and you think about people with a STEM career of any kind, engineering or science or or whatever. What do you think are some benefits to having a STEM career.

Ashley: Well, of course, like, it won't be long before most jobs become technology related in some way. I mean you got now electric cars, the internet, all this stuff. So that's definitely a reason is you are going to need it for future. But other than that. It just has, in my opinion,a lot more freedom than other jobs like especially nowadays because it's like with a computer science degree. For instance, you could go into practically any STEM field you want you to be programming self-driving cars, you could be making video games, you could You could be making the next iPhone for all you know. It's just such a diverse job field that to enter with a STEM degree of really any kind my opinion.

Interviewer: Okay, so then what do you think might be some drawbacks to having a STEM career?

Ashley: But workload, because even just with like college and even some high school work it. It takes time. It takes effort, especially compared to other jobs. I have a friend who still an engineering major and they barely get a sleep with how much work to do. It is difficult. And that's putting it lightly. That's the biggest drawback, I can think of.

And the other major drawback is it's a field that's constantly changing, especially nowadays because we've gone from Computers that take up entire buildings to computers, but we can put in our pocket in the span of 50 years so just constantly having to adapt to an ever-changing field is definitely another drawback I can think of.

Interviewer: Alright, so thinking about specifically your experience with this. I want you think back to things that you did inside or outside of school prior to college. In it, one of the big focuses that I have is on thinking about, like, what are the experiences that people had and how did that affect them. So I want to know what are some activities that you did or experiences that you had prior to college that you feel like affected your confidence in STEM or you're interested in STEM in some way.

Ashley: As I said before, DEFINITELY. The First Robotics Competition. I still go to the competitions to this day. That definitely boosted my, especially my confidence and what little I know about engineering definitely my interest. The other one is on occasion, I would go to my dad's work at (Air Force Base) and get to tour a facility, see them working on the airplanes and that really kick started my interest, I guess. It's just seeing people actually working with mechanics and computers and all this stuff and an actual Job field.

Interviewer: Cool, that's really interesting. Is there anything you can think of when you think about like in school experiences like thinking about as a class, like obviously robotics was tied to that and think about like your classroom experiences were there anything that maybe affected you know your confidence or you're interest in STEM based on something you did in school.

Ashley: In school. Not really no my school other than the robotics club was pretty outside of the STEM field, sadly, can't really think of anything for that. Sorry.

Interviewer: That's fine. Is there anything that happened in school that you feel like maybe had a negative impact on your confidence or interesting to them.

Ashley: Definitely the lack of it. For one thing, just, okay, basically not being present. Our robotics club barely even getting funding from the school basically all came out pocket from the members. Um, And then, again, just doing poorly in some of my more STEM related classes back then, such as chemistry, physics. Then it also doesn't help that what little technology or school had was extremely outdated and barely worked.

Interviewer: Sure. Okay, so something I'm thinking about, you know, you mentioned a lot of these things in school. Are there any teachers that you think of that maybe he had either a positive or negative impact on you, and if so, what, what was that about them.

Ashley: The first one that comes to mind would be (this teacher). He wasn't my chemistry professor when I took it, but I know he taught chemistry at the school, and he was like big, he was our teacher sponsor for robotics club and he actively took an interest in it he actively helped us out. He was definitely a massive positive experience for us.

Just helping us stay interested and whatnot.

As for negatives, No particular teacher comes to mind.

Interviewer: Okay. Well, I see that as a good thing. What about outside of, think of the people maybe who have maybe an influence on your life outside of teachers so I'm thinking, family members, I know you already kind of mentioned your dad briefly but family members or family, *friends, or anything like that. Any other people influenced that five of your, of your teachers who had an impact on your confidence are interested in them.*

Ashley: There's definitely my dad, of course, when he would take me to his job. My grandfather was on my dad's side was another massive influence because he would often show me like basic mechanics on his cars his motorbike. Yeah, um family friends of, there was one who, he would always come over. Whenever we were in the Robotics club and bring us like snacks help us with some of the smaller projects. And he was just a man from our neighborhood who took interest.

There's my uncle who taught calculus and physics at a different high school and he would always sit down and talk with me about like NASA and all this other stuff and he helped my interest a lot. And those are the major ones I can think of.

Interviewer: Okay, *what* was your dad's role at (air force base)?

Ashley: Oh God, that's a good. He's retired now so. If you're asking for official position. I couldn't tell you because it's been too long since I've heard it. I know at one point he worked on the floor actively like actively building the planes and repairing them. Towards his later years, he was like one of the heads of departments. I can't remember which

Interviewer: Okay, but he kind of worked at some of the technical aspects of Plane maintenance and things like that.

Ashley: Yes. I know at one point, he was like one of the main people who was looking at the instructions and trying to figure out, okay, how can we condense and shorten these and make them more efficient.

Interviewer: So thinking about, I know you've mentioned your, you know, those classes you took in college that kind of sent you on a different route. What, are there any other obstacles that you've encountered?

Ashley: Hmm. Others I'm, A big thing, and this was both for high school and college on some more lab based classes is when you do something wrong, it sucks it discourages you and that's a big thing is just making sure you can pick yourself up on your feet. But that's always difficult. That's the only real one that comes to mind for me at least.

Interviewer: All right, so what, When you think back to maybe your experiences in your classes or just any experiences you've had other any changes that you would have made like if you could go back and say, you know, if you had control and say, I could go back and make these changes to my school life situation. What changes would you make?

Ashley: In high school, I would have hopefully like to change the fact that actually pass my AP Chemistry course. But other than that, just, especially in high school, just trying to push more people to be more interest in the field. So I could just get a bigger audience and at least improve in my school.

As for college just putting more effort and hopefully doing better than I did in certain classes, to say the least.

Interviewer: Okay. Is there anything you thought about passing the AP Chem exam, which by the way is kind of, it's a beast. You know, that's a tough exam, but can you think of anything that could have helped you in that path. Like if something had been put in place that would have that would have gotten you to that point.

Ashley: For one thing, again, our school did not have a massive presence. We barely even had a lab set up to do proper assignments and so that's that would have definitely helped. Other than that, again, just a bigger emphasis on the course material and actually being able to do a proper assignments, because we basically just did book example problems all year long, and that not exactly fun or educational to say the least.

Interviewer: Gotcha. So when you think about like you know you you talked about your struggles coming in and with physics and in calc to in college is, is there anything that you would you attribute any of that back to any of your prior experiences like do you attribute, you're struggling with those classes in college to anything prior, or do you think, or is there, are there other things that you attribute that to

Ashley: Um, one big thing I attribute to is, I did not make good study habits in high school and that definitely carried on to college. That definitely made an impact. Other than that. That's definitely a big one. I'm trying to think of any others because I'm sure there are some. But not are coming to mind at the moment.

Interviewer: Sounds good. Alright, so that I mean that pretty much wraps it up, other than this. This is that is, is there anything else. When you think about your experiences. You know inside school outside of school, whatever is there anything that I haven't asked you about that you feel like maybe had some impact on your on your stem confidence or interest.

Ashley: No, nothing I can think of.

Interviewer: Well, with that being said, then that's all the questions I have for you. So thank you for the time you spent with me and for taking the time to do this.

Blake

Interviewer: Good afternoon. How are you doing?

Blake: I'm doing great, how are you?

Interviewer: I'm doing very well. Thank you so much for taking the time to come in here and be a part of this. I really appreciate it. Oh there we go. We're frozen.

Blake: It looks like it's, oh, it says, my connection. Okay, give me a second here. I'll just disconnect from the VPN that slows it down a little bit. (pause) Okay.

Interviewer: Okay, so. What I want to do is just kind of give you a little bit of a rundown of what I'm doing. And then we'll kind of get started with the questions. So, as you may have known from some of the things I've sent you, as all as well as the survey that you filled out a couple months ago. What I'm looking at is, I'm looking at particular types of experiences that students have had particularly prior to college that you have some sort of influence on their feelings about science, technology, engineering, math. And those classes in particular and so, so that's what I'm doing today. I'm just getting some, I'm just asking some questions. So I get a little bit of depth into, you know, taking some people's experiences and what they've had and, and what that really has done for them or you know in their lives in some way. So as I talk, One of the things I'll say, I might use the word STEM. Maybe an abbreviation you've heard before, but it's just literally shortening science, technology, engineering, or math. So if I say a STEM class I mean any classes related to things like that. First thing I want to know is just general stuff. So would you just give me your year in college and your major.

Blake: I am a freshman in mechanical engineering

Interviewer: Ok, so what was the thing. Like, what are some things that maybe initially sparked your interest in going that route in mechanical engineering?

Blake: So in the in my high school we add I'd say this was one of the more STEM-focused high schools out there. We had a STEM. They kind of had different endorsements, if you will. There's like a business path. There was a STEM path. There's like a cultural path. So I chose the STEM path in there and it started all the way back in middle school for me. I believe the class was. It was designed it was designed model in automation and there's another one about flight. I can't remember the exact name of the class because middle school was a while ago, but then freshman was Introduction to Engineering and Design, sophomore year was Principles of Engineering. And then after that, those were the more basic courses. That's where it kind of branched out and by junior year went into robotics, Robotics 1 and Digital Electronics. Those were definitely, that's where I'd say it really started. I really loved the robotics class and the digital electronics class. As much as I enjoyed that I would think electronics is more of a hobby kind of thing than I would say it as a career thing. And I think that class helped me realize that

Interviewer: Okay, that's awesome that you, you were very fortunate then I think to have those types of classes and those opportunities along the way. Is there anything that you could say maybe since that that time where you kind of said, Okay, this is the route I think I want to go?

Would you say there's anything that maybe helps you maintain that interest, whether it was higher up or high school or even the transition to college?

Blake: So for me, I would say it was I was already somewhat heading down that path. These classes and experiences more just reaffirmed my path choice. But I was also in the robotics club at my school which we had a best robotics and we were also in First Robotics. That's the bigger one. You might have heard, yeah.

Interviewer: Okay, awesome. So what I want to know is, as you're thinking about, you know, you're entering this field where you're intending on having a STEM career in the long run. So what are some advantages to having a STEM career?

Blake: Well for STEM career, although there's not necessarily advantages to it. There's, I mean, you can get a very good job in plenty of other industries, but I feel like for me personally, it's just it's a field that I enjoy. You know, I like the process of design.

Interviewer: Yeah. Um, is there anything you can think of, for STEM careers. Are there any drawbacks to an engineering career or stem in general?

Blake: The only real drawback, I could potentially see is very long hours.

Interviewer: Okay. So you've obviously had lots of opportunities for all kinds of different things through your career. So tell me about a time where you really felt successful in STEM?

Blake: Time, where I felt successful. Okay I'll trace it back to the Robotics 1 class. So that class was based around the Vex Robotics competition, I believe it was Turning Point was that year. And that that year. You know, I was in the team. I was the team leader and we took it home, we we won that competition.

Interviewer: Yeah, I can see that definitely being a huge success factor. Is there a time that you can think of where you felt particularly like you know, you were not successful in STEM?

Blake: Let's see here. Not too successful. I'm also going to trace that one back while we did have well we ended up winning that competition it we made, We kind of made a breakthrough kind of only about a month before the competition. And we didn't, it had. We had a ball launcher. And what we did was when you launch a ball through it, beforehand, It wasn't getting much distance. And we were not feeling very successful or good about it then. But it was when we eventually got the idea to put some rubber on them on the fly wheels and (hand motion showing the ball flying off). Things took off after that.

Interviewer: Cool. That's a great story. So when you think about these things, right, you've got these experiences. I want you to think to maybe to anything specific that happened where you feel, and you've shared a couple things along these lines already but think about, you know, in school, out of school, whatever. Are there any specific experiences that you had that maybe really had a big influence or impact on your interest or confidence in STEM.

Blake: Oh, yeah. So this one was in a. This was actually a physics class assignment. It was also in the same year as digital electronics. I used some of the things I learned in that digital electronics class in the in this physics project and the project was a it was a trolley car. There were like two electrified wires kind of running across the ceiling of the class. And you had to you would connect a positive terminal to one wire and negative to the other. You had to use that energy to move a car across all the way across the classroom on those wires.

Interviewer: Okay that is incredibly interesting what class was that again.

Blake: That was in physics.

Interviewer: Wow, that's awesome. I'm. Again, I'm kind of, you know, you've had some really great opportunities in high school. And that's really fortunate. And that's really great. I'm glad you had that. Is there anything outside of school that that was influential to you in any way?

Blake: Depends on how you would consider out of school. I will. I was in the robotics club. But that's still kind of tied to school. I would. And outside of school. Let's see here. I, I went into a programming summer camp, a really long time ago for Python. In terms of STEM. I think that's really about it in terms of outside.

Interviewer: Okay. Well then thinking about maybe, you obviously you've mentioned a couple of classes and maybe kind of abstractly some teachers. But I'm going to ask you a little bit more specific about your teachers. Were there any teachers that you felt like had a particular influence on you in STEM. And I always say this good or bad, you know, it's a really good positive impact or negative impact on you when it comes to STEM and what was it about them that made them particularly influential?

Blake: So I've got one it was Mr (Teacher) from, this was a Robotics 2 in my senior year. He was also the head coach in my robotics club or robotics. And with him. You know, I'm he he taught me how to use a lot of industrial machines, you know like milling machine, laser engraver, plasma cutter, router, and 3D printers, for that matter. And I feel like he's probably one of I would say he's the most influential teacher I had in high school.

Interviewer: Awesome, he just he was able to just convey all these different skills and yeah, things like that for you. And you can kind of see yourself as being successful when you have that opportunity to be a part of all those things.

Blake: Mm hmm.

Interviewer: That's awesome. Is there anybody outside of your teachers like any any influential people in your life, maybe, family members, friends of the family, anything like that, that, that really had an impact on you choosing to go this route.

Blake: Well, it's almost family tradition at this point to become an engineer.

Interviewer: Okay.

Blake: Of all the cousins that I have that are around my age or college age. I'm the youngest cousin, so, essentially, the last one. But out of all of them only one did not go the engineering route.

Interviewer: So it sounds like that is a common, common denominator for you guys. Well, at least you have some conversation sure over over your holidays and things like that. And it all. I'm sure also provided some support, and that the ability to kind of get a feel for what this is like. And what you know your school is like what the career will be like, and so on.

So what about, do you feel like you've ever had. Do you feel like you've had any obstacles along the way you've had to overcome?

Blake: So an obstacle. I'll go back to that physics project that was in the circuit that I had to make on that just failed and fried so many times. Like I can vividly remember like resistors smoking on the thing. And then, I had capacitors on there and you reverse the terminals to get it to go back. I was like, oh no, turn it off.

Interviewer: Okay, So what do you, when you think about stuff like that you've had these opportunities to do these projects where you've had failure right. And you had failure and success and kind of this back and forth. Do you feel like those types of experiences helped prepare you for your career? Or your career choice. I know you're still kind of starting out this journey in engineering, but, or, or do you feel like there are other things that had better prepared you more thoroughly?

Blake: Um, I don't think there's things other than what I've had in high school that would prepare me better

Interviewer: Awesome. Okay, I'm just a couple more questions. I'm almost done. What is there anything that you would say, like, if you could go back. And you could put yourself in a situation and change something, whether it's something you did, something your school did, your teacher did, whatever. Is there anything that you would go back and change that you feel like would have, would have put you in even better position than you are now?

Blake: I, I really don't think there is any that much I could do. I mean I maybe would have said, Get involved and things like the robotics club sooner but that's really about it.

Interviewer: Okay.

Interviewer: So I've brought up a lot of different kind of aspects and kind of tried to take a several different viewpoint, but is there anything I haven't talked about today that you would say, like, this is something that really had a big impact on me that you haven't asked me about yet.

Blake: I really don't think so, as it relates to STEM

Interviewer: Okay, so one, one last thing is I just think about your story and and I know you talked about your initial interest kind of sparking in that track that you got on from middle school and then really pushing in through high school. Do you feel like, like do you feel like you were maybe on that track already once you hit middle school, or is there or was that really the thing that directed you

Blake: No, I feel like I really was already on that track and doing, all these things really just reaffirmed this. You know, just made my decision stronger.

Interviewer: Okay. Is there anything that happened when you like when you think back to you being like a kid, you know, a young, a young kid maybe elementary or even before that. Is there anything that that really you remember that got you going that direction. Activities that you did or just the things you talked about in your family, anything like that?

Blake: So I did a lot of Legos. I also remember Minecraft Redstone, that was fun.

Interviewer: Awesome. So it sounds like you just had your kind of always something that's been a part of you like you kind of have just all maybe always shown this interest, and leaning towards things like engineering and science and math.

Blake: Mmhmm

Interviewer: Awesome. Okay. Well, thank you so much for sharing your story with me, like I said, a big part of my research is just helping other, you know, students and teachers, figure out, like, what, what are some of the best ways that we can help students find this idea of STEM and what you know whether it whether you know not to get everybody into STEM. But for those who maybe don't have those opportunities. How do we help them find them. So that's kind of what my research is about and kind of where I direct that as I move forward.

Nolan

Interviewer: Good afternoon.

Nolan: Good afternoon.

Interviewer: How are you doing today?

Nolan: Good, how are you

Interviewer: So my name is Interviewer. Thank you so much for taking the time to do this and be a part of this study and just kind of giving your thoughts. I want to give you just a quick overview of what we do and And then we'll get started. So, as you may have seen from things are written in the survey that you took I'm doing a study that is essentially over learning experiences things that students have done in and out of school kind of leading into their college experiences and then maybe how those things might have influenced them or change their thoughts about me what careers, they pursued or what majors, they choose to take part in.

With that being said, I'm going to kind of get started. What I want to do want to do is just get a quick idea. This is primarily looking at things in the field of science, technology, engineering and mathematics. And so regardless of your thoughts on that we've all had some experiences in those classes and so, I might also shorten that to STEM. You may have heard the acronym before stem being an abbreviation for those fields. But if I say like STEM classes I mean a science classroom, math class, or engineering experiences in the class, things like that. So the first thing I'd like to know, just general information what. What year are you in school. And what is your major?

Nolan: I'm a freshman in college and I am an electrical and computer engineer.

Interviewer: Okay, awesome. Um, So what I want to know is, what kind of led you or what initially sparked your interest in your current career path.

Nolan: Do you mean engineering in general or specifically electrical engineering?

Interviewer: Either one, whatever, whatever you like stands out to you the most in terms of what may be started you down that path.

Nolan: For engineering in general, it was specifically because I like building things and work on projects and for electrical and computer, I was originally and mechanical and aerospace, however, after going through some college and Pre college STEM, I realized that wasn’t something I wanted to do and shifted to something that was more reorient…Hobby oriented. I guess you would say because I enjoy coding and programming, and circuits was a fun class that I took in high school.

Interviewer: Okay. Awesome. So then, um, is there anything that's happened along the way that's helped to kind of maintain that interest, whether it be classes, activities, a transition from high school to college. What, what kind of helps you keep that interest up?

Nolan: I enjoy doing math, and I enjoy things like physics but what's honestly kept it up is probably the research project that I'm in.

Interviewer: Tell me about that a little bit.

Nolan: The short version is it's a visualization project where you take pictures and increasing the number of them into a model where the computer can read to identify images. It's meant to help dementia patients and, It's extremely difficult by also enjoy doing it, and it's kind of cemented the fact that this is what I want to do. This isn't what I enjoy doing.

Interviewer: Gotcha. I'm thinking back to my questions are particularly thinking back to pre-college right so whether that's, you know, elementary junior high, high school in or out of school. But don't you know if there's something that sticks out from college from for the any of these questions. You know, you can throw that in as well. But tell me about a time where you felt successful in STEM.

Nolan: And sophomore year in my high school, I did a project with a group of people where we had to filter water and overall ours was the most successful of all of them. Basically, we had the worst quality water and got to the cleanest. I'm not sure if it was safe to drink considering we used carbonated carbonated, rocks, sand and carbon filter, however, it still worked well.

Interviewer: Awesome. So, this I kind of successful experience and working on that really made you feel like you could do this. Like it was something you could continue to pursue

Nolan: Yes.

Interviewer: Awesome. Is there ever a time or or any instances where you did not feel successful in STEM?

Nolan: That would have been last semester of high school where we had a senior design project that if we didn't have COVID probably would have failed miserably. That is being completely honest, it was we were, me and my partner were a tiny bit over ambitious and did not have the technical skills, nor the time to gain the technical skills to do it.

Interviewer: Gotcha.

Nolan: Which is our fault. We kind of overestimated ourselves in the rush and underestimate the time consumption of the project. So in that case if it didn't get cancelled because of COVID that would have failed. I'm pretty sure.

Interviewer: All right. So, what, what was this project for? Was it a class or

Nolan: It was. I went to (a technical school). See, it's a technical program and had the engineering program in it. And at the end of your senior year you're supposed to take everything that you learned to make a senior design project. It's supposed to mimic the senior design project in college, however a little bit more guidance, a little a less time intensive and that was to say the least a mess.

Interviewer: Gotcha. Interesting. How do you, do you think that you did that experience. Do you feel like it. And I know you're only now a semester in in college, but do you feel like in your engineering track this experience, it maybe prepared you in any way for for your career for your major.

Nolan: A little bit if. Not everything is straightforward like it had been up to then. Because everything else was like oh worksheets, physics, math. And so the Pre and you're just taught it and instead of doing it yourself and having everything yourself. It was kind of like a hit in the face, like, oh, this is a lot harder than I thought it was

Interviewer: Yeah, I mean, that makes sense, a lot of sense for sure. What are some, when you think about your future and in the STEM career and engineering and all those things like, what are some of the, what are some of the advantages to having a career in engineering?

Nolan: Two answers here. One is a generalized answer. And one's a specific answer. First generalized answer is that they pay well and that there's always going to be a job there because you always need somebody who can innovate and invent. However for me specifically it's because I like innovation and inventing things as well as working on teaching, I'm trying to think how to say this. Learning more about something I didn't know before and eventually I want to get to the point where I can make something that hasn't been made before

Interviewer: Yeah. That's awesome. That's definitely something that's cool in your field as you have those opportunities. I think that's really neat. What are some drawbacks in STEM careers?

Nolan: They're time consuming and extremely difficult. Those are the two major drawbacks. It's not just a, you have to be smart enough to do it. You have to be creative enough to do it. And you have to be in have to work hard enough to do it. And all of those things are individually difficult, put together and makes it so much harder.

Interviewer: Yeah, absolutely. I mean, I definitely do see what you're saying there. Okay, so now I want you to think about, again, going back to your experiences prior to college. I want you to think about some of the things that you did at some point, any activity that you participated in. Whether that be a school project a, you know, something you did outside of school, anything like that. What are some specific experiences you remember that had an impact on your confidence to participate in STEM. I know you already mentioned the project sophomore year. Is there anything else that stands out to you.

Nolan: Let's see, I was part of a robotics team for a year and we did well we made it to state. We didn't win, but we made it there. And that was kind of, That was one of the things that I did, but in all honesty, didn't enjoy. It was something that I'm like okay I can do this. It's just not what I want to be for the rest of my life.

Other than that. I did help out at a stem camp once for a summer, and that was not I didn't really build anything there are more or less help teach students and help them along in their projects and stuff or for those kind of I don't know. It was just nice to see other people taking an interest in trying to foster and interest in it. That just really stuck out to me for it was like helping the next generation.

Interviewer: That's awesome. Okay, so now I want you to think about, think about the teachers that you had, again, high school, elementary, middle school, whenever I want you to consider, you know, are there any teachers that you would say were particularly influential for you in terms of your STEM pursuit. And I say influential and I mean this influential positively or negatively. Are there any teachers that stand out to you that were influential to you and what was it about them that made them that way?

Nolan: First, just going in chronological order, my sophomore in high school teacher for the STEM class I took the one where I did the water filter was very, very supportive of us. And following your own ideas out even if they failed. And he was honestly one of the best teachers I've ever had. He helped a lot of kids including myself foster interest for STEM. And then the other two that I could think of that were influential is, one my physics teacher because he was the one that taught one of the engineering classes for my junior year. And he helped me. He was influential both positively and negatively. He let us figure it out ourselves and didn’t offer a lot of help. Which is both good and bad thing, because it let us think for ourselves without somebody guiding us along. At the same time it made life harder. Yeah. So overall, was positive, but at the time it felt like kind of an (inaudible) thing.

Another teacher was my math teacher. She just had a tendency to push us very hard to get stuff done, and be the best we could be. She helped. I don't think she is nearly as influential as the other two. But it was she did show most of us how to actually improve ourselves, instead of just staying where you’re at.

Interviewer: That's fantastic, and sounds like you had a collection of pretty good teachers in your, in your school. What about outside of teachers, think about other maybe influential people in your life to do so. I think maybe your family, family, friends, anything like that. Did you have any other people that really were big influences for you?

Nolan: My mom for the first probably 12 years of my life. She was the one who taught me for the most part. I'm, basically, she just wanted me to have a good foundation for wherever I want to do. And kept throwing math books at me. She also helped a lot in being able to take care of myself in general. Like, not only in just in general life teaching skills I needed. Overall also how to just function as a human being.

Interviewer: Yeah.

Nolan: Other than that, there's, other people have had influence but they aren't STEM related so

Interviewer: Okay. Um, alright, so I'm kind of nearing the end here. Are there any, are there any obstacles that you can identify that you've had to overcome on your path to where you are now?

Nolan: Not giving up. That's the most direct one because whether it was in high school or in college. Everything has been for the most part, difficult, and there's times where I go. Okay. I don't think this is going to work. And I just have to persevere through it and hope it gets better. It's kind of the light at the end of the tunnel. Just hard. That's it.

Interviewer: Yeah, absolutely. Alright so thing I've asked you about a lot of different influences and things that you've experienced today, is there anything else you can think of in terms of you getting to this point where you know you're interested in STEM. Is there anything else I haven't asked you about that you feel like was impactful or meaningful to you in your journey to your current major and career choice?

Nolan: The only thing that was kind of, it's been impactful is college related since then. Because most of the high school stuff or at most of the stuff was mostly in high school. It was only about three events. Since college. It's been trying out different things, I mean. This is not what I want to do, and also interacting with upper classmen and that. Honestly, they're kind of a reality check. They go, yeah, this is how everyone feels. Yeah, we all know, we're all here for you.

Interviewer: Okay, well, that's it. That's all the questions I have for you today. I really appreciate your insights and it's kind of interesting always to hear someone's journey as they get from place to place because each of us have our own paths here and there. And so I appreciate you sharing or with me. That's really beneficial to me, my goal. And all this is just to continue to make STEM experiences better for all students. Whether they end up in STEM fields or not. I just want to, I want to provide more resources for teachers and for students to know where you know what what type of resources are available and out there. So that's part of what my research is going towards and what I'm hoping to do.

VITA

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Doctor of Philosophy

Dissertation: PRE-COLLEGE STEM LEARNING EXPERIENCES AND THEIR EFFECT ON UNDERGRADUATES' STEM SELF-EFFICACY, OUTCOMES, INTERESTS, AND GOALS: A MIXED-METHODS STUDY

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