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College Students' Decision Making and Experiences in Changing Their STEM Major and Their Career Choice

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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Science, technology, engineering, and mathematics (STEM) education continues to be a priority to the United States. A large body of research exists around the topic of STEM education and retention in STEM majors in higher education, yet there continues to be a low retention rate in STEM fields and a shortage of STEM workers in the United States. The U.S. Bureau of Labor Statistics projected that even with the current focus on the nation's STEM retention, the demand for STEM professionals will outpace the number of qualified people. There is a limited body of knowledge regarding the college students' experiences in changing their STEM major to a non-STEM major in their third year or later. The purpose of this basic qualitative study was to examine STEM college attrition in their third year or later. Lent et al.'s social cognitive career theory and Astin's input-environment-output (I-E-O) model of college student development served as the framework. Three themes emerged from the analysis of interviews with 10 college students at one of California's research institutions. Students experienced poor academic and career fit, mental health issues, and low student satisfaction in their STEM major, which led to their decision to leave STEM. The study also brought to light the importance to STEM retention and attrition of social engagement, mental health, and time management. The positive social change implications of this study are the increased knowledge and understanding of the factors that may contribute to STEM attrition in the later years. The implications and recommendations may improve and inform higher education policy and STEM retention programs.

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Dedication

For Mia and KC, my joy.

For my parents, my first teachers and my first loves.

For James, my kindred soul.

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Chapter 1: Introduction to the Study

The National Science Foundation (2019) acknowledged that in today's era, technology is a vital part of everyday life, yet the United States continues to experience a shortage in science, technology, engineering, and mathematics (STEM) professionals. Increasing STEM employment is important to the country's economic prosperity, national security, and advancement of technology associated with STEM (Chen, 2013; Emekalam, 2019; Evans et al., 2020; Green & Sanderson, 2018). A career in STEM may mean economic mobility for students and their families as STEM degree holders earn more than some of their non-STEM colleagues. According to the U.S. Bureau of Labor of Statistics (2019), the national average annual wage for STEM occupations in 2019 was $86,980, more than double the national average wage for non-STEM occupations ($38,160).

Higher education institutions play a key role in addressing the shortage of STEM professionals. Colleges and universities teach STEM subjects, produce STEM graduates, and conduct STEM research, but they may also contribute to the shortage of STEM professionals by not being as effective as they might in addressing attrition from STEM majors. Research has shown that most STEM attrition in the United States occurs during the college years when compared to elementary, high school, and career STEM attrition (Green & Sanderson, 2018; Moller et al., 2014), particularly in the first 2 years of college (Chen, 2013; Jaradat & Mustafa, 2017; Sklar, 2018; Whitehead, 2018). The aim of this study was to fill the gap in the current literature and add to the existing research by exploring the reasons behind students' choice to leave STEM for a non-STEM major in the third year and beyond.

In this chapter, I present the background of the study, research questions, conceptual framework, and methodological approach to the study. The chapter concludes with definitions, scope, limitations, significance, and impact of the study on higher education policy and social change.

Background

Globally, the United States has fewer STEM graduates than Australia, China, England, Japan, and Russia and U.S. STEM graduates constitute only 10% of the global science and engineering bachelor's degrees (National Science Board, 2018; Sithole et al., 2017). The National Science Board (2018) reported that in the past decade, India and China outpaced the United States in the number of science and engineering bachelor's degrees awarded. The U.S. Bureau of Labor Statistics (2019) projected that even with the current focus on the nation's STEM retention, the demand for STEM professionals will outpace the number of qualified people.

In 2019, President Trump reestablished The President's Council of Advisors on Science and Technology (PCAST, 2020). PCAST (2020) recommended strengthening, growing, and diversifying the U.S. STEM workforce and emphasized the importance of working with industry, government, and academia. The federal government supports programs to improve STEM engagement, achievement, and retention such as bridge programs from high school to community colleges and 4-year institutions (see Prescod et al., 2018). According to the U.S. Bureau of Labor Statistics (2019), over 99% of STEM jobs require some type of college education for entry, and 73% of STEM occupations require a bachelor's degree, compared with 36% of overall employment. A better understanding of STEM attrition in higher education may be used to mitigate the shortage of STEM professionals.

For higher education institutions and policymakers, STEM attrition is a major concern. STEM programs recruit more students than non-STEM majors but half of these STEM-initiated majors do not earn a STEM degree (Chen, 2013; Emekalam, 2019; Green & Sanderson, 2018). Chen's (2013) study is often a point of reference related to STEM attrition because Chen used the latest national data sets starting in 2009 from the National Center for Educational Statistics' (NCES) Beginning Postsecondary Longitudinal Study (BPS:04/09) and the Postsecondary Education Transcript Study (PETS:09). Chen found that 20% of STEM majors change their major to a non-STEM field and 28% drop out of college completely. A later cohort of data was recently released by NCES and will not be available in late 2021. Dropping out of college may also lead to other negative consequences such as financial debt from student loans, limited career opportunities, and low self-esteem (King, 2015).

To further complicate the STEM shortage problem, the U.S. population is changing to be more diverse, but racial and ethnic minority groups are still experiencing high rates of STEM attrition. Racial and ethnic groups (Black/African American, Hispanic/Latinos, American Indians, and Alaska Natives) are underrepresented in STEM fields (National Science Foundation, 2019). The National Science Foundation (2019) reported that underrepresented groups comprise 27% of the U.S. population and are projected to make up 56% of the population by 2060; however, in 2017 they constituted only 11% of the STEM workforce, whereas 70% of workers in science and engineering jobs were White. In college, 53% of underrepresented students who failed their introductory STEM courses left college without a degree (Chen, 2013). Although Black and Latino/a students are as likely to major in STEM as their White peers, Riegle-Crumb et al. (2019) found that STEM is the only field in which Black and Hispanic students are significantly more likely to switch majors and earn a non-STEM degree compared to their White peers.

In response to the STEM retention problem, several studies on STEM retention and persistence in higher education have focused on precollege characteristics and demographics of students at 4-year institutions. Several studies have found that most STEM major changes happen in the first or second year (Chen, 2013; Jaradat & Mustafa, 2017; Sklar, 2018; Whitehead, 2018). The relative lack of literature around the later college years (3rd year and beyond) suggests a gap in the research. The qualitative study on STEM leavers aimed to fill the gap in the current literature and add to the existing research by exploring the reasons behind students' choice to leave STEM for a non-STEM major in the third year and beyond.

Findings from this study may be used to improve strategies that support students in STEM throughout the United States. Research that informs policymakers and leaders on why college students leave STEM majors is needed to reduce STEM attrition and support the success of STEM students. Furthermore, diversifying the STEM workforce can expand the ideas and perspectives needed for the continual advancement of technology (Fouad & Santana, 2017; Hall et al., 2017).

Problem Statement

The research problem was the limited ability of higher education leaders to retain STEM students more effectively in the field and the lack of scholarly understanding of the STEM leavers' experience after the first 2 years of college. Given the rigorous demands of STEM education, there has been an increasing number of studies related to STEM degree completion, persistence, and retention (Chen, 2013; Evans et al., 2020; Sklar, 2018; Xu, 2018) and fewer studies on the perceptions of students who leave STEM (Emekalam, 2019). The few studies on STEM major choice and retention mainly concentrate on precollege characteristics and demographics of students at 4-year institutions. The majority of the research points to factors that influence STEM persistence, particularly academic performance and academic ability (Chen, 2013; Evans et al., 2020; Seymour & Hewitt, 1997; Xu, 2018).

Several studies focused on persistence to graduation and claimed that most students change their major by the end of their second year (Chen, 2013; Jaradat & Mustafa, 2017; Sklar, 2018; Whitehead, 2018). Additional studies focused only on the first 2 years of college (Ashraf et al., 2018; Evans et al., 2020; Hall et al., 2017; Lent et al., 2015; Miller et al., 2015; Whitehead, 2018). Other factors have been studied that might influence attrition in year 3 or later. For instance, researchers have claimed that self-efficacy and science identity are strongly associated with STEM persistence, STEM community integration, and STEM career choice (Kuchynka et al., 2017; Lent et al., 2013, 2015; Miller et al., 2015). Students in their upper class levels may have different interpretations of their academic and social experiences than first-year students, who are new to the institution (Xu, 2018). Accordingly, this study sought to expand understanding of students' experiences by exploring the reasons students leave their STEM major in their third year or beyond.

Purpose Statement

The purpose of this qualitative study was to describe college students' experiences in changing their STEM major in their third year or later. I explored the students' perceptions of their decision-making and their experiences in changing their STEM major and career choice. The phenomenon of interest is STEM attrition in the later college years.

Research Question

What are college students' perceptions of their decision-making and their experiences in changing their STEM major and their career choice in their third year or later?

Conceptual Framework

Lent et al.'s (1994) social cognitive career theory (SCCT) and Astin's (1970) input-environment-output (I-E-O) model of college student development served as the conceptual framework for the study. I used Lent et al.'s theory and Astin's model as a lens through which to examine STEM persistence and STEM attrition. Astin's I-E-O model describes how students' characteristics and their interaction with their educational environment may affect persistence, whereas Lent et al.'s SCCT theory was used to understand STEM persistence as it relates to a student's career choice. I provide background on the SCCT and the I-E-O model in the following sections and a more detailed description in Chapter 2.

SCCT

Lent et al. (1994) developed a theory pertaining to career choice and decision making with the main assumption that self-efficacy beliefs guide human motivation and behavior. Lent et al. (1994) recognized that personal, environmental, and learning experiences and personal capacity to self-motivate and set goals affect career choice. SCCT indicates that students choose their career direction based on the interaction among three cognitive factors: self-efficacy beliefs, outcome expectations, and personal goals (Lent et al., 1994). Self-efficacy is defined as one's belief in their ability to succeed in a task (Bandura, 1986). Outcome expectations reflect one's belief that participation in particular activities will lead to a positive or negative outcome (Lent et al., 1994). The third factor of SCCT is personal goals, which are influenced by self-efficacy and outcome expectations factors. SCCT has been often used to understand the academic and career choice of undergraduates in STEM majors (Byars-Winston & Rogers, 2019; Fouad & Santana, 2017; Kuchynka et al., 2017; Lent et al., 2013; Miller et al., 2015).

In previous studies, The SCCT provided a basis to study factors that contribute to the persistence of racial, ethnic minorities, and women in STEM (see Fouad & Santana, 2017; Miller et al., 2015; Wang, 2013). The SCCT assesses the mechanisms behind academic and career development, career choices, and performance outcomes.

Astin's I-E-O Model

Astin's (1970) I-E-O model was developed to study student involvement in higher education. Astin's model consists of three elements, inputs (I), environment (E), and outputs (O), and has been used to assess how the inputs and the environment affects student outcomes. *Inputs* are defined as student characteristics at the time they start college; *environment* is defined as the different educational experiences, people, policies, and programs that students are exposed to in college; and *output* is the student's characteristics and outcomes after their college experience (Astin, 1970). A key finding of Astin's study (1970) was that students' involvement with their college environment affected student persistence. Astin (1984) defined involvement as "the amount of physical and psychological energy devoted to the college experience and measured by the level of learning, participation, and intensity of the student involvement with their campus experience" (p. 518). The inclusion of Astin's (1970) I-E-O model in this study provided a mechanism to understand how student background and the college environment impact their ability to persist in STEM and college. A more detailed analysis of both SCCT and the I-E-O model is included in Chapter 2.

Nature of the Study

For my qualitative study, I used a basic qualitative research design. Using basic qualitative research design, researchers seek to understand the meaning of a phenomenon or a process based on the perceptions of the people involved (Caelli et al., 2003). Meanings are discovered by focusing on how individuals interpret their experiences with their social environment (Kahlke, 2014).

The studied phenomenon is STEM attrition in the later college years. I collected data through semistructured interviews with 10 college students currently pursuing their bachelor's degree who changed their STEM major to a non-STEM major in their third year or later. By asking open-ended questions in a semistructured interview approach, I allowed participants to speak about their experience in STEM and leaving STEM. I inductively analyzed the interviews to identify recurring patterns and themes.

Definitions

In order to understand the terms used in the study, I define student retention, persistence, attrition, STEM leavers, STEM fields, non-STEM majors, and third year or later.

Student retention in higher education is defined as a student's continued enrollment from the first year to the second year (Burke, 2019; Spady, 1970; Tinto, 1975).

Student persistence often used interchangeably with retention. However, Burke (2019) defined persistence as a student's continued enrollment from Year 2 to graduation. For this study, I used the term student persistence when referring to continued enrollment from Year 2 to graduation.

Attrition or dropout can be defined as permanent or temporary withdrawal, voluntary withdrawal, or academic failure from a program or college (Tinto, 1993).

STEM leavers is the term I used in this study to refer to students who choose to change their STEM major to a non-STEM major or leave STEM by dropping out of college.

STEM fields, for this study*,* are the National Science Foundation's (2019) list of degrees included in its scholarship program: biological sciences (except medicine and other clinical fields); physical sciences (physics, chemistry, astronomy, and materials science), mathematics, statistics, computer and information sciences, technology areas (such as biotechnology), and information technology.

Non-STEM majors refer to studies in the humanities, arts, business, and social sciences in this study.

Third year or later refer to undergraduate students who have junior class standing or higher, which is defined as an undergraduate student who completed 90 or more quarter units at the selected research university.

Assumptions

This qualitative study was based on a few assumptions. One assumption is that participants answered all interview questions open and honestly. Second, I assumed participants were aware of their career choice and decision to leave STEM. Lastly, I assumed that participants were willing to share their experience in STEM and their choice to leave STEM during the interview.

Scope and Delimitations

In this study, I focused on one public research university in California. The public research university is one of 10 universities within the system. The study focused on students who recently changed their major from a STEM field to a non-STEM major in their third year or later (using the National Science Foundation's (2019) list of STEM majors) and excluded students who switched majors in year one or two. The participants included students who started at the 4-year institution.

Limitations

The study was limited to the perceptions and experiences of students at just one research university and may not fully represent the experiences of all STEM leavers in their third year or later. The results may not be transferable to similar populations due to the small sample size, though the findings may have implications for further studies. The study was also limited to the experiences of STEM leavers in a particular period and may not be reflective of STEM leavers in other years. Because I am using the National Science Foundation's (2019) list of majors, it might not apply to other science related majors such as medicine.

A final limitation of the study was the possible bias of the researcher. Because the researcher is an instrument in qualitative research, research bias may affect the formulation of interview questions, data collection, and the data analysis process (Poggenpoel & Myburgh, 2003). As a former advisor for college students majoring in the mathematical and physical sciences, there may be potential bias that led to inaccurate presumptions when I listened to the participants' experiences in STEM. To limit the presence of bias, I used a reflective journal to document my thoughts and feelings throughout the study.

Significance of the Study

The primary goal of the study was to contribute to the body of knowledge that exists on STEM attrition by directly interviewing students who have experienced the

STEM attrition phenomena. By better understanding the STEM attrition, we may help higher education researchers better understand student retention and persistence. The study may also have potential implications for higher education policy related to major changing and selection. The study's findings may add to the knowledge higher education stakeholders have about the causes of STEM attrition and may be used to implement strategies that better support STEM majors and STEM leavers. They may also help students overcome barriers from completing their original major, or support students in major transition. The findings of the study may have a positive impact on social change by possibly influencing policy related to enrollment, change of major, and student support services including admissions, counseling, academic advising, career counseling, and student orientation. By better understanding the experience of STEM leavers, higher education institutions may be able to improve graduation rates, lower student costs, save students time, and increase college and career satisfaction.

Summary

Increasing STEM employment is important to the United States' future (Chen, 2013; Emekalam, 2019; Evans et al., 2020). Higher education institutions are key partners for addressing the STEM shortage in the United States. Given the demand to increase STEM retention in college, a body of knowledge exists around STEM retention but there is still a shortage of STEM professionals. The U.S. Bureau of Labor Statistics (2019) projected that even with the current focus on the nation's STEM retention the demand for STEM professionals will outpace the number of qualified people. The study sought to contribute to the knowledge around STEM leavers.

Chapter 2 consists of a literature review of research related to retention, persistence, and attrition in higher education, particularly in the STEM fields. I will also discuss the literature search and the conceptual framework.

Chapter 2: Literature Review

The research problem was the lack of scholarly understanding of the STEM leavers' experience after the first 2 years of college. The purpose of the study was to describe college students' experiences in changing their STEM major in their third year or later. The study aimed to provide more knowledge in the limited research around STEM leavers and the lack of research investigating their experience in STEM and their choice to change to a non-STEM degree in the third year or later. The literature review presents the multifaceted areas of student retention and persistence, STEM retention and persistence, major selection, career choice, and STEM attrition literature.

The chapter starts with a description of the literature research strategy as well as Astin's (1970) I-E-O model and Lent et al.'s (1994) SCCT as the framework chosen for the study. I then analyze the research on how various variables are linked to STEM persistence. The chapter concludes with a summary of the themes in the literature and how the study may extend the knowledge about STEM persistence.

Literature Search Strategy

My literature review began with a thorough search for peer-reviewed articles in electronic databases in education, social sciences, and STEM that focused on student retention and persistence in STEM. Databases included Education Source, Education Resources Information Center (ERIC), PsychINFO, Sage Premier, ProQuest Central Academic Search, and Science Direct.

Next, I examined peer-reviewed and empirical articles from 2000 to 2019 related to retention, persistence, and attrition in higher education. I narrowed my search to peer-reviewed articles within the last 5 years and searched for specific terms: *major choice in higher education*, *career choice*, *persistence*, and *retention*. I realized that there were articles related to retention among various student groups, so I reviewed articles on retention for female, Latino/a, Black students, student athletes, and first-generation students. I also searched *retention, persistence, and attrition in STEM careers*. Reviewing articles on STEM career choice led to peer-reviewed articles of self-efficacy. Finally, I searched for articles related to self-efficacy and the SCCT.

Conceptual Foundation

Astin's (1970) I-E-O model and Lent et al.'s (1994) SCCT were used as the conceptual foundation for the study. Both the I-E-O model and the SCCT were used to guide the development of the interview questions. This section addresses the literature surrounding the I-E-O model and the SCCT.

Astin's I-E-O Model

Astin (1970) presented the I-E-O model to explain the influence of the college environment on student development. This model recognized and explained the interactions between the input, environment, and output factors. In the I-E-O model, inputs are personal qualities that the student brings to the educational program (Astin, 1970). *Inputs* are defined as the pre-college environments (e.g., family, math and science high school courses, and SAT/ACT scores), student demographics, and academic performance. Inputs may affect the college environment as well as the outputs being measured. The college environment encompasses any interactions and relationships a student experiences in college including the institutional culture, school policies, facilities, curriculum, and teaching (Astin, 1970). Astin defined *outputs* as "the measures of the student's achievements, knowledge, skills, values, attitudes, aspirations, interests, and daily activities" after college (p. 224).

Astin's (1970) I-E-O model was used to study the relationship between student inputs to the college environment, the relationship between the college environment and student outputs, and the relationship between student input and output. Astin theorized that the influence of student input on output depends on the college environment and the effect of college environment depends on the type of student. The impact of the college environment and the focus on student outcomes in Astin's model can be applied and has been applied to student persistence or attrition models.

Through the years, Astin expanded his theory by introducing the concept of student involvement on student learning and change. Astin (1984) described student involvement as the amount of energy a student devotes to their college experience. Like the Freudian concept of cathexis, Astin pointed out that students could invest energy in others and their environment. He claimed a highly involved student is typically a student, who devotes a large amount of their time to studying, actively participates in student organizations, spends time on campus, and frequently interacts with faculty. On the other hand, an uninvolved student may spend little time studying, does not participate in school activities, and has minimal contact with faculty and other students. His theory suggests that student learning and outcomes are not just the result of the college environment but are also a product of the level of student involvement in college (Astin, 1984). Astin's

(1970) student involvement theory has been the foundation for modern persistence and retention theories.

SCCT

Built from Bandura's (1986) social-cognitive theory, Lent et al.'s (1994) SCCT indicates that students choose their educational or career directions based on the interaction between three cognitive variables: self-efficacy beliefs, outcome expectations, and personal goals. The outcome expectations variable pertains to one's belief that participation in particular activities will lead to a positive or negative outcome (Lent et al., 1994). Bandura identified different types of outcome expectations: physical outcomes (e.g., money), social outcomes (e.g., approval), and self-evaluative (e.g., self-satisfaction). Lent et al. argued that self-efficacy and outcome expectations directly and indirectly influence an individual's career interests, goals, and performance.

Out of the two factors, self-efficacy is a stronger influence on behavior than outcome expectation (Lent et al., 1994). For example, a student may anticipate that physicians can expect a high salary and approval from family and friends but based on their doubts on their science capability may choose another career. Self-efficacy is defined as one's belief in their ability to succeed in a task (Bandura, 1986). In the social cognitive view, self-efficacy is a "dynamic set of self-beliefs" that is formed by experiences and behaviors (Lent et al., 1994). A student may choose their major based on their belief of their performance in that subject. For instance, a student who feels a low self-efficacy in math may think that math is not the major for them. Their past performances in math may have them convinced that they do not have what it takes to be a math major. Bandura (1986) argued that self-efficacy is a mindset and determinant of behavior, effort, persistence, thought patterns, and emotional reactions when confronted with challenges. Outcome expectations may be more influential in certain scenarios. For example, a student who has a high self-efficacy in math may choose a non-math career if she expects negative outcomes like work and family conflicts.

Another SCCT assumption was that students are able to establish short- or long-term goals and participate in activities to help them attain their goals. Bandura (1986) defined goals as the determination to engage in a particular activity for a desired future outcome. For example, a student who set a goal to work in a particular field or earn a certain grade point average (GPA) may take on more rigorous study habits. Lent et al. (1994) theorized that goals are self-motivating because goal fulfillment can be linked to self-satisfaction. They also recognized that reaching a goal or failure to reach a goal could also validate a person's choice and beliefs.

The SCCT assumes that personal inputs like race, ethnicity, and gender may influence self-efficacy, career interests, career choice, and goals. Lent et al. (1994) viewed race, ethnicity, and gender as social constructs that shape career-related experiences and the career development process. For example, girls may have a low self-efficacy in math and science based on the assumption that boys are better in math than girls or certain cultures may promote a particular career.

The SCCT also holds that contextual determinants are environmental influences that may affect academic and career choice: proximal (e.g., personal career network, structural barriers) and background influences (e.g., exposure to mentors or role models in a specific career). Lent et al. (1994) theorized that one's perception of support, opportunities, and barriers are unique to one's own beliefs, and a person plays an active role in the interpretation of their environment.

The SCCT has continued to be the major theoretical framework used to study factors that contribute to the persistence of racial, ethnic minorities, and women in STEM (Byars-Winston & Rogers, 2019; Fouad & Santana, 2017; Lent et al., 2013; Lent et al., 2015; Miller et al., 2015). In 2013, Lent et al. created an integrative model of SCCT for investigating STEM career trajectory by combining the interest, choice, and performance model to predict persistence. They tested their holistic model on over 1,300 first-year engineering students at two historically Black universities and two predominantly White universities. Aligning with the SCCT career model, Lent et al. (2013) found that student interests predicted satisfaction, which predicted persistence, regardless of race or gender; but there is no direct association with interests to persistence. Lent et al. (2015) followed up with the engineering students they assessed as freshman in their 2013 study and found that self-efficacy was the strongest predictor of academic satisfaction and persistence. They found that self-efficacy in the first semester (Time 1) predicted academic satisfaction and persistence in the later semesters.

The majority of SCCT research has used quantitative methods but Miller et al. (2015) suggested that the SCCT model could be used qualitatively to capture more individually oriented research that could identify specific supports and barriers and such data could be used to inform retention efforts in STEM education and to understand complex views of the social contexts of students major/career choices. Fouad and

Santana (2017) asserted that SCCT could be an asset for higher education practitioners because it points to areas of intervention that can influence career decision making. They conducted a review of research that has used SCCT as a framework to investigate factors that may explain STEM choices, career decisions, and the barriers related STEM career access and found that the use of the integrated SCCT model had consistent results with the Lent et al. (2013) study. Fouad and Santana suggested that future research focus on understanding the key points of intervention to help improve students' self-efficacy beliefs and better understanding of the role of contextual supports such as professors, financial aid, mentors, or research experiences. The SCCT and Astin's I-E-O model were used as the study's framework to guide the construction of interview questions.

Empirical Literature Review Related to Key Factors and Concepts

There are various factors that may affect a student's choice to stay in STEM, which I address in this literature review: pre-college environment and high school math and science courses, race/ethnicity, first-generation status, gender, high school math and science courses, institutional factors, and social factors. The next section addresses the literature around these factors and how they relate to STEM persistence, retention, and attrition, beginning with a discussion of STEM attrition by class level.

STEM Attrition by Class Level

Past studies have shown that about 50% of students who enter STEM majors never earn a STEM degree (Chen, 2013; King, 2015). Chen's (2013) seminal study found that most first-year students (87%), regardless of major, enrolled in one or more STEM courses in their first year. About half (48%) of the students changed their STEM major after their first year (Chen, 2013; Jaradat & Mustafa, 2017) and in general, most major changes happen by the end of the second year (Sklar, 2018; Whitehead, 2018). Research related to SCCT and first-year engineering students found that self-efficacy was a predictor of academic satisfaction and persistence in STEM in the later years of college (Lent et al., 2015; Miller et al., 2015). The first-year experience is described in more detail in a later section of this chapter.

There is limited research that focuses on STEM attrition in the third year and beyond. Xu (2018) surveyed 404 college students in STEM majors at three public universities in Tennessee to examine their learning experiences and to identify factors that influence persistence. Xu found that class level itself became a significant factor to student's drop out intentions. Sklar (2018) described two distinct groups of major changers: the early changers, who modify their major during the first year, and the late changers, who modified their major in their sophomore year. Both Xu and Sklar suggested future research to examine the factors of changing majors later in a student's college career. The next sections address the literature on precollege environment and high school math and science courses, race/ethnicity, first-generation status, gender, high school math and science courses, institutional factors, and social factors that may affect a student's choice to stay in STEM, and some of that research included class level as a factor.

Precollege Characteristics and High School Math and Science Preparation

Astin (1970) and Tinto (1975) suggested that students matriculate to institutions of higher education from a variety of precollege environments and with a variety of characteristics. The research indicated that a student's personal traits, high school experience, and family context influence major choice and college persistence (Tinto, 2006; Xu & Weber, 2018). Researchers found that many students decide to major in STEM while they are in high school, and the strongest predictors to choosing STEM is their interest in STEM, taking rigorous high school courses, and their confidence in the STEM abilities (Evans et al.,2020; Moller et al., 2014). Research showed that K-12 classroom teachers are typically the first educators to foster and create awareness about STEM in students (Moller et al., 2014; Whitehead, 2018). Moller et al. (2014) interviewed STEM professionals and found that teachers who shared their excitement about STEM in the classroom were influential in participants' decisions to pursue a STEM major. Lack of exposure to STEM professionals during K-12 years can result in underrepresented students believing that STEM careers are not for them (Dewsbury et al., 2019; Syed et al., 2011).

Using regression analysis of data from the National Center of Education Statistics, Green and Sanderson (2018) analyzed the impact of high school math and science preparation, self-efficacy, and postsecondary educational experiences of college students on persistence and attainment in STEM. The findings indicated that high school math and science preparation, not collegiate educational experiences, was a strong predictor of success in STEM fields. For incoming non-STEM college students, taking calculus in high school increased the likelihood that they would switch to STEM by 29% compared to students who took less than high school precalculus (Green & Sanderson, 2018). Green and Sanderson concluded that students with a weaker math background might have to take remedial math courses in college to declare a STEM major, which may take them longer to graduate. Evans et al. (2020) found a positive association with math self-efficacy and the likelihood of a student declaring STEM. Moakler and Kim (2014) suggested that math self-efficacy increases when a student is successful in math, which then decreases their stress and provides a positive view on math. Brown et al. (2017) found that teachers might play an important role in the development of math self-efficacy and STEM self-efficacy by providing an engaging learning environment.

Although background characteristics like race/ethnicity, gender, and high school experience may impact persistence, researchers have concluded that they fail to predict student success on their own (Kuh et al., 2005; Xu & Weber, 2018). According to Xu and Weber (2018), student demographics had no significant relationships with attrition or changing majors. Student demographics may have an indirect impact on degree completion, and institutions have little control over a student's prior experiences (Adelman, 2006; Xu & Weber, 2018).

Demographic Variables

In this section, I review literature on students' race and ethnicity, first generation status, and gender.

Race and Ethnicity

The share of STEM degrees have been on the gradual rise among underrepresented groups (Black/African American, American Indian/Alaskan, Hispanic/Latino/a) in the United States since 1996 (National Science Foundation, 2019). Despite the growing representation of underrepresented students at higher education institutions, research using national representative samples suggested that White and Asian students persist and earn STEM degrees at almost twice the rate of underrepresented groups (Chen, 2009; National Science Board, 2018). Although Latino/a students' mathematics performance in elementary school is comparable to White students', Latino/a are underrepresented in STEM professions (Moller et al., 2014).

Riegle-Crumb et al. (2019) conducted a quantitative study using national data to examine whether the patterns of Black and Latino/a STEM students differed from Black and Latino/a in non-STEM fields. Using a multivariate analysis, Riegle-Crumb et al. found that there was little difference in declaring a STEM major between Latino/a (20%), Black (18%), and White students (19%). However, 40% of Black students and 37% of Latino/a students switched out of their STEM major compared to 29% of White students (Riegle-Crumb et al., 2019). Regarding dropout rates, Latino/a (20%) and Black (26%) STEM majors left college without a degree at a higher rate than White STEM majors (13%) (Riegle-Crumb et al., 2019). However, in business and social sciences there was not a statistically significant difference among Latino/a, Black, and White students switching out of the major; Black students were significantly less likely to switch out of their humanities major than White students (Riegle-Crumb et al., 2019). Riegle-Crumb et al. hypothesized that the difference among underrepresented majors may have to do with the STEM classroom environment and suggested that future studies focus on why STEM students of color are dropping out.

Research has suggested that there are various factors that contribute to the STEM achievement gap among underrepresented students. Tinto's (1993) model theorized that race/ethnicity shape a student's perspective about their education and may affect their academic and social integration. Stereotypes about being inferior in STEM and lack of community may lead underrepresented students to leave STEM or college, altogether (Tinto, 2006; see in Fouad & Santana, 2017; Riegle-Crumb et al., 2019). Racism may also directly affect underrepresented students' career choice (see in Fouad & Santana, 2017). Hall et al. (2017) found that ethnic discrimination was negatively associated with academic efficacy and both science and math efficacy among ethnic groups.

First Generation

First generation students are the first in their family to attend college and earn a college degree. According to the National Science Foundation (2019), White and Asian male students in STEM are more likely to come from families that have similar STEM higher education background than underrepresented ethnic students. First generation students in STEM may not receive the encouragement or advice from their parents that is needed to be successful in STEM (Dewsbury et al., 2019). Students with parents in STEM fields have the advantage of tapping into their parents' perspective and their STEM network, which may affect their choice to major in STEM and persist (Fernandez et al., 2008; Lent et al., 2013; Moakler & Kim, 2014).

Hilts et al. (2018) studied whether undergraduate STEM students' perceptions of their competence and relatedness to their peers influenced their performance and intent to leave STEM and whether social supports had an effect on their perception of their STEM competence and relatedness. Hilt et al. found similar levels of social support, competence, and relatedness reported by all students; however, in the multi-group path analysis, first generation STEM students highly valued classroom contact and the value they placed on friend and STEM peers majoring in STEM had a direct effect to STEM persistence. Hilts et al. suggested that future research should focus on the intersectionality in underrepresented students (gender, race/ethnicity, and first generation) and how it affects their perceptions of competence and how it influences STEM retention.

Gender

Gender is another demographic variable that influences STEM persistence. Researchers found that women are more likely to graduate college but are less likely to complete STEM degrees, even when controlling for ability and math preparation (Green & Sanderson, 2018). Female students are less likely to declare a STEM major than male students (National Science Board, 2018; National Science Foundation, 2019). Evans et al. (2020) found that the likelihood of a female student declaring a STEM major after 2 years was 66% lower than their male peers. Moreover, the odds of female engineering students switching majors were higher than for females in other majors (Sklar, 2018). Chen (2013) found that 29% of female students who declared STEM majors earned STEM degrees, while 40% of male STEM students earned STEM degrees.

Research points to different reasons for the gender gap in STEM. Ost (2010) found that female STEM students were more likely to leave STEM majors than male STEM students even if they had stronger grades in non-STEM fields. Gender discrimination is another factor explored to explain for STEM attrition among women in science and engineering (see Kuchynka et al., 2017). Fouad and Santana (2017) asserted in their conclusion that the focus of retaining women in STEM tends to focus on "fixing" women to fit in the male-dominated STEM culture. On the contrary, in a qualitative study, fewer than 2% of female participant respondents indicated that gender discrimination hindered their success in engineering (Miller et al., 2015). Miller et al. (2015) noted that their interview questions did not directly ask about gender-related factors and suggested that future researchers could explicitly ask gender-related questions to elicit more detailed information to better understand the experiences of engineering students.

Kuchynka et al. (2017) conducted a study surrounding the experience of female undergraduate students in STEM and how their perceptions of sexism (hostile or benevolent) influenced STEM retention. Their quantitative study at a large, Southeastern public university in the United States found that women in STEM experience gender stereotypes such as a lack of STEM aptitude and these stereotypes affected STEM major intentions, STEM self-efficacy, and STEM performance. Women perceived more benevolent sexism than hostile sexism in STEM and it predicted lower STEM major intentions, self-efficacy, and GPA in female students who were weakly invested in STEM (Kuchynka et al., 2017). Kuchynka et al. (2017) defined benevolent sexism as the "affectively positive but condescending attitudes and reactions to women who embrace traditional gender roles" (pg. 1).

Institutional Practices

Students enter college from various backgrounds and carry different academic abilities and social influences. The college experience and their performance in STEM may either build their interest in STEM or sway them to major in a non-STEM field or leave college. Research shows that institutional practices such as quality of the academic program, instruction, and classroom environment may influence STEM persistence (King, 2015; Miller et al., 2015; Xu, 2018). Xu (2018) found the perceived quality of the academic program and the accessibility to faculty increased their intent to persist in STEM and degree completion. In this section, I review the research on the first-year college curriculum, academic advising, and grading practices as it relates to STEM major persistence and attrition.

The First-Year College Curriculum

The first-year college curriculum may also be a factor on whether a student leaves STEM. Research about the first-year student experience suggests that weaker first-year performance increases the likelihood of STEM attrition and college dropout rates (Adelman, 2006; Chen, 2013; Ost, 2010; Seymour & Hewitt, 1997; Xu, 2018). STEM courses tend to require multiple prerequisites, which could be another potential barrier that impacts STEM major persistence (King, 2015). Evans et al. (2020) found that earning credits in introductory science laboratory courses and advanced college math courses increased the likelihood of a student choosing a STEM major. Their findings highlight the need to engage STEM students early in the laboratory experience in college.

Miller et al. (2015) used the SCCT in a qualitative study to examine the factors that either hinder or enable first-year students' adjustment to engineering majors and that inform self-efficacy beliefs and outcome expectations in pursuit of an engineering career. Miller et al. found that internal academic barriers (e.g. poor test performance) and development skill deficits, such as time management, were the most frequently mentioned challenge.

Academic Advising

Academic advising may be another factor that influences major selection and persistence in a student's chosen major. Tinto (2006) found that advising supports retention when advisors help students with selecting a major and provide guidance in navigating college. In qualitative studies, using the SCCT model, students reported inadequate advising as a major barrier to success in engineering (Fernandez et al., 2008; Miller et al., 2015) However, Jaradat and Mustafa (2017) collected survey data from 1,725 undergraduate students from all year levels and suggested that academic advisors have no influence on major selection, but when students receive academic advising throughout their college years, the possibilities of major-changing significantly decreases.

Grading Practices

Curved graded courses, a common practice in STEM courses, forces students to compete with each other for the top grades in the class. Studies found that the competitive environment of curved grading focused on performance versus learning and made students feel that they had to prove that they deserved to remain in STEM majors (King, 2015; Seymour & Hewitt, 1997).

Social Factors

Numerous social factors may contribute to the selection of STEM majors and STEM persistence. Social engagement is considered an important part of the college experience (Kuh et al., 2005; Tinto, 1975) Whitehead (2018) found family members and high school educators played an early influence in STEM major in interviews with four first-year undergraduate students at a mid-Atlantic university and others have found students' major choice was highly influenced by their parents and peers (Chen & Soldner, 2013; Rice et al., 2013). However, Xu (2018) found that social engagement with peers in college did not seem to affect STEM persistence. Relationships with STEM professors may influence STEM major persistence (Tuthill & Berestecky, 2017). On the contrary, some researchers found that faculty interaction might not have a direct effect or be statistically significant in regards to the decision to choose STEM (Evans et al., 2020; Green & Sanderson, 2018).

Impact of Changing Majors

Changing majors, especially in the later years, may have a detrimental impact on students. A change of major may have implications for a student's academic future and later life, and the most frequently identified life regret for U.S. college graduates (Fain, 2017; Roese & Summerville, 2005). Ashraf et al. (2018) found that 87% of students who took 8 or more years to graduate had switched their original majors. King (2015) suggested that changing majors also negatively affects the ability to find a career after college. Ashraf et al. concluded that students switched their major because it did not match their interests, career goals, or abilities. Researchers found that students will likely change majors in college and they most likely changed their majors at the end of the second year (Jaradat & Mustafa, 2017; Sklar, 2018; Whitehead, 2018).

Students who change their major are more likely to have had low levels of self-efficacy and are more prone to self-doubt (Cunningham & Smothers, 2010; Sklar, 2018).

They also have been found to experience higher levels of anxiety when it comes to academic and career decisions (Cunningham & Smothers, 2010; Sklar, 2018).

Impact of Changing Majors - STEM

Sklar (2018) specifically studied major changing in STEM disciplines. Using a discrete-time event history analysis method to study the likelihood of changing STEM majors for a cohort of first-time first-year students at the California Polytechnic State University, Sklar (2018) found that students who had initially declared STEM majors were at higher risk of changing majors than other students from non-STEM majors.

Seymour and Hewitt's (1997) ethnographic study of 335 students at seven institutions is the most often referenced qualitative study in the literature. They interviewed students that left their STEM majors for a non-STEM major. The study found that the STEM classroom environment and dissatisfaction with the coursework led students to leave their STEM major (Seymour & Hewitt, 1997). The study is now over 20 years old and may not be reflective on the experience of the new generation of STEM leavers. More recent qualitative research can contribute to the on-going discussion about STEM persistence.

Career Development in STEM

Many factors may influence a students' decision to leave their STEM major. Prescod et al. (2018) suggested that career development theory could provide additional insight into the factors that influence a STEM-interested student to select a non-STEM career. Prescod et al. studied negative career thoughts in declared and undeclared STEM students and found significant differences between both groups. Prescod et al. found that undeclared, but STEM-interested students reported greater negative career thoughts. Using Kuh et al.'s (2005) student engagement model, Jaradat and Mustafa (2017) found career advancement opportunities, job opportunities, and a student's interests may have a strong relationship with major selection.

Summary and Conclusions

Using the literature presented in Chapter 2, I provided an analysis of factors that may affect a student's choice to stay in STEM, such as pre-college environment and high school math and science courses, race/ethnicity, first-generation status, gender, high school math and science courses, institutional factors, and social factors. I also examined the impacts of changing majors and the influence of family, friends, faculty, academic advising, and career development on their decision to leave STEM. A recurring theme in the literature is the interaction among the different factors on STEM persistence. The conceptual framework provides two different contextual lens to understand STEM attrition. The qualitative study on STEM leavers aimed to fill the gap in the current literature and add to the existing literature by exploring the reasons behind an undergraduate's choice to leave STEM for a non-STEM major. The study expands on the knowledge related to STEM attrition and explores the student experience related to a student's departure from STEM.

In Chapter 3, I review the methodology used in this basic qualitative design study. I also discuss the data collection and data analysis plan and address issues of trustworthiness and ethical procedures.

Chapter 3: Research Method

The purpose of the study was to describe college students' experiences in changing their STEM major in their third year or later. In this chapter, I explore the basic qualitative method for the study. I present a detailed description of the qualitative research design, methodology, procedures for data collection, and the data analysis process. I discuss my role as the researcher and how it relates to the data collection process. Lastly, I address issues of trustworthiness and ethical procedures.

Research Design and Rationale

The research question of the study was: What are college students' perceptions of their decision-making and their experiences in changing their STEM major and career choice in their third year or later? The research question was explored using a basic qualitative inquiry. The overall purpose of basic qualitative design is to understand how people make sense of their lives and their experiences (Merriam & Tisdell, 2016). Basic qualitative design can be found in various disciplines but is the most common form of qualitative research found in education (Merriam & Tisdell, 2016). Based on constructivism, basic qualitative research acknowledges that people construct meaning as they engage with the world. The goal of basic qualitative research is to interpret meaning. I decided on the basic qualitative research design because it is not guided by a specific or traditional philosophical assumption like the other qualitative research approaches (Caelli et al., 2003). The basic qualitative design allowed me to explore social and institutional factors through interviews as they relate to student engagement, self-efficacy, student satisfaction, persistence, and career interests and goals.

The narrative approach in qualitative study focuses on stories to examine human experiences through the lens of the narrative (Patton, 2015). Patton (2015) described stories as a mechanism to communicate, organize, and shape the human experience. Personal narratives and family stories are examples of how humans can reveal cultural and social meaning through a person's lived experience. Researchers then transcribe, analyze for patterns, and reveal themes to help understand specific individuals and the society and culture (Patton, 2015). Because the focus of my study was on the meaning of the students' experiences versus the content of their stories, the narrative approach was not a suitable fit.

Role of the Researcher

My role as the researcher was to serve as the main instrument of the data collection process. Through the facilitative interaction with the participants, the researcher creates a context where participants share their experiences, which provides the rich data for the study (Poggenpoel & Myburgh, 2003). During the interviews, I asked open-ended questions and follow up questions to the participants. I listened to the participants, observed them during the interviews, and kept a researcher's journal. After the interviews, I examined the transcripts of the interviews and generated codes, categories, and themes.

Biases can affect the reliability and validity of research findings in a qualitative study (Patton, 2015). My previous job as a mathematical and physical sciences academic advisor may influence my analysis of the study. One of my previous duties was to help guide students majoring in math, physics, chemistry, statistics, and computer science. To help alleviate my bias, I used a reflective journal to document my thoughts during the interview process. I no longer work directly with STEM undergraduate students and did not interview students who I advised in the past.

Methodology

The methodology section includes a detailed explanation of the logic of participation selection, instrumentation, and the data analysis plan of the basic qualitative design.

Participant Selection Logic

The criteria for the population for this study were college students in their third year or later who changed their STEM major to a non-STEM major. I selected students who majored in chemistry, biology, mathematics, physics, geology, statistics, computer science, and engineering. The population of students included full- or part-time students with no age limitations. The study excluded transfer students and only included students who started at the 4-year college as a freshman. The college under study was a 4-year, public research institution located in Northern California.

Sample Size

According to Mason (2010), the scope of the study, the population being studied, and the research design are a few factors to consider when thinking about the sample size and data saturation for the study. For qualitative research, Patton (2002) suggested that saturation could be reached with between one to 10 participants. Accordingly, on the assumption of being able to reach saturation, I interviewed 10 participants.

Recruiting Participants

The college under study and Walden University required institutional review board (IRB) approval. Upon approval from both institutions, using purposeful sampling, the STEM program advisors and program chairs assisted in identifying students who changed their major to a non-STEM major in their third year or later through the college's registration database. The advisors assisted me in e-mailing the students' basic information about the study.

I emailed participants the Walden IRB-approved consent form before they participated in the study. I provided an information guide to all my participants, which included the purpose of the study, what to expect during the interview, and the use of pseudonyms to protect their identity, and logistical information about the interview schedule. I informed the participants that I could provide them a copy of their interview transcript and the results of the study. The first 10 respondents who met the minimum qualifications of the study and provided consent were included in my study.

Data Collection

After receiving IRB approval (Approval No. 03-23-21-0655301), I conducted semistructured, one-on-one interviews as my data collection method, instead of focus groups. Merriam and Tisdell (2016) suggested that the main difference between focus groups and one-on-one interviews is that in focus group data collection is done in a group setting. A focus group would have been a poor choice for topics that are sensitive, highly personal, and culturally difficulty to talk about in a room of strangers (Merriam & Tisdell, 2016). Because my questions asked about their personal experience with leaving

STEM that may be tied to negative feelings, a focus group would not have been suitable for the study.

I allotted 45-60 minutes for each interview, and my participants could choose to stop the interview at any time. I began each interview with an opening statement, which provided a brief background on myself and the study, and the purpose of the study. After asking my interview questions and probes, I ended with information about the transcript review and next steps. I asked for an additional 10- to 15-minute interview if I had follow-up questions. However, I did not have to ask for any follow-up interviews. If students disclosed mental health challenges or felt emotional distress when talking about their experience in leaving their STEM major, I was ready to offer a list of resources for them to use if they needed mental health support after the interview. However, none of the students reported mental health challenges or emotional distress during or after their interview.

Due to COVID-19, interviews were conducted and recorded using the Zoom videoconferencing platform. The recorded interviews were transcribed by a transcription application called Otter.ai. cloud. After I received the transcriptions, I emailed a copy of the transcript to the participant for review. Participants had 5 days to edit or respond to the transcription. After the 5-day review window, I sent each participant an email of appreciation and an electronic Amazon gift card of $25.

Instrumentation

As I am an instrument in the study, I used an open-ended, semistructured interview approach to encourage participants to authentically recollect their experiences and perceptions of their STEM attrition decisions. Rubin and Rubin (2012) suggested that semistructured interviews allow researchers to focus on the research question and not control the response. For this study, I developed interview questions that align with the conceptual framework and the research question and then drew from the empirical literature review for probes (see Appendix).

Data Analysis Plan

Thematic analysis is a type of content analysis that can be used in various types of qualitative research designs. According to Braun and Clarke (2013), the thematic analysis has six steps: familiarization, coding, generating themes, reviewing themes, defining and naming themes, and writing up. Familiarization is the transcribing of the interview audio and reading through my notes in my research journal. I used initial coding, also known as open coding. Initial coding provides a starting point to closely examine and compare similarities and differences (Saldana, 2016). I started the coding process by highlighting sections of the interview transcription organized in a table in Microsoft Word. I compared the highlighted key words or phrases across all the interview transcriptions and generated codes for similar concepts or words on a spreadsheet. After reading the interview transcriptions multiple times, I looked for patterns or similarities in the codes. I grouped the similar codes together. Once I identified the similar codes, I generated themes that best explain the groups of codes.

Issues of Trustworthiness

In order to establish trustworthiness in this study, I focused on four key components: credibility, transferability, dependability, and confirmability. As the researcher, it was important to the integrity of my research to ensure that key aspects of trustworthiness are met.

Credibility

According to Merriam and Tisdell (2016), triangulation is a frequently used strategy to establish credibility. Triangulation may be achieved by using different methods of data collection, collecting data from people with different perspectives, and comparing and crosschecking the collected data (Merriam & Tisdell, 2016). To achieve credibility, I reached saturation by interviewing 10 students, which allowed me to triangulate among the several interviews and add credibility to the findings. I also wrote notes in a journal to capture my observations and reflections throughout the whole data collection process to manage any possible research bias. Credibility was ensured by maintaining consistency in the data collection process, including the qualification of participants, asking the same interview questions, and journaling during the process. The participants reviewed the transcripts to ensure that their experiences were captured with accuracy to ensure credibility was achieved. Lastly, my dissertation committee provided me feedback on my data analysis section.

Transferability

In order to establish transferability in this study, I utilized rich, thick descriptions of the setting, participants, and provide a detailed description of the findings. I present quotes from the participant interviews in Chapter 4.

Dependability

Merriam and Tisdell (2016) suggested that triangulation and peer review, which I addressed in the credibility section, might also ensure dependability. Merriam and Tisdell suggested that the use of journal to serve as an audit trail to document how data were collected, how categories were derived, and how often I engaged with the data. In light of these recommendations, I kept a journal throughout the data collection process and wrote memos when coding to help me understand how I extrapolated the codes and themes.

Confirmability

Lastly, to ensure confirmability, I used the journal throughout the data collection process not only to document the data collection process but also to reflect on my own values, interests, and biases towards STEM attrition. The journal helped provide insight to me during the data analysis process.

Ethical Procedures

After IRB approval, I began recruiting participants and conducting interviews. Building rapport and protecting an interviewee's privacy are important to collecting rich, quality data (Merriam & Tisdell, 2016). Confidentiality was maintained throughout the study by collecting informed consent agreements from the participants. Before the interviews, I provided an information guide to all my participants, which included the purpose of the study, what to expect during the interview, and the use of pseudonyms to protect their identity, and logistical information about the interview schedule. The informed consent followed the guidelines of Walden University. To ensure confidentiality of the records, recordings, emails, informed consent forms, and transcripts of the interviews are secured on my password-protected home computer. All collected data for this study will be destroyed after 5 years for all ethical considerations.

Summary

In Chapter 3, I outlined my basic qualitative study design to address the research question. I used open-ended questions in semistructured interviews to explore the perceptions and experiences of college students who changed their major and career choice from STEM to non-STEM in their third year or later. I explained the methodology, participant selection, instrumentation, and data analysis plan. Lastly, I addressed the issues of trustworthiness of the study and ethical procedures.

Chapter 4: Results

The purpose of the study was to describe college students' experiences in changing their STEM major in their third year or later. The study addresses the following research question: What are college students' perceptions of their decision-making and their experiences in changing their STEM major and career choice in their third year or later? In the following chapter, I provide the results of the study, beginning with a description of the setting where I conducted the study and the demographic group. Then, I describe the data collection and data analysis process. I then discuss the evidence of trustworthiness and present the results of the study.

Setting

The setting for this study was a public research university in California. The data collection took place during the COVID-19 pandemic, so interviews were conducted via videoconferencing instead of in person. I recruited participants for the study by emailing the email invitation with basic information about the study to various advisors at the university. These advisors forwarded the basic information and email invitation to their students via their student listserv. The emails generated all of the responses.

Demographics

All 10 participants self-identified as undergraduate students who majored in STEM but changed to a non-STEM major in their third year or later. All 10 students started at a 4-year college. Seven of the participants were first generation college students. Eight students self-identified as women and two as men. Eight participants were in their last year of study and two participants were recent college graduates (graduated in the last 6 months). Two of the participants majored in STEM majors that were not initially considered in the participant selection criteria: agricultural and environmental sciences. After researching both programs, I concluded that both majors are considered STEM majors at the college and both majors require similar math and science requirements as the other STEM majors. To keep the 10 participants' identities confidential, I created pseudonyms that align with the participants' gender identification (see Table 1).

Table 1

Participant Demographics

Pseudonym	Gender identification	First generation	STEM major	Non-STEM pathway
Albert	Male	Yes	Bioengineering, Environmental Sciences	Social Sciences
Anna	Female	No	Computer Science	Humanities
Barbara	Female	No	Physics	Arts & Humanities
Beth	Female	No	Mathematics, Statistics	Humanities
Carlos	Male	Yes	Computer Science & Engineering	Humanities
Cathy	Female	Yes	Agricultural and Environmental Sciences	Humanities
Diana	Female	Yes	Mathematics	Humanities
Eleanor	Female	No	Forensic Chemistry	Social Sciences
Frances	Female	Yes	Biology	Humanities & Social Sciences
Grace	Female	Yes	Aerospace Engineering	Humanities

Data Collection

Data collection began in March 2021 and concluded in April 2021. I conducted all 10 interviews using the Zoom videoconference platform. Interviews were scheduled during the late afternoon or evening to accommodate the participants' work and school schedules. All participants participated in one-on-one audio-recorded interviews with their video camera on and each interview lasted an average of 50 minutes depending on the depth of answers provided. I audio recorded all the interviews using the Zoom platform. I reached saturation by my eighth interview but interviewed 10 participants for assurance. All 10 participants answered all seven interview questions, and I followed each question with one or two probing questions. Most of the participants answered the interview questions with in-depth responses; therefore, I did not need to request any follow-up interviews.

Each interview was transcribed using the Otter.ai cloud software. Participants had the chance to read their transcript to review their responses and confirm accuracy, offer feedback, suggest edits, or elaborate on their responses. All participants responded by email noting that their transcript accurately reflected their interview. Two participants emailed me new thoughts they had on some of the interview questions. I added their additional information to their interview transcript. I electronically sent participants a $25 Amazon gift card in appreciation for their participation in the study. I reached data saturation by the eighth interview, as the responses suggested redundancy (Merriam & Tisdell, 2016). The responses collected across all 10 interviews provided rich data, which I analyzed to create the themes discussed in the results section.

Data Analysis

The aim of the data analysis process was to answer my research question. I used Braun and Clarke's (2013) six-step approach to thematic analysis. According to Braun and Clarke, thematic analysis is used to examine a data set to find repeated patterns of meaning. I used the inductive approach, as I did not use pre-existing codes, and allowed the patterns and themes to emerge from the interview responses. Starting with the first step of transcription and familiarization, I listened to the audio recordings and read the generated transcripts. I read the text, edited the transcripts for translation or grammatical errors, and took initial notes. Next, I started Braun and Clarke's second step of coding. In the initial coding process, I highlighted various phrases and words in the transcriptions that stood out for me. I then copied and pasted the highlighted phrases and words on to a spreadsheet organized by interview question and participant response. I labeled common concepts, actions, and events with key words or phrases. The generated codes were the main points and common meanings that emerged throughout the data. The initial coding process generated 52 codes. By clustering, the secondary review reduced the number of codes to 33. In the ongoing analysis, I then further reduced the codes by combining closely related codes that were well represented by a single code. I also examined the generated codes for similarities and differences. In the third step of thematic analysis, I generated themes by grouping similar codes into one theme. The grouping of similar codes resulted in five overall themes associated with the research question. The fourth step was reviewing the themes. I reviewed the themes and examined them for similarities. The first theme required creation of subthemes to adequately represent the codes. Then in the fifth step, I continued to develop the themes by naming and defining the three themes. The final step, writing up the themes with extensive quotes from the interviews, confirmed the three themes as adequate to represent the data and answer the research question.

The three themes and the first theme's three subthemes reflect the participants' perceptions of their experiences and their decision-making in changing their major and career choice in their third year or later. An overview of the thematic structure is provided in Table 2.

Table 2

Overview of Thematic Structure

Theme	Subthemes	Codes
College students experienced poor academic and career fit and changed their STEM major and their career choice.	Academic concerns Disillusionment with STEM careers Shift to non-STEM major and career	Low grades in courses, academic probation, low GPA, struggled with studying, struggled with materials, failed courses and had to repeat, intimidating large class size, hard to manage time, lack of motivation, study hard but still barely passing, feeling frustrated, feeling drained, had other life commitments, did not see a future career in STEM, STEM career did not align with passions or interests, doubts about future courses, STEM curriculum not connected to practice or career, introduced and enjoyed a non-STEM course, engaged in non-STEM organizations and clubs, introduced to a non-STEM possibility, introduced to a non-STEM career, revisited a past interest.
Their decision-making was influenced by their mental health.		Stress, anxiety, low self-efficacy, felt out of place, did not feel smart, embarrassed about grades, social stigmas (female, male, social sciences), confusion, feeling lost
Their decision making was influenced by their low student satisfaction in the STEM major program		Misadvised, did not seek advice, unable to get an appointment with advisor, faculty were intimidating, faculty not helpful.

Evidence of Trustworthiness

Qualitative researchers must take measures to ensure the validity of their work and to address the trustworthiness of their study's findings. The criteria for trustworthiness include credibility, transferability, dependability, and confirmability. In the following sections, I describe each of these criteria and their applicability to the study.

Credibility

According to Merriam and Tisdell (2016), triangulation is a frequently used strategy to establish credibility. Triangulation may be achieved by using different methods of data collection, collecting data from people with different perspectives, and comparing and crosschecking the collected data (Merriam & Tisdell, 2016). I reached saturation by my eighth interview but interviewed 10 participants in total. The students shared different experiences and perspectives. I compared and crosschecked the interviews during the transcript review and through the data analysis process. I also wrote notes in a journal to capture my observations and reflections throughout the whole data collection process to manage any possible research bias.

Credibility was ensured by maintaining consistency in the data collection process, including the qualification of participants, asking the same interview questions, and journaling during the process. I developed an interview guide and practiced my interview questions on colleagues before the study. The practice interviews ensured that the questions were clear and answered the research question. After the interviews, transcript checking was completed to establish credibility. Participants received a copy of their interview transcript. Transcripts were sent electronically to each participants e-mail account. After a few days of send the email and transcript, all participants replied to the message. Two noted that they had corrections or additions and I added the information to their interview transcript. The other eight participants noted that they did not have any corrections or additions. Lastly, my dissertation committee reviewed my analysis to ensure I accurately represented the participants' perspectives.

Transferability

Transferability is the applicability of findings based on comparability of contexts (Lincoln & Guba, 1985). In order to establish transferability in this study, I utilized rich, thick descriptions of the setting, participants, and provided a detailed description of the findings and data analysis. I described the procedures, context, and participants in sufficient detail while maintaining the confidentiality of participants and the research site. The rich description may allow future researchers to understand the research method and use it for the development and design of their own studies examining STEM attrition college students or similar phenomenon.

Dependability

Merriam and Tisdell (2016) suggested that triangulation and peer review, which I addressed in the credibility section, might also ensure dependability. Merriam and Tisdell suggested the use of a journal to serve as an audit trail to document how data were collected, how categories were derived, and how often I engaged with the data. In light of these recommendations, I wrote in a journal throughout the data collection process and kept memos when coding to help me understand how I extrapolated the codes, categories, and themes. I also verbally discussed my data collection process with my dissertation committee chair throughout the data analysis time, which helped me better understand how I developed my codes, categories, and themes.

Confirmability

Lastly, to ensure confirmability, I wrote in a reflective journal throughout the data collection process, which I addressed in the dependability section. The reflective journal not only documented the data collection process but also allowed me to reflect on my own values, interests, and biases towards STEM attrition. I used the notes in the journal to ensure that the study's results represented the data collected and not my own personal bias or assumptions. I also made notes during each interview and wrote notes if I felt it was important to capture my feelings towards a participant's answer to the interview questions. I used the notes to ask for clarification from each participant during the interview to ensure I captured the correct information for the data analysis process.

Results

Three themes emerged from the data analysis as possible contributors to the decision to leave STEM in the later college years. These three themes address the research question of this study. The first theme is that college students experienced poor academic and career fit and therefore changed their STEM major and their career choice. It was the most dominant theme and has three subthemes related to the experiences and perceptions: academic concerns, disillusionment with STEM careers, and shift to non-STEM major and career. In the following section, I present the themes that emerged during the study, including representative and illustrative excerpts from the interviews.

Theme 1: College Students Experienced Poor Academic and Career Fit and Changed Their STEM Major and Their Career Choice

The participants disclosed that their experiences in STEM were a poor academic and career fit for them. Participants described their experience in STEM as "difficult", "confusing", and "frustrating." The most common word used when participants described their experience was "struggling." Carlos explained his time in STEM "as the worst years of my college life." He provided a detailed description of his experience:

> When it came to the classes, oh my God. It felt from the start they just assumed that we knew so much more than a lot of us did, because I definitely wasn't the only person struggling [in the class]. All the computer science classes I took were so difficult and they were pretty much all the classes that I got the worst grades in. They required so many hours to study for and to do the work for. The projects would take forever. And if you got one small thing wrong, it was a headache to try to find where it was. Another thing that I really hated was the curriculum for it. It was really, really rigid. There was no room to take anything that you want.

Albert "always felt like I just wasn't cut out for it." The experience of poor academic and career fit was an influential factor for students to stop pursuing STEM. The students experienced academic concerns such as disappointing grades and overly demanding time commitments. The students also discussed that they could not see the connection between their STEM major and a STEM career they were interested in pursuing. Some participants talked about how their academic concerns and lack of STEM career possibilities led them to find alternative majors and careers outside of STEM, whereas other participants were introduced to non-STEM majors and careers that aligned better with their interest and passions. For instance, a few participants talked about how their peers connected them to a non-STEM job. The academic concerns, disillusionment with STEM careers, and the shift to a non-STEM major or career, all of which were discussed by the participants as influential factors in their decision to change their STEM major and career choice, serve as the three subthemes for the first theme.

Academic Concerns

The students identified various academic concerns, like intimidating class size, a different experience from their high school STEM experience, their low grades and GPA, and overly demanding time commitment, all of which were mentioned as influencing their decisions to change their STEM major in their third year or later. When asked about their experience in their STEM major, most of the participants recalled the size of their STEM classes being an issue for them. Eleanor explained that struggling in a large STEM class with 300 to 400 students made her feel overwhelmed. She described her experience with the material and the curriculum in the STEM courses:

> I felt like it was all for passing the class and it is always kind of in STEM about passing the class. I had some professors who didn’t care. They liked the material but they were focused on either research or just had too many students. These professors have so many. It’s just insane.

For all the first-generation students, their STEM courses were large and intimidating. Cathy revealed “being scared” to speak up and talk to professors in the large lecture style STEM course, even if the professors were nice:

> Because the classes that I did take for that major were super big, it was a lot of students and just one professor teaching the class. And I would find it hard to speak up. So I've never asked questions during class. But the professors, for the most part, were really nice, they were a little scary, or they look scary to approach, but maybe that was just me being scared. For the most part, I would say that they were nice, it was just kind of hard to approach them because it was super big classes. I would feel scared to approach them myself.

Frances stated that it was difficult to create personal interactions because of the large size of her STEM classes:

> I really doubted my capabilities and my own ability to succeed in higher education because it was so difficult to create those personal interactions with students. A lot of my STEM classes, especially in the beginning, ranged from 120 to 300 something students and that was completely new for me. And not having a mentor, or someone to guide me through those classes, especially within that major, was very difficult.

Another academic challenge was the difference between their experience of their high school STEM courses and their college STEM courses. The participants all expressed their college STEM courses to be very different from their STEM experience in high school. Frances described her STEM courses as independent learning based: "it was all mostly just independent work without the social interactions that I would have had in a regular classroom setting. And that was really difficulty for me." Barbara and Frances talked about curved grading in their STEM courses being another academic challenge. Frances described a "huge sense of competitiveness among students" and how that hindered a lot of the opportunities to build relationships. Barbara explained how curved grading made her feel uncomfortable:

> The whole idea of grading on a curve, and like, everyone's doing poorly, but at the end, like everyone will actually be doing okay, I never really got that. I never really understood that or felt comfortable with that. So definitely felt like I was super failing even though, I was probably actually doing fine.

The students revealed that their experience of low grades in their STEM courses, low GPA, or their academic probation status was another academic concern. All but one student discussed their low grades or low GPA. All 10 students described themselves as being high achieving students in high school, and receiving low grades in college impacted their STEM major experience. They talked about feeling disappointed in themselves because they were not conditioned to get low grades. After receiving low marks in their STEM courses, the students tried studying more, utilizing their professors' office hours, attending group tutoring, or studying with other peers. The students were further disappointed when their extra effort still led to similar grades in their STEM courses or very little improvement to their GPA. They started to question whether the amount of time and effort was worth it. Grace asked herself, "At a certain point, if I'm going to be working hard like this and striving like this to no avail, or sometimes little improvement, do I actually even want to do this?"

However, first generation students Frances, Grace, and Carlos talked about not knowing how to study for their STEM courses. Frances expressed that her high school

STEM courses did not prepare her for the rigor of college STEM courses, which made her feel invalidated:

> Entering this new school system that had all these expectations and we were expected to come in knowing all these certain things and realizing that my high school classes hadn't covered a lot of material. I just felt like I was constantly catching up or trying to catch up. And even when I was in class, there was kind of this disconnect between professors and TAs and students and I often felt like I was invalidated.

Because studying for their STEM courses took a lot of their time, most of the participants revealed that they did not have a lot of time to do anything outside of the STEM courses or socialize with others, which was another academic concern. For instance, Carlos explained his lack of enjoyment in college was tied to his experience in STEM. He recalled that the curriculum for computer science allowed "no space to choose anything of your own interest, besides that major." Anna shared a similar experience and talked about studying and working on STEM projects until the late hours of the night and not having time to socialize with peers or study for their other courses. The demanding time commitment to studying STEM forced most of the students to sacrifice other aspects of their college experience like engaging in extracurricular activities. Nine of the participants talked about their little to no engagement with STEM clubs and organization because of the lack of time and always feeling behind.

Some students started to question the future. They came to believe that if they were struggling with their introductory courses, it would mean that they would continue to struggle in their advanced STEM courses. For instance, Beth started to question her ability to succeed in her upper division courses:

> I was just getting Cs in all my calculus courses, which kind of led me to that crisis. Getting Cs in all of these preparatory courses for this math major. What is going to happen when I'm actually taking upper division courses?

Anna talked about her interest in STEM decreased because she felt overwhelmed.

> When I was taking all the STEM courses, it was very interesting to me. And it got like more and more interesting as I figured out more and more things to get interested in. But then, as it was getting harder, and as I started to struggle in the math courses, and I started to not have as much fun anymore. It got less interesting to me and it just got overwhelming.

The students started to realize that they were not willing to sacrifice certain aspects of their college experience nor were they willing to embrace a highly demanding and stressful academic environment. This realization combined with the experience of studying hard and still barely passing eventually linked to their low level of motivation and discouragement to continue in STEM.

Some students discussed their struggle with time management. Carlos and Anna recalled that not having good time management skills elevated their level of stress in STEM. Diana expressed a similar sentiment about her experience in STEM:

> I hated my time there. I hated it. And I think it was the fact that I didn't have good time management skills. I also didn't know how to study. So that together and I

> have never had experience in an actual lab, I didn't know what I was doing. I was just there, lost, and I hated it.

Four of the participants explained having other personal commitments that made time management and studying for their STEM major more difficult. Eleanor was a student athlete who participated in crew. Her schedule had her up at 4:20 am every day. The time commitment to crew and STEM affected her social life and made it hard for her to socialize with other students in her STEM major.

> I would wake up early and then I have to go to my classes, and then I'd be studying, and then I basically go to sleep. So I didn't have much of a social life. I don't think I studied enough. I had a hard time focusing and just staying engaged in the material.

A few of the students worked while in college. Carlos, Anna, and Frances are first generation students who discussed balancing work with their STEM major. Anna and Frances shared similar sentiments about the difficulty of working while studying in STEM. Frances started working at the end of her first year and talked about the challenge of work life balance:

> I got a job so that I can sustain my education. Balancing work and school was very difficult. I first saw my grades plummet in that last quarter of my freshman year. And because I was now engaging in new material that I had never seen before, it was very difficult. I'm trying to balance everything out and keeping this really delicate balance with outside social interactions, my job, and stuff. It was really hard to find balance especially with the rigor that a lot of my classes held.

Grace, a student parent, reflected on her experience of studying STEM and taking care of her daughter. She remembered having challenges in her STEM courses when she was pregnant and raising a young daughter. She discussed the lack of accommodations for student parents forced her to have to do "a lot of stuff in order to just a get a decent grade." She had to bring her daughter with her just attend office hours and would have to sacrifice time to be both mom and student. Grace described the amount of time and effort she dedicated to her STEM major and the continued disappointment in her grades as "not joyful" and the factor that contributed to her decision to leave STEM.

Disillusionment with STEM Careers

The second subtheme emerged from the participants' experiences of a poor career fit in STEM. They became disillusioned about STEM careers early in their college years. Albert, Diana, Beth, and Carlos explained how they had not been thinking about the connection between their STEM major to future STEM career. For example, Diana knew from a young age that she would attend college but did not think getting into college and how her major would be connected to career.

> I never thought about what I would do after college. It was always about going to get into college and everything I did was to get into college. But I never thought about what I would major in and what I would do as a career. So when I heard I could be an engineer, it just sounded cool, like engineering is an amazing career. So it was about the prestige that I could to be an engineer, but I never gave it so much thought to it.

When participants were asked about their experiences that influenced them to major in STEM and pursue a STEM career, they indicated that their parents and high school teachers were influential in their decision to major in STEM. High school was a formative time for all 10 of the participants' decisions to major in STEM. All the participants recalled having an initial interest in math and science and receiving good grades in their high school math and science courses. High school teachers would encourage them to participate in extracurricular activities such as robotics clubs and competitions. Some participants joined a STEM preparation high school program. Albert discussed how his interest in engineering grew after taking engineering courses in high school.

> I think I kind of had an interest in engineering. And then, come my freshman year of high school, they were having what was called a pathway in my high school, where it's pretty much you take a 1 to 4 year course. So I took the engineering course starting my freshman year, and I finished my senior year. Throughout that whole period, we took classes tailored around engineering principles, and things like that. So then, that's kind of what pushed me further into engineering and kind of gave me the kind of experience of what it was actually going to be like.

The students recalled they would often look up to their STEM teachers as role models too. Albert discussed how the teacher for his engineering courses was a former full time engineer.

> My teacher was a former full time engineer herself so she was an example of you can go into a STEM major, like an engineering major, and become an educator at

> the same time. So I always had that idea that I want to pursue the same kind of career path as her. It is something I'd be passionate about or want to pursue so I definitely think her being that role model made STEM a good idea for me.

Diana shared a similar experience with her teachers in high school and her 11th grade teacher, in particular, who had a graduate degree in STEM.

> My algebra one teacher in 10th grade even told me that I would be a really good engineer. And in fact, I love math. And then in 11th grade, I had a teacher who went to Stanford. She got her Master's in physics, so of course, she was pushing for me to go into STEM. She wanted me specifically to go into pre-med. I didn't see myself being a doctor though. I never told her my decision; but, she always pushed me to be something STEM.

High school teachers would also promote STEM careers to the students because of the prestige and financial security. For female students like Beth and Frances, their high school teachers talked about the appeal of being women in STEM. Beth recalled her experience of choosing math was connected her high school teachers encouraging STEM for women.

> In high school, definitely there was kind of this I would say, like wave of STEM being marketed or STEM education being something where women are underrepresented in this field and they should go in to doing STEM disciplines. They would market a wellspring of support for women who wanted to pursue STEM, despite being historically underrepresented in STEM, and they would accompany models and statistics that put numbers to show how many women

> majored in these disciplines and went on to become professors, etc. It motivated me to give math a try and see where it took me.

Frances also reflected on the pressure from her high school science teachers to major in STEM.

> There were numerous mentors that I had in high school that didn't exactly tell me what to do, but they really, really pushed that I'm a STEM major, especially when I was filling my college applications. I remember my biology teacher and my math teacher, who helped me and guided me along the way of applying to college. It was just this really immense pressure to apply under a STEM major. I think that was just a reflection that STEM guaranteed a career and it's an upcoming and growing industry.

The participants also talked about their parents' influence on their decision to major in STEM. Beth and Carlos started thinking about majoring in STEM because their parents noticed they were good at math or computers. Albert and Eleanor experienced their parents introducing them to family friends in STEM who then showed them where they worked and what they did at their job. They both discussed how looking at examples of successful family friends in their professional STEM field influenced their interest to pursue a STEM career. First generation students Albert, Carlos, and Cathy mentioned how their parents would strongly encourage them to study STEM because it would lead to financial wealth and prestige. Carlos's parents, for instance, pushed STEM because of the salary.

> Growing up, my parents, being first generation immigrants, along with myself, would really put an emphasis to go to college and choose a field that they saw had a lot of potential, good salary, and ease to find a job; stuff like that. Naturally, they pushed me towards becoming a doctor or a veterinarian, stuff in the medical field. But, when they saw my interest in computers in my early teenage years, they started to see computers as a potential career opportunity for me. My parents push for me to get into a better paying field than they had when they came here.

Students also talked about how their parents were proud to tell others that their children were pursuing STEM in college and as a career. Eleanor discussed how her parents would brag about her decision to major and pursue a career in chemistry.

> I feel like it was largely influenced by my parents. I know a lot of kids pick their majors and stuff because of their parents. I thought I was doing it a little differently. But looking back, it was because my parents really wanted me to make money and do something really interesting and cool and that looks good to everyone else. And so chemistry was largely for that. I think my parents wanted to be validated as parents because I was successful and making money and doing something interesting.

Once they were in college and after taking several STEM major courses, some of the participants realized that their STEM major led to careers that did not capture their interests or passions as they thought in high school. For some of the participants, the lack of an "interesting" STEM career demotivated them to continue studying STEM. Diana expressed feeling stressed over her STEM courses, but was different from the other participants because she did not experience receiving low grades in her STEM courses. She talked about her lack of exposure to possible STEM careers.

> I didn't know what I was going to do with it. I was getting good grades. But getting those grades was stressing me out so much. I didn't want to do this. I didn't see an end goal. I'm taking these really hard classes and I'm explaining this material to my friends, but I don't know what I'm going to do with this once I graduate. I didn't see any opportunities with it and it’s probably because I wasn't exposed to them.

She had reached out to her math professor to talk about possible careers in math and was not intrigued by the information she received.

> So I went to office hours regularly and I asked questions, and she also encouraged me to stay in math. I told her that I don't know what I'm going to do with this and she pulled up a catalog with all the different options. Then she told me about her experience as a PhD student. I wasn't intrigued. I was like, “okay, I could do this. I could analyze data”. I know, I could do this, but I just I wasn't interested in it. It didn't call my attention.

Albert, a first generation student, started out as a bioengineering major then changed to another STEM major of environmental sciences before leaving STEM in his third year to a major in the social sciences. He talked about reaching the point when he realized that he did not have a purposeful connection to both his bioengineering and environmental sciences major.

> I think it was probably hitting a point in my college education that I had to figure something out. I'm a first generation college student; so this is something completely new to myself. And I never had to imagine that one day I would have to determine what I am going to pursue as a college education and this would define the rest of my life - this is something that I do for the rest of my life. I went from the engineering major to environmental science. I was passionate about those things, but I never felt the human connection or something that really made me feel comfortable or made me feel like I was being effective and purposeful in what I did.

Shift of Interest to a Non-STEM Major and Career

The third subtheme focuses on the participants' shift of interest to a non-STEM major and career. All the participants talked about their experience of locating an alternative major or career away from STEM. After experiencing a poor academic and career fit in STEM, participants felt discouraged to continue their STEM major. They used various strategies to engage with a non-STEM major or career.

A common experience among the participants was taking a non-STEM course as a general education requirement or as a class to balance their STEM courses. Some participants were advised to take a non-STEM course by their academic advisor or by their friends and taking a non-STEM course introduced them to a possible alternative major or career. The students reported they would take more non-STEM courses when they realized that they did not face the same kinds of obstacles as they did in STEM.

Cathy was introduced to her non-STEM major after her experience in her humanities course and how it differed from her STEM course experience,

> I took an ethnic studies course. It was the first [ethnic studies] related class that I'd taken and that class was just so different from any of the classes that I'd take before. I felt like it was super welcoming and people within the class were super open to talk to, even during class.

She also enjoyed the material and felt a connection to her identity.

> That class, also really got me into [Ethnic Studies] and learning more about my roots because throughout high school, we don't hear about stuff like that, and you don't really get to learn the history of our people. So after taking that class, I thinking that's what really changed my mind and I started thinking about maybe pursuing that major instead.

She continued to take more ethnic studies classes in her second year and decided in her third year to switch majors because of the welcoming environment.

> A lot of the Ethnic Studies classes had discussion classes so you would actually get to talk a bit more with the students. And we would discuss a lot about our experiences in life. And I did feel a lot more welcomed and I belonged in that major. Just because, I was able to relate to a lot of the things that would be talked about in class and the things we would learn. But yeah, I would say that my sense of belonging definitely changed a lot when I switched majors.

Barbara discussed how her non-STEM courses felt less restrictive than her physics courses.

> It was easier. I felt less restricted. I guess, I felt restricted in physics, even though astrophysics was what I really wanted to do. I felt like I continually had to prove that I was smart enough. With [art], it's just something that I was interested in and that was kind of all you needed to do, be interested in it, and then whatever you brought to the table was okay.

Three of the participants were introduced to a non-STEM pathway through a job. Barbara worked on a ship that increased her interest in the arts. Carlos and Frances started working at an elementary school and enjoyed the work duties. Frances started working for an afterschool program at an elementary school tutoring children with unique learning abilities. She talked about how the experience at the afterschool program sparked an interest in education.

> This experience not only kind of helped me become more passionate about advocating for marginalized identities and student groups, but also it helped me reflect a lot on my own personal experience. And it helped me look back and see the difficulties that I faced as a student, and realizing that these are some difficulties that students still face today. And that kind of sparked that education interest in me, and that political science of improving curriculums and improving education policy.

A few students explained how they revisited past interests when researching other majors. Grace discussed how she considered law school in high school so she met with careers advisors to learn about majors related to education policy. Carlos was not active in STEM-related clubs but was actively participated in different language clubs and held leadership positions in those clubs. In high school, he had an interest in speaking different languages so it was not a surprise to him that he decided to change his career to a language teacher, instead of an engineer. Albert was active in social justice organizations in his community, which lead him to discover his new major, sociology.

> Going through high school, I've always been told “you're a very charismatic person, you're somebody who gives, and can explain things that might otherwise be very complex, and breaking down into a much more understandable way, or form”. I really didn't want to switch anymore. I want to do something that I can stick to and be happy with. And then I think sociology kind of blended a good amount of everything I been very involved in, in terms of like political organizations.

Most of the participants expressed feeling comfortable engaging with their non-STEM major faculty because the major courses were smaller. Barbara, who reported her social anxiety was a barrier to engaging with others in her STEM course, noticed that she had more time and opportunity to engage with other in her arts and humanities majors. “Switching to the arts major gave me more of an opportunity to lean into that social group as well as the humanities social group because I was becoming more invested. I felt like we could actually have time to socialize now.” When asked about his experience switching to his non-STEM major, Carlos discussed how his sense of belonging changed because of the smaller class sizes.

> I think it may be just even something as simple as the classes being a lot smaller. Generally they would cap the courses anywhere from 30 to 60 people, if they

> even filled up that much at all. I would see the same students or a lot of my peers over and over. It just made me feel like I belonged a lot more, because then I would recognize people, I could talk to them a lot more easily.

Carlos continued to talk about how contact with the instructors also increased his sense of belonging. “I would see the same teaching assistants and professors all the time. It definitely felt like I was I was belonging a lot more.” Like Carlos, Grace, Albert, and Barbara experienced a difference in their interactions with faculty. Grace, who spoke about unaccommodating faculty in STEM, experienced more accommodating faculty in her non-STEM major.

> I wouldn't even feel comfortable telling my math professors that I was a student parent and needed to nurse my child because they're all men. And my professors over in the humanities are men too; but there is more openness and you could tell that they'll be receptive … of that information and want to accommodate or help you in any way that they can. So I definitely feel like I belong here.

Alberta and Barbara also talked about their non-STEM faculty but related to diversity. They mentioned that the faculty in their non-STEM courses perceived to be more diverse than their STEM courses. For example, when Albert was asked about his experience in changing his major and career choice, he talked about his perception of seeing more self-identified diverse people in social sciences compared to his STEM majors.

> I definitely think throughout my switch into social sciences, I've met people with much more diverse backgrounds in terms of race and also how they identify by

> their gender. Like one of my professors was part of the LGBTQ+ community and that's not someone that I had ever met when I was in my STEM major. Also when I switched to social sciences I had one of my first professors who was African American. When I was doing my STEM major I think I only had one Hispanic or Latina professor so I definitely do think that switching from Stem to non-STEM that I have seen an increase in diversity.

When asked about their experience switching to a non-STEM major and pursuing a non-STEM career choice, all the participants expressed happiness in their decision to leave STEM and in their discovery of a major program and a career choice that better suits them and their interests. All of the participants also shared a more positive outlook when they reflected on future job opportunities or educational paths like graduate school which differ from their experience as revealed in the theme of disillusionment with STEM careers. Six of the participants mentioned going to graduate school after they graduate to pursue a non-STEM career in education, law, or policy. Beth described joy in switching to her humanities major and Albert, Grace, Frances, and Carlos talked about seeing a change in their motivation and self-growth. Carlos talked about his level of involvement increased when he changed his major.

> I was loving the new [humanities] material. But I also wasn't spending all night on a project [as I did in STEM]. I was having a lot more free time which led me to things that I wanted to do, which was when I kept staying involved in my clubs and I got to pursue a minor. I got to start working out more. I finally had time to

> do things for myself that I enjoyed, and that I felt were benefiting to my growth as a person at college.

Eleanor called her non-STEM major a "passion project" and discussed how the change in her major impacted her mental health in a positive way.

> Changing my major had a great impact on my mental health and I definitely benefited it. I'm not sure if that's a big part of what you're researching but I think about the personal impact changing your major has had on me. It is not just about where I see myself going but how I see a change in myself and my confidence, like I feel way more confident. Like, I've never felt this like confident in my academics and it's not because I'm getting good grades, which is nice. But it's because I actually know what I want to do and I feel secure in that. And that's really exciting to me and I think that's important.

Theme 2: Their Decision Making was Influenced by Their Mental Health

The second theme emerged from several participants talking about the negative psychological impact that came with the stress of their STEM major. The students' poor academic and career fit in STEM was perceived to affect their mental health. Participants talked about stress, anxiety, imposter syndrome, low self-esteem, personal defeat, mental health, and self-doubt. Albert described his STEM major as a "challenging time, in terms of my mental health and everything else." Other participants also described the experience of low self-efficacy. Barbara dropped out of her first calculus course because she felt like she was failing. Diana recalled in her first couple of years struggling with what she called "imposter syndrome" during her professor's office hours. "Just because I don’t know, I felt my professor was helping smart people, when I was still there. I felt like an imposter. It was the imposter syndrome”. Eleanor expressed a similar experience of feeling like what she called a “faker”.

> It just felt very strange to be the chemistry major and you get such a reaction from everyone when you say you’re a chem major. Everyone’s like, “Wow, that’s so hard.” I know, I’m barely doing it. Yeah, that is kind of how I felt. I always felt like a faker, I guess. I always felt I wasn’t actually what they were picturing when I said I was a chem major.

Eleanor went on to talk about her experience of seeking therapy by the end of her first year.

> I wasn’t super depressed my entire childhood or anything like that. But I think it’s really nice to have a therapist, someone to talk to and just get your emotion out and think through things logically. So towards the end of my freshman year, I got a therapist and was voicing my feelings about inferiority within my major, just kind of feeling like a faker. Like I said, that feeling of being a fraud and not actually deserving the praise people give you when they find out what you’re studying. All of that just kind of had an impact on my self-esteem.

Frances felt personal defeat in her STEM major.

> I was feeling very defeated. I think I even throughout high school, I was always this 4.0 student and I had never really struggled with the ability to have to really keep up my high grades. And I think it was a personal defeat to my self-esteem as a student because you know these feelings of “am I capable, am I worthy of being

here? I don't belong here and it is showing because of my grades." This feeling of failure [was] because of my grades were plummeting. I wouldn't be able to it anymore. It was very difficult to kind of manage everything.

Six of the participants mentioned their mental health as an influential factor for leaving their STEM major. Carlos talked about one of the main factors of leaving STEM were his poor grades that were bordering on academic probation and could not see himself doing STEM as a career later on without "hating myself". He talked about the anxiety of bordering on academic probation.

> It gave me so much anxiety all the time. It would always be looming in the back of my mind that I have to make sure to do well in this class or else I am going to end up getting into academic probation. It was a huge stress and huge anxiety for me, especially in my second year.

When asked if he was normally an anxious person, Carlos responded, "Actually no, I generally consider myself a pretty chill person. But I had never experienced anxiety like that." According to Barbara, her mental health was the most influential factor for her decision to leave STEM.

> Well, the most influential factor was my mental health. I just could not get myself to do my physics and math problems every week, and that was very frustrating. Yeah, there was a lot of self-doubt and low self-esteem tied up in that and eventually I decided that I'd had enough and I didn't want to do anymore.

Some of the participants talked about a long internal conflict they had about gender norms. Arthur worried that a man entering social sciences was not as acceptable as a man pursuing STEM. Beth, Diana, and Grace did not want to leave their STEM major because they wanted to add more female representation to the STEM field. Diana wanted to be an advocate for younger female generations and it influenced her to stay longer in STEM.

> It was definitely because of women in STEM. I wanted to be an advocate. I wanted to be that percentage, a woman in STEM, and an influence to younger generations to do this. It would have been amazing to be a first generation Latina in STEM. I feel like it looks better. It looks nicer. It looks like," wow, she did it". So I definitely do think that it influenced it. Because I wanted to be part of that small percentage who got something in STEM.

Beth also described a similar experience. She felt an internal pressure to stay in her STEM major because women are underrepresented in STEM.

> This was a long internal battle that I had because I did cling on to statistics for a while. Because, like I mentioned a few questions ago about why I initially chose math as my major was just about women in STEM. It was being super advertised about women in STEM and the disparities between the number of women that study it and things like that. And so I just had this perception of, "well, if I'm not doing anything STEM related, what does that say about me?" And so I found a lot of pressure to remain in STEM.

Grace discussed how she thought her struggle in STEM was letting her whole race down.

> It's different. I don't know if anybody thinks like, "Oh, because you're Black, you can do it." But when I was going through my specific engineering courses, there was hardly any Black people. So then it makes you feel like maybe you're the token or maybe you're the one that made it. And then if you fail, you failed your whole race, you know, and because you're the only one around to even speak up for that, or even try.

Eleanor talked to her parents pressuring her to stay in her STEM major and were against her idea of switching.

> So I told my parents about switching my major, and they were super-duper against it. And they basically told me that I would not make any money. Like, this is a terrible idea and I am throwing away a really good opportunity. It was all about money to them. Outwardly, I do not know what it was but I think they wanted to know that they could be validated as parents because I was successful and making money and doing something interesting.

Grace and Albert also talked about the stigma of majoring in the arts or social sciences. Grace reflected on her thoughts of pursuing an arts degree as a first generation student.

> I just think that sometimes we have to ask ourselves, what is it that, yes, we're trying to get Black people and women into STEM majors and make it to where there's more of us, but at the same time, don't make it seem like arts majors are less than a STEM major. Because everybody is getting the degree and

> everybody's changing their generation, if they're first generation, everybody's changing their family's trajectory, regardless of what degree they get.

Albert discussed the social stigma he experienced when thinking of a social science major as a male student and feeling pressure to pursue STEM.

> I definitely think that social sciences are much more acceptable if you were female and that you would go into the hard sciences or like a STEM major if you're male. So I do definitely think like there's gender norms. For being different, it definitely felt like whether you see that you are a representative or represented within that field. Also it is what your culture believes you shouldn't be pursuing solely because of your gender, which for me, of course, would probably be much more of a hard science like engineering.

Theme 3: Their Decision Making was Influenced by Their Low Student Satisfaction in the STEM Major Program

While there were mentions of some positive experiences with STEM faculty and advisors, the students also described experiences where STEM faculty and advisors were not supportive or helpful. Eleanor shared in her description of her large STEM classes that her professor was helpful in passing the class but "didn't really do much for learning". She described her professors to be more focused on their research and they "just had too many students". Anna said her first-year STEM professor was "too scary to approach" so she would not ask questions in class. She also shared that whenever she went to a professor with questions, "they would kind of answer questions, but not really, so it wasn't very encouraging". Anna recalled a specific experience with her computer science course professor:

> There was this one computer science course. I had taken it in the quarter I had to drop out of so I had to retake it. And the professor was just kind of a jerk and it was very confusing. I would ask questions, and not get any good answers. He would go around my question or not even answer at all. And when I would go to office hours, he was very rude. And I decided that if all the professors were like this, then I just would prefer not to deal with it.

Carlos expressed feeling "dissuaded" to make connections with his STEM professors and teaching assistants.

> In my two years in computer science, I never had the same professor more than once which did not help with forming bonds with the STEM faculty. All my classes for computer science really dissuaded me from trying to get close to any professors, especially because there would be for any given class, there would be four to six teaching assistants. Because, otherwise, it's so hard to manage that many students. I would, if anything, instead of trying to get closer to the professors, I probably tried with the teaching assistant. I can only imagine how busy they were. They didn't always seem to have the best attitude and that would just dissuade me from wanting to ask.

Beth also shared a lack of connection or guidance from her STEM professors:

> I distinctly remember how different it was from high school, because you don't have that one on one with professors unless you're like, really, really trying hard

> to have that connection. I think at that first-year stage, I wasn't making any faculty connections or feeling super guided, and so by the time I had gone to the end of my second year, I decided to switch to statistics.

Beth switched her math major to another STEM major, statistics, then ultimately leave STEM in her fourth year. Anna and Grace talked about the lack of accommodations from their faculty as a discouraging factor to continue in STEM. Grace talked about her time as a pregnant student and felt disappointed that her female professor was not understanding to her condition:

> And I was just having a complicated pregnancy. I stayed in school the whole time. I haven't had a break yet and I was having a hard time of dealing with the science part of my major. So I think I had fainted on campus one time and then it's just like, no accommodations. I asked my professor if I can I take a quiz another time because I just fainted on campus and I'd rather not come back today. I'd rather just rest like my doctor told me. And they said no, you can't. You could just get a zero and we'll drop it and that'll be your lowest score. But what if I got a two on the other quiz? I would have already dropped that one. What if I could possibly get a five on this quiz, or seven or whatever? So her whole solution was like, well just make that your lowest score. But I'm like, 'No, I just want to come back and take the quiz. You don't know if that's going to be my low score.' And it's just the lack of the accommodations and going all the way back to campus. Also, having to go to office hours, but you're pregnant or you have a kid and you have to do the

> stroller. It was a lot of stuff that I just had to do in order to get a decent grade, but could not afford to do.

Some of the students from underrepresented backgrounds also expressed the lack of diversity in the faculty and staff advisors as a deterrent for seeking help or connecting to the major program. Albert recalled his experience as a first generation, Latino student in STEM: “It was a lack of diversity or kind of lack of people who have my background that just didn't allow me to fully connect with the major and with the college and it kind of just made me feel a bit out of place.”

The female students shared similar sentiments about not having many female professors in STEM. Frances discussed her experience:

> I think there was also a lack of cultural sensitivity and kind of intersectionality and underlying difficulties of being a STEM major. As an undocumented and Latinx woman, it's so difficult to see other role models that look like me and have similar experiences like me in my major.

The participants also expressed having academic advisors in STEM that were not helpful. Beth, who was having a difficult time connecting with faculty, recalled that her STEM advisors did not reach out to discuss her class or her career plan which made her feel less supported. Cathy had a confusing experience at her freshman orientation with her advisor because her orientation was grouped with another major:

> When I had come in for orientation, they help you choose some of the classes that you need to take for your first year. But because it is a lot of students that are at orientation, it was kind of hard to get an advisor to talk to you about what classes

> you needed. It was even more confusing, because they would be recommending, classes that didn't pertain to my major, but the other major, so I ended up scheduling for two classes that I didn't really need.

The students expressed difficulty of making an appointment with their academic advisor. They said that their advisors would be booked until later in the quarter which would be too late for them to give advice about resources to help improve their grades or change their course. Students would seek help from the student advisors who were less intimidating and at times more comforting; but were limited in the amount of advice they can give. Beth recalled her peer advisors having a “pre-mixed recipe” for offering help.

Barbara and Eleanor expressed that their low grades made them feel embarrassed to ask for help from faculty, staff advisors, and peer advisors. Barbara said that she was “too shy” in her first year to approach her professors or advisors. Furthermore, when she started to struggle in her STEM courses, Barbara did not want to admit that she was struggling.

Summary

In this study, I interviewed 10 undergraduates who changed their STEM major to a non-STEM major in their third year or later. Using Braun and Clarke’s (2013) thematic analysis, three themes emerged:

- Theme 1: College students experienced poor academic and career fit and changed their STEM major and their career choice.
- Theme 2: Their decision-making was influenced by their mental health.

- Theme 3: Their decision-making was influenced by their low student satisfaction in the STEM major program.

The experience of poor academic and career fit was the dominant theme and it had three subthemes: academic concerns, disillusionment with the STEM career, and shift to a non-STEM major and career.

Many participants noted various academic concerns. When asked about their experience in their STEM major, several participants revealed disappointing grades, intimidating large class sizes, very rigorous material, and challenges with time management and balancing personal commitments. Overall, the academic concerns left many of them “drained” and “discouraged.” The second subtheme, the disillusionment with STEM careers, represents the participants’ experience of poor career fit in STEM. The participants were asked about their initial interest and experience in choosing a STEM major and STEM career. Some participants talked about high school teachers and parents pushing them to pursue STEM. First generation students recalled their teachers and parents discussing the financial security and prestige connected with STEM careers. Once they entered college, they realized that their STEM major did not lead to STEM careers that aligned with their interests or passions. A couple participants talked about the importance of purpose. The disillusionment with their STEM career resulted in less motivation to continue in the STEM major.

The participants started to consider an alternative non-STEM major and career. The third subtheme focused on the participants’ experience in shifting to non-STEM major and career. Some participants talked about how a job or revisiting non-STEM past interests influenced their decision to change their major to a non-STEM major in their third year or later. Most of the participants recalled taking a non-STEM course to fulfill their general requirements, and how they did not experience the same academic concerns in the non-STEM courses that they experienced in their STEM major courses. Some students described smaller class sizes and a more welcoming environment that increased their sense of belonging. All the participants expressed more positive feelings and positive outlook when they talked about their experience leaving their STEM major to non-STEM major.

Their experiences of poor academic and career fit are linked to the other themes. For instance, participants discussed how the academic concerns made them feel “embarrassed” and “intimidated” so they did not seek out help from faculty and advisors, which is discussed in the third theme. The challenge of academic and career misfit also affected their mental health, which was a factor on their decision to leave STEM.

The second theme focused on the participants’ mental health and how they perceived their decision to leave STEM was influenced by their mental health. Participants recalled feelings of stress, anxiety, imposter syndrome, low self-esteem, personal defeat, mental health, and self-doubt. Some participants also discussed how cultural and gender norms affected their experience and decision making in changing their STEM major and their career.

The third theme discussed the college students’ experience of low student satisfaction in the STEM major influenced their decisions to leave STEM in their third year or later. The students identified various reasons why they felt the STEM faculty and the staff were not helpful: faculty had too many students, were too focused on research, or did not know how to help. Some students discussed not receiving STEM career advice from their professors and advisors.

In Chapter 5, I interpret the findings using the conceptual framework and empirical literature discussed in Chapter 2. I also examine the limitations and implications of the study, as well as the recommendations for future research.

Chapter 5: Interpretations, Limitations, Implications, and Recommendations

The purpose of the study was to describe college students' experiences in changing their STEM major in their third year or later. Using basic qualitative design, the study investigated the phenomena of STEM attrition in college in the later years. During the data analysis process, three themes emerged regarding the research question: What are college students' perceptions of their decision-making and their experiences in changing their STEM major and career choice in their third year or later? The three themes reflect students' experiences and decision-making.

- Theme 1: College students experienced poor academic and career fit and changed their STEM major and their career choice.
- Theme 2: Their decision making in their third year or later was influenced by their mental health.
- Theme 3: Their decision making in their third year or later was influenced by their low student satisfaction in the STEM major program.

In this chapter, I provide an interpretation of the findings of the study and present the limitations and recommendations for future research. The chapter concludes with the study's possible implications for positive social change for students in higher education.

Interpretations of the Findings

The findings are consistent with the studies and theories associated with STEM attrition in college reviewed in Chapter 2. Astin's (1970) I-E-O model and Lent et al.'s (1994) SCCT were used as the conceptual framework to examine college students' experiences and decision-making process to leave their STEM major in their third year or later. The interpretation of the findings of the study is organized in four sections. In the first section, I reflect on the findings in light of each of two theories that served as the conceptual framework. In the subsequent sections, I interpret the three themes, including the subthemes of Theme 1, in the context of the empirical literature.

Interpretations in Light of the Conceptual Framework

The first theory I used as part of the conceptual framework is Astin's (1970) I-E-O model to explain the influence of the college environment on student development. The I-E-O model recognized and explained the relationship between student inputs to the college environment, the relationship between the college environment and student outputs, and the relationship between student input and output as being important for college persistence and retention. Astin theorized that the influence of student input on output depends on the college environment and the effect of college environment depends on the type of student. The findings of this study confirm Astin's I-E-O model as participants reflected in the first and most dominant theme, the relationship between the poor academic and career fit in their STEM major and their decision to leave STEM, which is a student output. Many of the participants mentioned academic concerns that discouraged them from continuing in STEM. The poor academic and career fit influenced the level of engagement with their STEM program and their low student satisfaction in their interaction with STEM faculty and staff.

The findings of the study also confirmed Astin's (1970) model that student inputs (precollege environment) also contribute to the college environment and the student outputs. Throughout the interviews, the participants discussed their high school experiences, their family, and their upbringing. A majority of the participants also reflected on their experience in STEM as it relates to their gender, class, status, and race and how it affected their experience and choice to switch to a non-STEM major.

In Chapter 2, I also reviewed how Astin’s (1970) I-E-O model includes the concept of student involvement on student learning and change. Astin (1984) described student involvement as the amount of energy a student devotes to their college experience. A highly involved student, Astin (1984) claimed, is typically a student who devotes a large amount of their time to studying, actively participates in student organizations, spends time on campus, and frequently interacts with faculty. On the other hand, an uninvolved student may spend little time studying, does not participate in school activities, and has minimal contact with faculty and other students. Most of the findings of the study did confirm Astin’s (1984) theory on student involvement, as the participants mentioned not actively participating in STEM clubs and infrequent interaction with STEM faculty and advisors and their regret in their inability to do so. Moreover, in their non-STEM major, the participants also reported high levels of involvement and more interaction with faculty once they switched to their non-STEM major.

However, the findings do not align completely with Astin’s (1984) theory that the amount of energy and time (student involvement) is directly correlated to academic performance. As stated in Chapter 4, a few students reported studying a lot and dedicating so much of their time to STEM that they did not have capacity to socialize or engage. Participants increased the number of hours dedicated to studying in hopes to improve their grades; however, they reported their increased time commitment did not improve their academic experience, and for some participants, it negatively affected their mental health, and some experienced feelings of isolation. For those students, they eventually realized that the little to no improvement in their STEM experience was not worth their amount of sacrifice, stress, time, and energy.

In the second theory of the conceptual framework, Lent et al.'s (1994) SCCT indicated that students choose their educational or career directions based on the interaction between three cognitive variables: self-efficacy beliefs, outcome expectations, and personal goals. Lent et al. argued that self-efficacy and outcome expectations directly and indirectly influence an individual's career interests, goals, and performance and argued self-efficacy is a stronger influence on behavior than outcome expectation (Lent et al., 1994). The findings of the study strengthen the SCCT's assumption about the stronger influence of self-efficacy compared to outcome expectation. Participants described having low self-efficacy in their STEM major. Two participants talked about imposter syndrome, whereas others expressed self-doubt and feeling behind when compared to their peers. For some participants, the low self-efficacy affected their comfort in seeking out support from their STEM faculty and staff. Students Cathy and Barbara described themselves as too embarrassed to ask for help from their professors, peers, or advisors. Diana was too intimidated to go to her professors and staff advisors for help so she would only seek advice from the STEM peer student advisors. The participants also expressed an increase in their self-efficacy when they engaged in non-STEM majors and explored new career opportunities. The findings reinforced the influence of outcome expectations to their decision to change majors to STEM. Participants recalled that outcome expectations like financial security, approval from their parents and others, and satisfaction were factors that initially influenced them to pursue STEM in college. As their self-efficacy lowered due to academic concerns such as disappointing grades, and the value of the outcomes of a STEM degree diminished as well, the participants decided to look at alternative non-STEM majors and careers.

The study's findings also confirmed Lent et al.'s (1994) assumption that goals are self-motivating because goal fulfillment can be linked to self-satisfaction. The participants talked about how their inability to improve their grades by trying new strategies like studying more, attending office hours or tutoring, influenced their belief that they could not be successful in STEM.

Similar to Astin's (1970) I-E-O model, Lent at al. 's (1994) SCCT assumes that personal inputs like race, ethnicity, and gender might influence self-efficacy, career interests, career choice, and goals. The findings of the study reinforced the SCCT assumptions as some participants viewed their race, ethnicity, or gender as social constructs that shaped their choice in choosing STEM as their initial major and in their decision to leave their STEM major and career.

Interpretation in Light of the Empirical Literature

The results indicated that for the participants, the decision-making focused on the choice to stay in or leave STEM. Researchers have found that about half of the students changed their STEM major after their first year (Chen, 2013; Emekalam, 2019; Jaradat & Mustafa, 2017), and in general, most major changes happen by the end of the second year (Sklar, 2018; Whitehead, 2018). All the participants in the study changed their major after their second year. Some participants talked about staying in the major longer because they felt pressure from their family and themselves to persist. Eleanor talked to her parents about switching out of her STEM major, but her parents were against it.

Some participants connected leaving their STEM major to failure as one study showed that 53% of underrepresented college students who failed their introductory STEM courses left college without a degree (Chen, 2013). The idea of being a failure may have caused some students to stay in the major longer. For instance, Beth experienced an internal battle and continued to pursue her STEM major in her fourth year before switching to humanities because she felt like she was supporting the social narrative that women cannot do STEM. Chen (2013) found that 29% of female students who declared STEM majors earned STEM degrees, while 40% of male STEM students earned STEM degrees. All the participants in this study eventually decided to leave their STEM major in their later years because of poor academic and career fit, mental health issues, and low student satisfaction. In the next sections, I interpret the findings in light of the empirical literature regarding the threads in the empirical literature: high school, career development, academic programs, social engagement, and mental health.

High School Experience

The participants in the study all described their high school experience as an influential factor to their choice of majoring in STEM in college. The findings aligned with the STEM research around major choice in college. Researchers have found that many students decide to major in STEM while they are in high school, and the strongest predictors to choosing STEM is their interest in STEM, taking rigorous high school courses, and their confidence in the STEM abilities (Evans et al., 2020; Moller et al., 2014). All the participants recalled choosing their STEM major in high school and getting above-average grades in their math and science courses. Six participants participated in high school programs focused on STEM. Brown et al. (2017) found that teachers may play an important role in the development of math self-efficacy and STEM self-efficacy by providing an engaging learning environment. Carlos and Diana discussed positive experiences with their learning environment. Outside of the classroom, Diana recalled a positive experience competing in a STEM robotics competition in which her team received second place for their STEM project.

When asked about their experience in choosing STEM as a major, most of the participants recalled how their high school teachers were influential in choosing STEM as their college major. Some participants talked about teachers pushing them towards STEM and other participants described high school math and science teachers serving as role models in STEM. The participants' experiences confirmed the research regarding high school teachers and STEM. Research showed that K-12 classroom teachers are typically the first educators to foster and create awareness about STEM in students (Moller et al., 2014; Whitehead, 2018).

Green and Sanderson (2018) indicated that high school math and science preparation, not collegiate educational experiences, was a strong predictor of success in STEM fields. The data in this study suggest otherwise. Although the participants all reported feeling confident in their ability to do STEM in high school and achieving above average grades in high school, a majority of the participants discussed how their high school STEM preparation did not adequately prepare them for their STEM courses in college. Upon entering college, some participants felt behind in their STEM courses compared to their peers. Two participants talked about the not having good time management skills while others discussed not having good study skills to excel in their STEM courses. The participants connected their ill preparation to stress in their environment. For Frances, the feeling of being behind and having to catch up was a factor for leaving her STEM major. The findings of this study did not support the argument that high school math and science preparation are the strongest predictor for STEM success in college; however, it is important to note that the participants were not asked about the rigor of their high school courses, which is important factor in their STEM preparation.

Need for Career Development

When asked to describe their STEM career goals, a few participants noted that they had not been thinking about the connection between their STEM major and a future STEM career. They chose STEM as their major based on their high school experience and the influence of parents and high school teachers. Once in college, some participants talked about how the lack of an "interesting" STEM career demotivated them to continue studying STEM in college. Diana recalled talking to a math professor and not feeling interested in any career options that the professor presented to her. The perceived lack of interesting careers in STEM eventually led participants like Diana, Carlos, Albert, and Cathy, to find an alternative major or career choice outside of STEM. The findings of this study confirm Jaradat and Mustafa's (2017) findings, which suggested that career advancement opportunities, job opportunities, and a student's interests might have a strong relationship with major selection. Prescod et al. (2018) also suggested that career development theory could provide additional insight into the factors that influence a STEM-interested student to select a non-STEM career.

Academic Programs

The study's findings are consistent with the research around institutional practices. The research shows that the quality of the academic program, instruction, and classroom environment may influence STEM persistence (King, 2015; Miller et al., 2015; Xu, 2018). Xu (2018) found the perceived quality of the academic program and the accessibility to faculty increased their intent to persist in STEM and degree completion. The findings are also consistent with the research about the first-year student experience. The researchers suggested that weaker first-year performance increases the likelihood of STEM attrition and college drop-out rates (Adelman, 2006; Chen, 2013; Ost, 2010; Seymour & Hewitt, 1997; Xu, 2018). The findings suggested that the academic concerns such as large classes, disappointing grades, rigorous courses discouraged participants to continue pursuing STEM.

The results support Miller et al.'s (2015) findings that internal academic barriers (e.g., poor test performance) and development skill deficits, such as time management, were the most frequently mentioned challenge. A majority of the participants recalled not having adequate study skills and time management skills to be successful in their STEM courses.

The findings also supported the research around academic advising. Tinto (2006) found that advising supports retention when advisors help students with selecting a major and provide guidance in navigating college. In qualitative studies, using the SCCT model, students reported inadequate advising as a major barrier to success in engineering (Fernandez et al., 2008; Miller et al., 2015). Some participants reported having a difficult time scheduling appointments with their academic advisor and being misadvised by their advisors. The lack of staff advisor support was linked to their poor academic and career fit and low student satisfaction.

The findings supported Tuthill and Berestecky's (2017) assumption that relationships with STEM professors may influence STEM major persistence. Participants emphasized their lack of support from their professors. On the contrary, some researchers have found that faculty interaction might not have a direct effect or be statistically significant to the decision to choose STEM (Evans et al., 2020; Green & Sanderson, 2018).

Importance of Social Engagement

The study's findings confirmed higher education theorists' assumptions that social engagement is considered an important part of the college experience (Kuh et al., 2005; Tinto, 1975). Nine of the participants talked about their little to no engagement with STEM clubs and organizations because of the lack of time and always feeling behind. However, Xu (2018) found that social engagement with peers in college did not seem to affect STEM persistence. The findings of the study add to the existing literature because students recalled low engagement with their STEM program and peers because of the challenging time commitment to their STEM coursework and other personal commitments, like work.

The findings also highlighted how their social engagement and sense of belonging changed when exploring their non-STEM major and it was factor for their decision to leave their STEM major. A majority of the participants described positive interactions with non-STEM faculty and feeling more welcomed in their non-STEM courses. A few participants from underrepresented backgrounds talked about interacting with more diverse faculty, which increased their sense of belonging. Their positive experience differed from their STEM experience, which motivated them to pursue a non-STEM major.

Mental Health is a Factor

The study's findings brought light to the importance of mental health in higher education and STEM persistence. Mental health was not a factor I reviewed in the empirical literature review. It was surprising that 6 of the 10 participants mentioned their mental health as an influential factor for leaving their STEM major. A study by Andrews et al. (2020) studying STEM attrition in the Engineering Futures Project found a similar unpredicted outcome, a majority of the students experienced issues with their mental health in the last 12 months. According to a national survey, college students cited depression, anxiety, and stress as the most common mental health concerns and the rates of these mental health issues have been steadily increasing in the last 6 years (Center for Collegiate Mental Health, 2020). The findings of the study support Leppink et al. (2016) findings that depression, anxiety, and stress have negative effects on students' academic achievement and retention.

Limitations of the Study

There are several limitations associated with this study. The findings of the study are limited to the perceptions and experiences of 10 students at just one research university and may not fully represent the experiences of all STEM leavers in their third year or later. The findings may not be transferable to similar populations due to the small sample size; also, the characteristics of the one research university may not fully represent the factors influencing STEM attrition at other higher education institutions.

The study was limited to the perspective of students who attended the research university as freshman. The study does not capture the perspective of other STEM students, like transfer students. The study is also limited to the experiences of STEM students in a particular period and may not be reflective of STEM students in other years. Because I used the NSF list of majors and two other majors, I had not considered at the university from which I recruited, the findings of the study might not apply to other science related programs such as pre-medical students. Not including transfer students and those from other science majors may limit the richness of the data.

Another limitation is that participants had the ability to self-select themselves for the study, a limitation inherent in basic qualitative approaches. Students selected to participate in the study volunteered to participate in the study after receiving an email invitation from their academic advisor. The students who volunteered may have similar backgrounds and experiences and an eagerness to share their experiences that might not be the same as students who may be unhappy in their new major.

Recommendations for Future Research

This qualitative study aimed to add to the existing research on STEM attrition by exploring the reasons behind students' choice to leave STEM for a non-STEM major in the third year and beyond. The findings suggest several implications for future research. One of the strengths of this study was the focus on the phenomenon of STEM attrition from the experiences of students who decided to change their STEM major to a non-STEM major at one research university in California. Future qualitative research is needed to further examine STEM attrition from the perspective of students who attend different kinds of higher education institutions. Studying STEM attrition at different college campuses could help researchers and higher education leaders learn what factors consistently affect STEM attrition or might be unique to individual institutions.

Additional research could explore the different factors that emerged from the findings. For instance, STEM researchers and higher education leaders would benefit from studies that examine the influence of mental health on STEM attrition, as the study's participants revealed that mental health was a factor behind their decision to leave STEM. A mixed method study could be designed to look at the various issues like GPA, studying and tutoring time, engagement with STEM clubs, and hours of professor and advisor interaction and how they intersect with mental health. Finally, many participants talked about the lack of support from faculty and staff. Further research could investigate the STEM faculty and staff perspective of working with underrepresented students in STEM, particularly first generation, undocumented, LGBTQ+, and female students and their possibly unique needs, as well as faculty perception of effective practices.

Implications

Implications for positive social change based on the results of the study may include a deeper understanding of the perceptions of students who leave their STEM major for a non-STEM major. The goal of this study was to provide higher education professionals information on the factors that may contribute to STEM attrition in the later college years to help design or improve STEM retention programs. Based on the results of the study it appears that higher education institutions may increase retention in STEM programs as well as student satisfaction and self-efficacy by developing and expanding academic advising programs. Three areas to consider enhancing would be first-year advising programs, career advising, and mental health counseling. New students entering STEM may benefit in having early access to talk one-on-one with their academic advisor about the expectations of their STEM classes and their schedule. According to the participants, career advising was not offered or was not readily accessible for them. I would recommend that higher education institutions make career counseling mandatory in the first 2 years of college, focusing on career options for their major and courses. This recommendation would require hiring more career counselors or more advisor development on career advising. The third area is to increase access to mental health services and focus on destigmatizing mental health in higher education.

Higher education institutions could also collaborate with local high schools to expose high school students to college-level STEM coursework and work with high school teachers to increase the rigor of their math and science courses. As the findings and existing research indicated, high school math and science preparation are strong predictors of STEM persistence. High school programs could also include college preparation courses that focus on improving study skills, time management, and introduce them to possible STEM careers. Also, exposing high school students to career options in the STEM field might align their outcome expectations (Lent et al., 1994).

The findings of the study may also contribute to the scholarly literature regarding STEM attrition by highlighting the happiness the participants experienced when they found a non-STEM major and career that better fit their interests and passion. All the participants reported a sense of relief and positive outlook in their new non-STEM major and future career opportunities. Some of the perspectives of the participants and the statistics introduced in Background section of Chapter 1 connect STEM attrition to failure in college. For instance, in college, 53% of underrepresented students who failed their introductory STEM courses left college without a degree (Chen, 2013). In contrast, the participants in the study associated their experience of leaving STEM with positivity and hopefulness.

Conclusion

Chapter 1 highlighted that higher education STEM programs recruit more students than non-STEM majors but one-half of these STEM initiated majors do not earn a STEM degree (Chen, 2013; Emekalam, 2019; Green & Sanderson, 2018). The empirical literature suggested a limited ability of higher education leaders to effectively retain STEM students in the field and the lack of scholarly understanding of the STEM leavers' experience after the first 2 years of college. With this dissertation, I wanted to explore the potential reasons for STEM attrition in the later college years. By interviewing 10 participants and using thematic data analysis, I was able to discern three themes to describe and explain the experiences and the decision making of students who leave their STEM major in their third year or later. Participants decided to change their major and career choice because of poor academic and career fit, mental health issues, and low student satisfaction. The findings of the study highlighted how important the high school experience was to the participants' initial STEM major and career choice. The study also brought to light the importance of social engagement, mental health, and time management to STEM retention and attrition.

The existing literature on STEM attrition is mostly quantitative and focuses on the first 2 years of college. This basic qualitative design study brings new insight to STEM attrition as it describes the detailed experience of college students who leave their STEM major and change their career choice in their third year or later. With this research, I was able to contribute to the knowledge on STEM attrition and offer implications for positive social change and recommendations for future research. My implications and recommendations may improve and inform higher education policy and STEM retention programs.

References

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* U.S. Department of Education. https://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

Andrews, J., Clark, R., & Phull, S. (2020). Attrition, mental health and student support in engineering education: the Engineering Futures Project. *Widening Participation & Lifelong Learning, 22*(3), 8–29. https://doi.org/10.5456/WPLL.22.3.8

Ashraf, R., Godbey, J. M., Shrikhande, M. M., & Widman, T. A. (2018). Student motivation and perseverance: Do they explain college graduation? *Journal of the Scholarship of Teaching and Learning*, *18*(3), 87–115. https://doi.org/10.14434/josotl.v18i3.22649

Astin, A. W. (1970), The methodology of research on college impact, part one*, Sociology of Education, 43*(3), p. 223-254. https://doi.org/10.2307/2112065

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel*, *25*(4), 297-308.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall.

Beggs, J. M., Bantham, J. H., & Taylor, S. (2008). Distinguishing the factors influencing college students' choice of major. *College Student Journal, 42*(2), 381-394.

Braun, V., & Clarke, V. (2013). *Successful qualitative research; A practical guide for beginners*. SAGE.

Brown, R., Ernst, J., Clark, A., DeLuca, B., & Kelly, D. (2017). Engaging females in

STEM: Despite students' actual abilities in STEM, their self-perceptions can be the ultimate deciding factor in what courses they choose to pursue. *Technology & Engineering Teacher, 77*(3), 29–31.

Bureau of Labor Statistics. (2019, January). *Fastest growing occupations*. U.S. Department of Labor. https://www.bls.gov/emp/tables/fastest-growing-occupations.htm

Burke, A. (2019). Student retention models in higher education: A literature review. *College and University*, *94*(2), 12–21.

Byars-Winston, A., & Rogers, J. G. (2019). Testing intersectionality of race/ethnicity × gender in a social–cognitive career theory model with science identity. *Journal of Counseling Psychology, 66*(1), 30–44. https://doi.org/10.1037/cou0000309

Caelli, K., Ray, L., & Mill, J. (2003). "Clear as mud": Toward greater clarity in generic qualitative research. *International Journal of Qualitative Methods*, *2*(2), 1–23. https://doi.org/10.1177/160940690300200201

Center for Collegiate Mental Health. (2020). *2020 Annual report* (Publication No. STA 21-045). Penn State University. https://ccmh.psu.edu/assets/docs/2020%20CCMH%20Annual%20Report.pdf

Charleston, L. J. (2012). A qualitative investigation of African Americans' decision to pursue computing science degrees: Implications for cultivating career choice and aspiration. *Journal of Diversity in Higher Education*, *5*(4), 222–243. https://doi.org/10.1037/a0028918

Chen, X. (2009). *Students who study science, technology, engineering, and mathematics*

(STEM) in postsecondary education (NCES 2009-161). U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2009/2009161.pdf

Chen, X. (2013). *STEM attrition: College students' paths into and out of STEM fields* (NCES 2014-001) [Statistical Analysis Report]. U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2014/2014001rev.pdf

Chen, X. (2015). STEM attrition among high-performing college students: Scope and potential causes. *Journal of Technology and Science Education*, *5*(1). https://doi.org/10.3926/jotse.136

Chen, X., & Soldner, M. (2013). *STEM attrition: College students' paths into and out of STEM fields statistical analysis report* (NCES 2014 – 001). U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2014/2014001rev.pdf

Committee on STEM Education of the National Science & Technology Council. (2018). *Charting a course for success: America's strategy for STEM education*. Office of Science and Technology Policy. https://www.energy.gov/sites/default/files/2019/05/f62/STEM-Education-Strategic-Plan-2018.pdf

Cunningham, K. E., & Smothers, A. W. (2010). The effect of self-efficacy and psychosocial development on major-changing behavior. *NACADA Journal*, *30*(2), 65-71. https://doi.org/10.12930/0271-9517-30.2.65

Dewsbury, B. M., Taylor, C., Reid, A., & Viamonte, C. (2019). Career choice among first-generation, minority STEM college students. *Journal of Microbiology & Biology Education*, *20*(3). https://doi.org/10.1128/jmbe.v20i3.1775

Durkheim, E. (1951). *Suicide: A study in sociology.* Simon & Schuster.

Emekalam, A. (2019). Reducing attrition from STEM disciplines: understanding the student athlete's perspective. *Peer Review, 21*(1–2), 34.

Evans, C. A., Chen, R., & Hudes, R. P. (2020). Understanding determinants for STEM major choice among students beginning community college. *Community College Review, 48*(3), 227–251. https://doi.org/10.1177/0091552120917214

Fain, P. (2017, June 1). Second thoughts about higher education decisions. *Inside Higher Ed*. https://www.insidehighered.com/news/2017/06/01/survey-finds-regrets-among-most-former-college-students-belief-quality-their

Fernandez, M. J., Trenor, J. M., Zerda, K. S., & Cortes, C. (2008). First generation college students in engineering: A qualitative investigation of barriers to academic plans. *2008 38th Annual Frontiers in Education Conference*. https://doi.org/10.1109/fie.2008.4720256

Fouad, N. A., & Santana, M. C. (2017). SCCT and underrepresented populations in STEM fields: Moving the needle. *Journal of Career Assessment, 25*(1), 24–39. https://doi.org/10.1177/1069072716658324

Green, A., & Sanderson, D. (2018). The roots of STEM achievement: An analysis of persistence and attainment in STEM majors. *American Economist*, *63*(1), 79-93. https://doi.org/10.1177/0569434517721770

Hall, A. R., Nishina, A., & Lewis, J. A. (2017). Discrimination, friendship diversity, and STEM-related outcomes for incoming ethnic minority college students. *Journal of Vocational Behavior*, *103*, 76–87. https://doi.org/10.1016/j.jvb.2017.08.010

Hilts, A., Part, R., Bernacki, M. L. (2018). The roles of social influences on student competence, relatedness, achievement, and retention in STEM. *Science Education, 102*(4), 744-770. https://doi.org/10.1002/sce.21449

Institute of Medicine, National Academy of Engineering, National Academy of Sciences, Engineering, and Public Policy Committee on Science, & Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (Competitiveness)*. National Academies Press.

Jaradat, M. S., & Mustafa, M. B. (2017). Academic advising and maintaining major: Is there relation? *Social Sciences (2076-0760), 6*(4), 1. https://doi.org/10.3390/socsci6040151

Kahlke, R. M. (2014). Generic qualitative approaches: Pitfalls and benefits of methodological mixology. *International Journal of Qualitative Methods*, 37–52.

King, B. (2015). Changing college majors: Does it happen more in STEM and do grades matter? *Journal of College Science Teaching, 44*(3), 44–51. https://doi.org/10.2505/4/jcst15_044_03_44

Kuchynka, S. L., Salomon, K., Bosson, J. K., El-Hout, M., Kiebel, E., Cooperman, C., & Toomey, R. (2017). Hostile and benevolent sexism and college women's STEM outcomes. *Psychology of Women Quarterly*, *42*(1), 72–87. https://doi.org/10.1177/0361684317741889

Kuh, G. D., Kinzie, J., Schuh, J. H., & Whitt, E. J. (2005). *Student success in college: Creating conditions that matter*. John Wiley & Sons.

Leppink, E. W., Odlaug, B. L., Lust, K., Christenson, G., Grant, J. E. (2016). The young and the stressed: Stress, impulse control, and health in college students. *The Journal of Nervous and Mental Disease*, 204, 931–938. https://doi.org/10.1097/NMD.0000000000000586

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance (Monograph). *Journal of Vocational Behavior, 45,* 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Miller, M. J., Smith, P. E., Watford, B. A., Lim, R. H., Hui, K., … Williams, K. (2013). Social cognitive predictors of adjustment to engineering majors across gender and race/ethnicity. *Journal of Vocational Behavior*, *83*(1), 22–30. https://doi.org/10.1016/j.jvb.2013.02.006

Lent, R. W., Miller, M. J., Smith, P. E., Watford, B. A., Hui, K., & Lim, R. H. (2015). Social cognitive model of adjustment to engineering majors: Longitudinal test across gender and race/ethnicity. *Journal of Vocational Behavior, 86*, 77–85. https://doi.org/10.1016/j.jvb.2014.11.004

Lincoln, YS. & Guba, EG. (1985). *Naturalistic inquiry.* Sage Publications.

Mason, M. (2010). Sample size and saturation in PhD studies using qualitative interviews. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, *11*(3). https://doi.org/10.17169/fqs-11.3.1428

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Miller, M. J., Lent, R. W., Lim, R. H., Hui, K., Martin, H. M., Jezzi, M. M., Bryan, N. A., Morrison, M. A., Smith, P. E., Watford, B., Wilkins, G., & Williams, K. (2015). Pursuing and adjusting to engineering majors: A qualitative analysis. *Journal of Career Assessment, 23*(1), 48–63. https://doi.org/10.1177/1069072714523084

Milsom, A., & Coughlin, J. (2015). Satisfaction with college major: A grounded theory study. *NACADA Journal*, *35*(2), 5–14. https://doi.org/10.12930/NACADA-14-026

Moakler, M. W., & Kim, M. M. (2014). College major choice in stem: Revisiting confidence and demographic factors. *The Career Development Quarterly, 62*(2), 128–142. http://dx.doi.org/10.1002/j.2161-0045.2014.00075.x.

Moller, S., Banerjee, N., Bottia, M. C., Stearns, E., Mickelson, R. A., Dancy, M., … Valentino, L. (2014). Moving latino/a students into STEM majors in college. *Journal of Hispanic Higher Education*, *14*(1), 3–33. https://doi.org/10.1177/1538192714540533

National Science Board. (2018). *Science and engineering indicators report 2018.* (Federal No. NSB-2018 –2). National Science Foundation. https://www.nsf.gov/statistics/2018/nsb20181/report

National Science Foundation. (2019). *Women, minorities, and persons with disabilities in science and engineering* (Federal No. NSF 19–304). National Science

Foundation. https://ncses.nsf.gov/pubs/nsf19304/

Ost, B. (2010). The role of peers and grades in determining major persistence in the sciences. *Economics of Education Review*, *29*(6), 923–934. https://doi.org/10.1016/j.econedurev.2010.06.011

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). SAGE.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). SAGE.

Poggenpoel, M., & Myburgh, C. (2003). The researcher as research instrument in educational research: A possible threat to trustworthiness? *Education*, *124*(2), 418-44.

Prescod, D.J., Daire, A.P., Young, C., Dagley, M., & Georgiopoulos, M. (2018). Exploring negative career thoughts between STEM-declared and STEM-interested students. *Journal of Employment Counseling*, *55*: 166-175. https://doi.org/10.1002/joec.12096

President's Council of Advisors on Science and Technology. (2020). *Recommendations for strengthening American leadership in industries of the future. Report to the President*. https://science.osti.gov/-/media/_/pdf/about/pcast/202006/PCAST_June_2020_Report.pdf?la=en&hash=019A4F17C79FDEE5005C51D3D6CAC81FB31E3ABC

Rice, L., Barth, J. M., Guadagno, R. E., Smith, G. P. A., & McCallum, D. M. (2013). The role of social support in students' perceived abilities and attitudes toward math and science. *Journal of Youth and Adolescence*, *42*, 1028–1040.

doi:10.1007/s10964-012-9801-8

Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. *Educational Researcher*, *48*(3), 133–144. https://doi.org/10.3102/0013189x19831006

Roese, N. J., & Summerville, A. (2005). What we regret most... and why. *The Neuroscientist*, *31*(9), 340–352. https://doi.org/10.1177/107385840100700410

Rubin, H. J., & Rubin, I. (2012). *Qualitative interviewing: The art of hearing data.* (3rd ed). SAGE.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed). SAGE.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Westview Press.

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies*, *7*(1), 46–59. http://dx.doi.org/10.5539/hes.v7n1p46

Sklar, J. C. (2018). Event history analysis for investigating the likelihood and timing of changing majors. *NACADA Journal, 38*(1), 47–60. https://doi.org/10.12930/NACADA-17-039

Social Cognitive Career Theory - IResearchNet. (2016, February 7). Retrieved January 14, 2020, from https://psychology.iresearchnet.com/counseling-psychology/career-counseling/social-cognitive-career-theory/

Spady, W. G. (1970). Dropouts from higher education: An interdisciplinary review and synthesis. *Interchange*, *1*(1), 64–85. https://doi.org/10.1007/bf02214313

Syed, M., Azmitia, M., & Cooper, C. R. (2011). Identity and academic success among underrepresented ethnic minorities: An interdisciplinary review and integration. *Journal of Social Issues*, *67*(3), 442–468. https://doi.org/10.1111/j.1540-4560.2011.01709.x

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, *45*(1), 89-125.

Tinto, V. (1993). Building community. *Liberal Education*, *79*(4), 16-21.

Tinto, V. (2006). Research and practice of student retention: What's next? *Journal of College Student Retention: Research, Theory & Practice*, *8*(1), 1-19.

Tuthill, M. C., Berestecky, J. M. (2017). Integrating undergraduate research at 2-year colleges. *Journal of College Science Teaching, 46*(4), 12–17. https://www.jstor.org/stable/44579908

Wang, X. (2013). Modeling entrance into STEM fields of study among students beginning at community colleges and 4-year institutions. *Research in Higher Education, 54*(6), 664–692. https://doi.org/10.1007/s11162-013-9291-x

Whitehead, A. (2018). Examining influence of family, friends, and educators on first-year college student selection STEM major selection. *Journal of Mason Graduate Research,5*(2), 58-84. http://dx.doi.org/10.13021/G8jmgr.v5i2.1963

Xu, Y. J. (2018). The experience and persistence of college students in STEM majors. *Journal of College Student Retention: Research, Theory & Practice, 19*(4), 413–432. https://doi.org/10.1177/1521025116638344

Xu, Y. J., & Webber, K. L. (2018). College student retention on a racially diverse campus: A theoretically guided reality check. *Journal of College Student Retention: Research, Theory & Practice*, *20*(1), 2-28.

Appendix: Interview Protocol

RQ: What are college students' perceptions of their decision making and their experiences in changing their STEM major and career choice in their third year or later?

Warm-up questions: These questions are not designed to collect demographic information but to provide context for the interview and help the participants acclimate to the topic.

- What was your specific STEM major?
- What is your current year in college?
- What non-STEM major are you currently pursuing?

1) I am interested in hearing the story of how you came to major in your STEM major. Thinking back over the course of your life, what are some of your experiences that influenced your choice to major in STEM?

   Possible probing questions:

   a. What kind of career/life plans did you have along the way?
   b. Are there any other experiences that stand out as encouraging you toward majoring in STEM?
   c. Were there people who influenced your decision to major in STEM? Parents? Teachers? Friends?
   d. What might have influenced your choice in attending this school?

2) Tell me about your time as a STEM major?

   Possible probing questions:

a. Can you tell me about your engagement with academic advising?

    i. How often did you meet with your academic advisors? What was the nature of those meetings? Were any of those meetings mandatory?

b. Tell me about your experience in your STEM major courses.

c. Tell me about your professors in your courses.

d. Tell me what you liked or disliked about your courses.

e. How about GPA?

3) Do you feel a sense of belonging in your STEM major? Did you ever feel out of place? Why or why not?

Possible probing questions:

a. Did those feelings change over time? If so, what led to the change?

b. Tell me about your peers in your STEM major. How often did you socialize with people who are STEM majors? Did you enjoy socializing with them?

c. How often did you study with other students in STEM major? Were there ways that your peer relationships or shared study may have contributed to your decisions?

d. Tell me about how your advisors and/or professors may have contributed to your sense of belonging.

e. Tell me about how formal or peer mentoring programs may have contributed to your sense of belonging.

f. Did you belong to any clubs or organizations related to your STEM program? Why or why not?

    i. If yes, tell me about the level of involvement in those clubs or organizations.

    ii. If not involved in STEM, were you involved in clubs or organizations not related to STEM?

g. Possible probing question related to gender if brought up: do you think the experience of pursuing a STEM major was different for you in relationship to your gender identity? Why or why not?

h. Possible probing question related to race, if brought up: do you think the experience of pursuing a STEM major is in relationship to your racial identity? Why or why not?

i. Possible probing questions related to international student status, if brought up: do you think the experience of pursuing a STEM major is different for you as an international student?

4) Since you started college, has your interest in science in general or your interest in your STEM major changed? Why or why not?

Possible probing questions:

a. If so, what contributed to your change in interest?

b. What do you think was the one most influential factor or experience in your decision to change your major from STEM major? Tell me about it.

5) Please describe what your experiences were when you changed your major from STEM to a non-STEM major?

Possible probing questions:

a. What was the decision making process like for you in deciding to change from a STEM to a non-STEM major?
b. When did you first know you would change your major to your non STEM major?
c. When changing your major, did you consider another area of STEM? Why or why not?
d. How does your family feel about your decision to change your major to your non-STEM major? What about your peers/friends?
e. Did your perceived sense of belonging change when you changed to the new major?

6) Please describe how, if at all, your career choice has changed as a result of switching from a STEM to a non-STEM major.

Possible probing questions:

a. Would you consider a different major if you could start over as a freshman (if so, why and what major would you pick?)?

7) Closing: I am interested in learning why people decide to leave their STEM major. Is there anything else along these lines that I have not asked about that I should have?

Debrief

1) Thank you so much for participating in my study. I will be reviewing the recording in the next month. How can I get in touch with you if I need you to verify or clarify parts of the interview? I will be sending you a transcript of the interview.
2) Once the study is complete, I will be happy to share the outcomes.
3) I will be sending you a gift card to thank you for your participation. Can I send it via email?