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Characteristics of Science, Technology, Engineering, And Mathematics Mentoring Relationship Practices In Secondary Education Settings: A Case Study

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ABSTRACT

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The use of science, technology, engineering, and mathematics (STEM) mentors in public school systems and other organizations has grown comparably with our economy's increasing demand for STEM industry professionals. However, inspiring students to pursue STEM careers by using STEM industry professionals as mentors requires an understanding of effective mentor practices. Limited research exists that focuses on the mentoring practices students respond to as they make academic and career plans. The purpose of this study was to investigate and identify practices that promote STEM careers among youth. The study sought to answer the question, "What STEM mentor practices, behaviors, and roles do students identify as increasing their interest in pursuing STEM careers?"

This study used a qualitative case study methodology. Golden Meadows School District was selected due to its extensive secondary education STEM mentoring programming. STEM education courses and activities are offered district-wide at the Center for STEM Instruction and Innovation (CSII). Golden Meadows was also chosen for the longevity of its program and the variety of STEM-focused project teams. The project teams were supported by industry mentors recruited from local businesses. The study focused on the perspectives of mentees working with industry mentors from various STEM disciplines. Students in the 11th and 12th grades were asked to participate in interviews. Participants answered questions about mentoring experiences that influenced their plans to pursue STEM professions. Interview responses and project team artifact review were used to analyze mentee perspectives. Two themes emerged from the findings which defined practices identified by mentees.

The findings revealed that mentees pursuit of STEM careers was influenced by mentor practices that built mentee self-confidence and a comprehensive understanding of STEM careers. The study is supported by previous research focused on the value of mentoring and its use to positively influence young people.

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TABLE OF CONTENTS

CHAPTER

APPENDIX

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Technological advancements have led to complex changes in science, technology, engineering, and mathematics (STEM) industries (Fayer et al., 2017). These changes have compelled education systems in the United States and worldwide to adjust the available STEM programming and curriculum for secondary school youth (Lister, 2017; Rangel et al., 2021). As schools prepare youth for a dynamic industry, they seek to understand the nature of current and future STEM careers (Rangel et al., 2021). There is also the need to hire and maintain a workforce of teaching professionals with the expertise to effectively instruct youth in STEM subjects (Alper, 2017). Through mentorship programs, educational leadership has recognized the need to connect with members of the STEM workforce because of the complexity of the industry (Alper, 2017). The resulting challenges require school systems to build relationships with industry mentors (Stelter et al., 2020). Providing context, evidence, and rationale for STEM mentoring programs is the purpose of chapter one. Mentorship programs are essential to providing comprehensive STEM education in secondary schools. Through STEM mentoring programs, students have the opportunity to explore careers in high-tech industries and receive specialized STEM instruction (P-TECH, 2023).

The Science, Technology, Engineering, and Mathematics Industry: A Changing Landscape

Recent years have seen rapid growth in the STEM industry. STEM industry companies belong to the high-tech industry that the U.S. Bureau of Labor and Statistics (as cited in Roberts & Wolf, 2018) defined as any industry requiring a high concentration of workers in STEM-related occupations. Companies such as International Business Machines (IBM), Google, and Apple Inc. are just a few notable names in the STEM industry. Compared to other industries, the high-tech industry is experiencing anomalous growth.

> Employment in STEM occupations grew by 10.5%, or 817,260 jobs, between May 2009 and May 2015, compared with 5.2% net growth in non-STEM occupations… Computer-related industries made up 45% of STEM employment in 2015. …Computer occupations and engineers were among the types of STEM occupations with the highest job gains (Fayer et al., 2017, p. 7).

STEM industries have experienced much of the aforementioned growth in the past two decades alone. "Employment in science, technology, engineering, and mathematics (STEM) occupations has grown 79% since 1990, from 9.7 million to 17.3 million, outpacing overall U.S. job growth" (Graf et al., 2018). Further, the high-tech sector continues to grow. According to Bureau of Labor Statistics (BLS) projections, which were developed prior to the COVID-19 pandemic of 2020, Science and Engineering (S&E) employment is expected to grow faster than overall employment through the 2019–29 period (10% vs. 4%) (Burke & Okrent, 2021). S&E managers, computer and mathematical scientists, and health care practitioners and technicians are expected to grow the most—at 18%, 13%, and 9%, respectively—from 2019 to 2029 (Burke & Okrent, 2021). High-tech industries will continue to change and many of the needs of the future workforce are currently unknown. According to Petit (2018), 65% of elementary school youth's future jobs are not yet a reality and many of them will be created by STEM industries. How do the public education system and high-tech industry prepare future generations for the unknown?

Although our current K-12 education system yields enough STEM-skilled talent to meet current employer requirements for traditional STEM jobs, more than 75% of qualified STEM-capable youth never pursue STEM careers (Rangel et al., 2021). The problem of filling the needed positions in the high-tech industry is compounded by rapid growth, which has caused problems as it has been unable to attract the required talent. Youths majoring in computer science in the nation's colleges is down by 70% since the year 2000 and American College Testing (ACT) data collected in 2019 projected job growth to continue to outpace student interest in computer science fields (Cuny, 2019).

Science, Technology, Engineering, and Mathematics Education

STEM education in schools has adapted to rapid changes in high-tech industries by increasing experiences within STEM disciplines for youth (Lister, 2017). By creating but failing to pass needed legislation for STEM education funding, the United States government has highlighted the need for more STEM education (Kastrenakes, 2016). However, state and local governments have answered the call by passing funding legislation (Kastrenakes, 2016). Many schools around the country now participate in the Pathways in Technology Early College High School (P-TECH) program (P-TECH, 2023). The P-TECH program is a "partnership among K-12, community college, and industry, each making long-term commitments and contributing their best expertise to provide youth with rigorous and hands-on academic, technical and workplace experiences" (P-TECH, 2023, p. 1). According to the Colorado Department of Education, in 2015, Governor Hickenlooper signed a P-TECH law that currently serves seven secondary schools in the state (Hunter, 2019).

Mentoring: A Response to Industry and Science, Technology, Engineering, and Mathematics Education Needs

In response to rapid advancements in STEM industries, STEM education has transformed. Thus, schools are required to provide opportunities for youth that facilitate the development of a solid workforce for industries (Kastrenakes, 2016). "Assessing, enabling and strengthening workforce pathways is essential to the mutually reinforcing goals of individual and national prosperity and competitiveness" (Board, 2015, p. 16). A STEM pathway involves providing youth with opportunities to gain knowledge from professionals in the STEM field. "Kids need STEM mentors and role models to look up to. They need more education about STEM degrees and related jobs so they can look forward to bright futures in these fields" (Barone, 2019). Through mentorship relationships, industry professionals provide an extension of STEM education.

Mentoring relationships with STEM professionals would increase youth involvement in STEM education and familiarize them with the field (Alper, 2017). Youth have the opportunity to develop the skills and passions required for STEM careers by exploring STEM careers in high school. Schools are implementing mentoring programs and industry mentors have a significant role to play in the educational process. As youth become involved in mentoring programs at the secondary education level, school-industry partnerships could serve long-term interests.

History of Mentoring

The positive influence of mentors on our youth has been documented over the years in the United States. To improve the circumstances of children in poverty, mentoring programs were developed in the early 19th century. Individuals with means and financial stability used their social status to benefit less fortunate individuals through early mentoring programs. A program of this type was the Friendly Visitor program. Campaigns such as these were designed to reduce the wealth gap (Rhodes, 2004). In addition, the campaigns provided relationship-building opportunities for less fortunate individuals as "…middle-class women attempted to form a personal relationship with children in poverty" (Rhodes, 2004, p. 127). Although this movement eventually faded, other organizations focused on mentoring were formed (Rhodes, 2004).

Mentoring organizations evolving from this initial effort have enjoyed some longevity in society. One such organization, Big Brother/Big Sisters, began as a call to action by Ernest K. Coulter who worked in the first children's court in New York (Miller, 2002). Coulter felt children were not being given guidance. Courts were placing children in reform schools, and they were not improving; many were re-offending regardless of attempts by schools at rehabilitation (Miller, 2002). The success and expansion of Big Brothers/Big Sisters inspired mentoring programs to begin to form at the nation's state and local levels (Rhodes, 2004). "Beginning in the early 1900s, individual agencies were founded in various cities" (Rhodes, 2004, p. 127). This growth inspired the establishment of a national organization created to help organize and inform mentoring programs.

The National Mentoring Partnership, which creates and distributes mentoring training materials nationally while developing partnership programs at the state and local levels, was born of this need (Rhodes, 2004). Through this partnership, education professionals recognized the trends and benefits of mentoring youth. In 1983, *A Nation at Risk* was created by the National Commission on Excellence in Education (Miller, 2002). In the report, schools, higher education institutions, and corporations were encouraged to form partnerships. In 1989, President Bush made a public service announcement promoting mentoring in education (Miller, 2002). Likewise, government officials encouraged the high-tech industry to begin participating in educational programming through mentorships. In 1990, "...the First National Mentoring Conference was held with Elizabeth Dole, Secretary of Labor, giving the keynote address and federal endorsement" (Miller, 2002, p. 5).

A connection was established, and mentoring has been a fixture in educational programming ever since. "Education departments have also identified areas of school improvement where mentoring can contribute to the twin goals of raising standards and countering social exclusion" (Miller, 2002, p. 22). It has only been recently that industry professionals realized the necessity of mentoring specifically to maintain and develop a workforce in the high-tech sector. Mentoring youth had previously been seen as a public relations effort or a charitable donation. Industries realized that the partnerships formed through mentoring might eventually become a part of the solution to the industry workforce shortage and professional development needs (Alper, 2017; Miller, 2002). "There is an even greater benefit to companies from involvement in mentoring programmes, and that is the staff development opportunities" (Miller, 2002, p. 57). The industry benefits from the development of its employees as mentors in the educational setting, leading to improved workplace participation (Miller, 2002).

Trends in Mentoring

In the era of long-distance communication and interaction enabled by the internet, mentoring is available in many new and evolving formats (Kupersmidt et al., 2018). Social media and several online instructional tools allow educators to connect individuals and resources that might have been unavailable or inaccessible in previous years (Ito et al., 2020). In recent years, education professionals have started to find new ways to reach out to youth and encourage STEM exploration and interaction with industry professionals (Kupersmidt et al., 2018).

Additionally, researchers consider the benefits of mentoring in terms of the connections made through the mentor's professional network (Ito et al., 2020).

Learning Ecologies, Teaching Artists, and Brokering

For educators who wish to take advantage of the STEM industry's resources, understanding the new contexts in which youth seek experiences is essential. To define these new contexts, the term "learning ecologies" was developed by Brigid Barron, a learning scientist who studied the variety of settings in which youth learn (Ching et al., 2016). The term describes the contexts youth participate in, such as after-school programs and clubs, which extend formal education. Many of these programs are staffed by industry professionals who "often have strong knowledge in the interest area as well as connections to individuals and institutions they can leverage on the young person's behalf" (Ching et al., 2016, p. 298).

Teaching artists are knowledgeable about their professions and could provide advice, connections to professionals, and recommendations based on their industry resources. This type of mentoring is called brokering and could provide a pathway into the mentor's profession (Ching et al., 2016). Brokering could create social networks for youth, especially those from different socioeconomic groups. For youth from lower socioeconomic levels, these connections might have been unknown and unavailable.

Researchers identified two specific outcomes that occur within effective brokering relationships: "the development of trusting, caring relationships between youth and educators (*i.e., youth trust of educator*) and a better understanding by educators of youths' interests and needs (*i.e., educator knowledge of youth*)" (Ching et al., 2016, p. 305). Mentoring relationships lead to natural exchanges between youth and mentors, resulting in a better understanding of youth goals and aspirations. Mentors who understand youth better could facilitate more authentic experiences and connect youth to industry members and opportunities focused on the industry.

Virtual Internships and Mentors

To reach a larger, more diverse audience of students and add variety to the learning experience, virtual mentoring was being developed as an additional delivery format (Ito et al., 2020). Opportunities to deliver mentoring experiences online made sense to universities struggling to increase and maintain student enrollment in STEM industry programming.

> Research has shown that engineering students who have meaningful experiences of engineering practice are more likely to persist beyond the first year of an engineering degree program than students whose first-year curriculum does not contain such experiences [8,9]. One way to provide meaningful experiences is through internships or other work-based learning opportunities, which help students begin to form the identity, values, and habits of mind of professional engineers. (Chesler et al., 2015, p. 2)

The virtual internship provides students with an ideal opportunity to simulate work experience. It is possible to maintain a high level of professionalism while delivering a virtual internship with a consistency not possible in a real-world setting. As a result, students have better access to mentors and a wider range of experiences, thereby leveling the playing field (Ito et al., 2020). The virtual internship program also has advantages concerning record keeping. A virtual program tracks student progress, mentors' interactions and communication, as well as collects student project and writing submissions to be consolidated into a body of work (Chesler et al., 2015).

There are many advantages to using technology to facilitate internships and mentoring. A mentor with a variety of backgrounds and professional experiences is more accessible to youth when proximity is not a factor. Through virtual internships and mentor programs offered in informal educational settings as well as clubs and programs, youth can access several high-level professionals online (Neely et al., 2017). E-mentoring programs might promote diversity among mentors as well. The flexibility of time and location parameters might enable mentors to participate in partnerships who would have otherwise been excluded. Through virtual partnerships, individuals could participate from anywhere at any time.

Connected Learning

Connected learning describes a model of programming that includes a network of opportunities available to youth through various platforms—virtual and physical. Due to technological advancements, experiential learning and mentoring could take place in a variety of contexts and environments. In doing so, the model allows for collaboration and interaction scenarios not possible through traditional programming and delivery methods. By building communities and collective capacity for learning and opportunity, connected learning pursues education outcomes rather than providing a specific "technique." It also provides a framework for analyzing the equity of learning opportunities across settings (Ito et al., 2020). Through peer interaction and mentorship, the model also supports relationship building and could provide long-term learning through interaction.

Connected learning experiences occur over various formats and include diverse learners and professionals (Ito et al., 2020). These experiences could be facilitated using many contexts including brokering opportunities, mentor relationship-building activities, and collective problem-solving groups that share goals and focus on the needs of a community of learners. Several mentor relationships within connected learning projects are formed informally and have been found to be more effective and organic (Ito et al., 2020). As a result, relationships form naturally, trust levels are quickly established, and relationships are effective and long-lasting in meeting youth needs (Ito et al., 2020).

Purpose of the Study

Effective STEM education programming very often requires industry professionals' participation in school activities and clubs. While STEM professionals are well-versed in their industries, they are not necessarily prepared to work with young people in an educational setting. It is possible to find many important truths about STEM mentors from youth who participate in STEM mentoring programs (Zand et al., 2009). Education professionals know student feedback is essential to effective educational programming (Kupersmidt et al., 2018). While training opportunities might be provided to mentors, what do we know about the effectiveness of preparation programs from a mentee perspective? What are mentees saying about their mentors' ability to build rapport, provide support, promote STEM professions, and share the benefits of entering a profession in the STEM industry? The success of mentoring programs is directly related to how they affect the career choices of mentees. When mentoring youth, what practices do mentors use? What are their perceptions of their mentor relationships? Among youth, what qualities, strengths, weaknesses, and habits do they attribute to their mentors?

STEM education decisions should be made by school leaders based on student needs and organizational problems. Leadership is essential to the successful implementation of mentoring programs in school systems (Komosa-Hawkins, 2010). In programs of this nature, there are many components that must be handled by experienced educational leaders who can delegate responsibilities and monitor efficacious practices. Educational leaders must employ the necessary programming to meet the needs of youth.

STEM industry professionals play an important role in ensuring the success of STEM educational programming (DuBois et al., 2011; Kupersmidt et al., 2018; Radcliffe & Bos, 2013). These tasks include but are not limited to increasing career readiness, reducing the student dropout rate, ensuring the success of at-risk youth, and providing career exploration opportunities and college prep programming to prepare youth for an increasingly complex high-tech industry and workforce (Alper, 2017; Kupersmidt et al., 2018).

Within larger school districts, consistency is essential and often challenging to maintain. Individual schools and personnel must manage systems created by district leadership. The success of a STEM mentoring program starts with a leadership team either at the district or individual school levels. The success of a mentoring program depends on the leadership's ability to communicate expectations and provide support including recruiting, screening, training, evaluating, funding, and relationship-building with community industry professionals (Alper, 2017; Kupersmidt et al., 2018). Schools invested in the sustainability of mentoring programs rely on researched practices and data gathered by evaluating programs and their components. School leaders could save time and money by discovering practices that work. In addition to providing school leaders with information about best practices, research provides a platform for encouraging staff and youth buy-in through dedicated and genuine participation.

The impact of mentor relationships should be evaluated further by exploring whether these youth go to college after graduation to pursue STEM degrees. How many participants are majoring in a high-tech field or enrolled in high-tech training programs? To increase youth participation in STEM degree programs and careers after high school, educators and industry leaders would benefit from specific information about how these relationships work. To identify mentor practices that encourage youth to pursue STEM careers after high school, these relationships should be explored as described by youth (Zand et al., 2009).

Research Question

This study sought to answer the following research question:

Q1 What STEM mentor practices, behaviors, and roles do students identify as increasing their interest in pursuing STEM careers?

Youth STEM education programs could be supported and encouraged by industry mentors, according to research. Further research could reveal specific strategies employed by mentors and the success or failure of those practices as identified by youth. Research investigating individual mentor practices that encourage youth to pursue STEM careers would be beneficial for STEM educators and leaders. In this study, I conducted interviews, created and maintained a research journal, and reviewed program artifacts. Such materials provided insight into the influence mentors had on the career choices of their mentees such as context descriptions found on the program website.

Qualitative case study methods produce multiple sources of information (Miles et al., 2014). Merriam and Tisdell (2016) identified a case study as a way to investigate a phenomenon within a specific system. A STEM mentoring program within a specific school district was selected for analysis as one such system. During this case study, youth were asked to describe specific STEM mentor practices that encouraged them to enter STEM careers.

Using a qualitative approach, this study sought to answer questions about program components that encourage youth to pursue and continue STEM training and college degrees (Merriam & Tisdell, 2016). This study sought to examine the phenomenon of mentoring relationships and its components as experienced by the participants—youth (Creswell & Poth, 2018). The purpose of this study was to investigate and identify practices that promote STEM careers among youth.

Definition of Key Terms

A few terms are essential to understanding mentorship programs and mentoring in STEM education.

Educational mentor. An individual taking part in an educational mentoring program for youth offered through a school or some institution of learning: "a mentor is defined as a supportive adult who works with a young person to build a relationship by offering guidance, support, and encouragement to help the young person's positive and healthy development over a period of time" (Bruce & Bridgeland, 2014, p. 13). A mentor is an experienced adult who guides a younger, inexperienced individual through an area of expertise (Dappen & Isernhagen, 2005). In addition to addressing the student's academic and social needs, the adult should communicate with the student's family and advocate on the student's behalf. The adult advocate should be thoroughly trained before being assigned a student. The adult and student should have time to meet regularly (Middle School Matters Institute, 2023).

Educational mentoring programs. Offer organized relationship-building opportunities for youth in educational settings. These educational programs are initiated with organizational support, a plan for implementation and maintenance, and financial and human resources (Dappen & Isernhagen, 2005). Mentoring programs could help youth build relationships with adults who could assist youth in goal setting, social interactions with peers and adults, and academic achievement (Middle School Matters Institute, 2023). The school setting offers relationship-building opportunities that take less time to form and mature than programs outside of a structured setting (Bayer et al., 2015).

Mentor. Someone who shares time and expertise with those who require guidance in a particular area or discipline (Freedman, 1993). Greek mythology used Mentor as a character in Homer's Odyssey: "Odysseus prepares to fight in the Trojan War and entrusts his friend, Mentor, with the care of his son, Telemachus. Mentor was responsible, as a wise and trusted adviser, for guiding all aspects of the boy's development" (Miller, 2002, p. 24). Through society's adoption of mentors, the term evolved. "The modern interpretation of Mentor is based on *Les Aventures de Telemaque*, published in the 18th century...the book's popularity explains the introduction of the term 'mentor' into the English language after 1750" (Miller, 2002, p. 24). Throughout history, mentors have inspired and guided great artists and architects of societies and modern cultures. History provides important examples in every field of fruitful, even transformative, mentoring relationships: Socrates mentored Plato, Freud mentored Jung, Lorenzo de/ Medici mentored Michelangelo, Haydn mentored Beethoven, Hammerstein mentored Sondheim, Miles Davis Mentored John Coltrane, James Taylor mentored Carole King (Alper, 2017, p. 45). Mentors are often crucial to the education and development of youth. "Norman Garmezy and researchers at the University of Minnesota reported the critical importance of at least one significant adult, usually an extra-familial adult, in the development of inner-city youth" (Freedman, 1993, p. 62). Mentors play a pivotal role in educating and developing young people.

Science, Technology, Engineering and Math education mentoring programs. Educational programs that focus on STEM disciplines offered through educational institutions and organizations. “In recent years, mentoring has become a cornerstone approach – from K12 settings through higher education and early career development – to increasing American performance in STEM and addressing issues of historical underrepresentation in STEM careers” (Kupersmidt et al., 2018, p. 1). Formats include one-to-one mentoring, mentors to small groups, large groups, near-peer mentor groups, and online mentoring (Kupersmidt et al., 2018; Tenenbaum et al., 2014). An example of this type of program is Girls4Tech provided by MasterCard Worldwide, a “global employee volunteer initiative” (Alper, 2017, p. 10). The program offers a STEM curriculum developed by MasterCard engineers and Informational Technology professionals (Alper, 2017). It is well known that mentoring is beneficial to youth and businesses in many ways; however, it is less clear whether high-tech industry mentoring helps recruit workers. Are there any specific mentoring practices youth identify as motivating them to pursue careers in high-tech?

Conclusion

A high-tech economy has brought unforeseen consequences for industry officials and educational institutions in recent decades (Rangel et al., 2021). With rapid growth in high-tech industries, there is an urgent need for trained workers in these fields (Fayer et al., 2017). A creative response to this growth is urgently needed by public education leaders. Graduates must be prepared for an unpredictable workforce and youth must be encouraged to join high-tech industries if an adequate response is to be achieved (Alper, 2017; Kupersmidt et al., 2018). Using industry mentors is one strategy to achieve this goal (Alper, 2017).

Mentoring enjoys a long history in the United States and is viewed as an essential resource by education and high-tech industry leaders (Rhodes, 2004). Mentoring has also been proven to motivate and encourage youth to succeed in various areas of life (Miller, 2002). In light of this, educational leadership should focus on the development of mentoring programs. Concerns need to be raised about youth's lack of interest in STEM-related industry professions (Alper, 2017; Cuny, 2019; Kupersmidt et al., 2018). Despite the advent of many new trends created by new technologies and internet platforms, youths fail to commit and actually participate in the high-tech workforce despite their potential and capacity to achieve success.

This chapter introduced STEM mentoring, its history, and purpose, and defined the terms. mentor, educational mentor, educational mentoring programs, and STEM educational mentoring programs. The next chapter outlines existing STEM mentoring research while demonstrating a lack of research that involves youth voices and feedback about mentors' influence on youth entering STEM industries.

CHAPTER II

LITERATURE REVIEW

Science, Technology, Engineering, and Mathematics Mentoring Programs

STEM education programs providing mentorship programs for youth must understand the needs of STEM and high-tech industries. Creating productive mentoring relationships requires that program administrators familiarize themselves with mentoring best practices as well as STEM industry resources. Researchers have investigated and evaluated mentoring programs in public schools in the United States to understand their current status. This literature review provides an overview of the current status of STEM mentoring programs, mentoring elements, successes and failures, and related learning theories important for understanding the use of mentoring. In addition, it explores the purpose and the need for STEM mentoring program implementation, evaluation, and sustainability.

Established programs such as Pathways in Technology Early College High School (P-TECH) lack evidence that proven and consistent practices are being applied. As a public-school model program started in New York City, P-TECH was created in partnership with IBM. As part of the program, youth were provided with college-level classes and programs as well as valuable industry experience (P-TECH, 2023). The P-TECH program offers guidelines and an overview of proven mentoring programs. However, current research offered little evidence that existing programs followed these guidelines. Mentoring programs are currently being compared with regular high school programs in research studies. Specific components, such as mentoring programs to encourage youth to pursue STEM careers, are not explicitly mentioned (Manpower Demonstration Research Corporation, 2018).

Science, Technology, Engineering, and Mathematics Mentoring Overview

The high-tech workforce and, more importantly, students with potential in the industry could benefit from mentoring programs in secondary schools. These programs are designed to influence skill levels and attitudes toward STEM education (Alper, 2017). The industry and educators become partners in these mutually beneficial situations by enhancing student participation in STEM education. Partnerships like these make sense and educators have recognized that they are increasingly necessary as they work with youth. Mentors could influence their mentees through social interaction, participation in skill development work, and modeling social and advocacy skills (Rhodes, 2004). Due to the complexity and rapid growth of the STEM industry, mentoring is necessary to enhance the delivery of rapidly changing content. As a result, STEM mentoring programs could combat the reluctance of youth to enter STEM fields (Alper, 2017).

STEM mentoring programs aim to promote STEM-related fields to youth, influence their beliefs in STEM, and discover student aptitudes (Alper, 2017; Kupersmidt et al., 2018; Radcliffe & Bos, 2013). Increased participation in STEM field-related studies is essential for the sustainability of a STEM workforce (Kupersmidt et al., 2018; Radcliffe & Bos, 2013). The pairing of mentors with youth from similar backgrounds has proven to be an important practice in mentoring (Freedman, 1993). Other practices include clear expectations for frequent contact, organized activities, ongoing mentor training, and implementation and management program monitoring (DuBois et al., 2011). The programs must also provide STEM activities proven to produce the desired results for youth. These activities include introducing design principles, career exploration, competition/design projects, and researching with experts and field veterans (Alper, 2017; Kupersmidt et al., 2018; Radcliffe & Bos, 2013). School leaders have been able to develop STEM mentoring programs based on their understanding of what works (Komosa-Hawkins, 2010). However, it is often difficult for public schools to deliver mentoring programs due to a lack of involvement, difficulties reaching youth, and lack of maintenance and follow-up by school personnel (Freedman, 1993). Mentor programs should continue to be evaluated for effectiveness and redesigned as new research becomes available.

Elements of Science, Technology, Engineering and Mathematics Mentoring Programs

Program Format

Mentoring programs can be delivered in several formats. Researchers have found that choosing a delivery format often depends on the program's purpose, the population of youth involved in mentoring, the availability of mentors, and whether youths and mentors could join onsite programs or participate virtually (Bayer et al., 2015). A range of program goals have been identified including mentoring programs for elementary and middle school students to introduce them to STEM, activities created for students to explore a variety of STEM subjects, engaging STEM activities to STEM careers, and providing research opportunities for high school students and college students (Kupersmidt et al., 2018):

> In reviewing the literature on STEM mentoring, we find that both in-person and online approaches are common. In-person mentoring, whether one-to-one or in groups, seems to be most common in programs intended to either spark initial interest in STEM for young children or in programs aimed at supporting older youth through some transition point (e.g., applying to college as a STEM major) (p. 10).

Many times, program delivery depends upon resources available to students at home and through their communities.

Students often face barriers because of their economic status and lack of access to Internet services and technology devices (Bayer et al., 2015). Furthermore, students require sophisticated tools and instruction to use those tools and trips to places where professionals could demonstrate the technology (Ito et al., 2020). STEM mentoring program delivery options might be formal or informal and include in-person or online/remote options. Mentors could be utilized in one-on-one settings, groups involving a collective of mentors supporting a single individual, small groups, or whole class or club settings in short-term settings such as seminars or conventions (National Academies of Sciences Engineering and Medicine, 2019). Programs could be delivered short-term for single sessions or over some time (Miller, 2002). Informal mentor relationships have also been shown to be effective with students.

> Because informal mentoring relationships form through personal and professional respect and admiration between mentor and mentee, and sometimes result in mentors and mentees sharing more identity characteristics with one another, mentees in informal mentoring relationships report being more satisfied with their mentors than mentees in more formal relationships, thereby reporting a high-quality relationship. (National Academies of Sciences Engineering and Medicine, 2019, p. 78)

The activities mentors and mentees participate in could determine the structure of any of the above-described types of programs. For example, many programs are designed around research projects in which mentors guide their mentees through "complex research projects that require significant subject matter knowledge and technical skills. Participation in these types of programs contributes to stronger interest in and commitment to a STEM career" (Stelter et al., 2020, p. 227). Other common mentor programs are designed for elementary or middle school students to introduce STEM and build interest by engaging students in related activities (Kupersmidt et al., 2018). Many STEM mentoring programs are created around STEM competitions, i.e., robotics, cybersecurity, design process STEM challenges, and require mentors to manage and advise teams (Kupersmidt et al., 2018). The format of each program depends on the organization sponsoring the program and the needs of the mentees (Stelter et al., 2020).

Program Components

Recruitment.

Experts and researchers agreed that when choosing STEM mentors, there are many factors to consider. A central question to be answered is, "What areas of expertise should the mentor be well versed in?" (Alper, 2017). Recruitment plans are often an organized way to find individuals to participate as mentors. A plan could organize STEM mentoring programs by identifying a goal for the number of mentors needed, creating a time frame, identifying resources needed and the required budget, establishing eligibility requirements, and developing a consistent message. Goals should identify organizations and businesses that might have appropriate mentors. They should also be included in recruiting presentations (Miller, 2002).

Identifying partners in the community could lead to the discovery of universities and corporations with whom connections could be built and cultivated. These partnerships have been shown to "provide a wide range of support/resources to school-based mentoring programs, depending on the needs of the program" (Komosa-Hawkins, 2010, p. 126). Miller (2002) also recommended some methods for the recruitment of mentors such as specific recruitment marketing campaigns, marketing literature, website and media creation, social events designed to recruit, and career fair booths.

Research suggested that contacting community leaders to identify other groups or individuals as potential mentors could effectively widen the pool of candidates (Dappen & Isernhagen, 2005). Another consideration when recruiting professionals to mentor in school programs is a company's organized community involvement efforts that often include opportunities for their professional employees to benefit from volunteering in their communities (Alper, 2017). Regardless of the motivation of mentors in joining STEM programs, the focus of the STEM mentoring program might determine the level of expertise and experience held by potential mentors.

Mentor programs focused on initial engagement in STEM, rather than programs designed to retain mentees in a STEM career path, would have different recruiting goals and lists of desired mentor characteristics. According to researchers, mentors and mentees whose personal and professional traits are well matched are much more likely to form strong bonds, establish lasting relationships, and engage in mutually beneficial interactions (Johnson & Ridley, 2018). Researchers also found connections between mentee characteristics and an early conclusion to the mentee and mentor relationships (Kupersmidt et al., 2017). For example, Kupersmidt et al. (2017) identified personal characteristics that might predict the premature end of a mentor/mentee match. Mentors who were characterized as experiencing career burnout and feeling overwhelmed or unappreciated had higher rates of premature match closure (Kupersmidt et al., 2017). Mentee characteristics associated with premature match closure included youth who were extrinsically rather than intrinsically motivated to participate, those with a history of behavior problems or mental illness, those engaging in risky or unhealthy behaviors, and youth with a history of school absences and low-grade point averages (Kupersmidt et al., 2017).

Training.

Once mentors have been screened and selected for a particular setting, mentor training should follow. As training is a pre-match activity, mentors and mentees are not paired until after training. The training of mentors is essential to preparing them for working with youths and to identifying the goals and outcomes of mentoring programs. The STEM mentoring programs also vary greatly based upon the goals of the program (e.g., piquing STEM interest and strengthening STEM skills), targeted mentee population (e.g., youth with disabilities), and age of mentees.

> [T]hus the goals and desired outcomes of the program and the target population will inform the training of mentors as well as the relevant mentor knowledge, attitudes, and behaviors that the training will be designed to increase. In addition, many STEM mentoring programs take the approach of using mentors to engage in specific STEM activities with their mentees, although the amount of structure for these activities varies greatly across programs. (Stelter et al., 2020, p. 227)

Training for mentors might include the use of training curricula developed through research and program study (Kupersmidt et al., 2018). There are many ways to implement training for mentors working with K-12 youth. Mentors need to be provided with information concerning the specific elements of the mentoring program such as the level of youth they would be interacting with and the program's goals. Miller (2002) identified three central objectives of mentor training: identifying program objectives, expected conduct and procedure adherence by the mentor, and skill development and implementation expectations.

Miller (2002) identified a number of components of mentor training that contributed to the effectiveness of the program including the amount of time dedicated to training. According to research, mentors who receive less than two hours of training reported limited relationship-building success with mentees (Komosa-Hawkins, 2010). To ensure the effectiveness of training, it is equally important to know how much time should be devoted to it and what topics should be covered.

Essential classroom management topics should be included in mentor training including equity and diversity training, health, safety, confidentiality, project-based learning strategies and components, and lesson planning and delivery (Miller, 2002). In general, trained mentors have been found to have better skills in the areas of communication, expectations, and professional development (Stelter et al., 2020). Years of research have identified effective program practices and three specific program components are effective in mentor training.

> The three themes are: (1) knowledge and attitudes regarding disparities in STEM career achievement, (2) mentor roles that will promote STEM outcomes, and (3) mentor behaviors that can promote mentees' positive attitudes about and commitment to a STEM education or career. (Stelter et al., 2020, p. 228)

Likewise, STEM mentors who had received diversity training were more likely to discuss these issues openly with their mentees than mentors who had not (Stelter et al., 2020).

Training also depended on the setting and program delivery needs. Research indicated that mentors engaged in group mentoring needed training to manage youth in groups as they learned and interacted in project-based activities or research-based activities (Kupersmidt et al., 2018). Topics mentors needed for group settings might focus on creating and setting rules for group interaction and behavior, peer mentoring behaviors, including all group members, and awareness of behaviors that might cause students to feel excluded. Also, mentors need information specific to the program such as activities, lab safety, and the specific curricula that might be utilized by the mentor (Stelter et al., 2020).

In addition, there is the point of view of the mentor to consider when planning for participation. Many corporate participants rely on the program to define the purpose of mentoring, the time commitment, and a clear description of their role as mentors (Alper, 2017). Training delivery formats could be structured to meet the mentor's needs and might depend on the program's capacity to deliver training in person or online due to time and money constraints (Stelter et al., 2020). The optimal training length, delivery methods, specific topics of value, and the effect of this training on mentor-mentee relationships need further research (Stelter et al., 2020).

Monitoring and Support.

An institution's support of STEM mentoring programs and mentors within educational institutions is crucial.

> Though mentorship is an activity based on personal relationships – and its successes or failures ultimately hinge on the quality of those relationships – institutions can play a critical role in fostering and supporting mentor-mentee relationships. Institutional culture can promote mentorship by creating settings where faculty members and staff jointly commit themselves to promoting mentoring and facilitate mentors' abilities to be more effective and culturally responsive in their mentorship of STEM students. (National Academies of Sciences Engineering and Medicine, 2019, location 3,736)

Stages of the personal relationships are evident in most mentoring programs through monitoring and support. According to research, well-matched mentors and mentees demonstrated growth and formed bonds as they interacted (National Academies of Sciences Engineering and Medicine, 2019).

Mentorship behaviors could be applied in some or all of the stages of relationships. Groundbreaking research published in 1985 by Kram (as cited in National Academies of Sciences Engineering and Medicine, 2019) conceptualized four sequential stages through which mentoring relationships evolved based on qualitative research in an organizational setting:

> (a) Initiation when mentors and mentees form expectations and get to know one another, (b) Cultivation when the relationship matures, and mentors typically provide the greatest degree of psychosocial and career support, (c) Separation when mentees seek autonomy and more independence from mentors, and (d) Redefinition when mentors and mentees transition into a different form of relationship characterized by more peer-like interactions or terminate the relationship. (location 1,108)

Mentors often receive ongoing training to assist them in meeting the goals of mentoring programs. In site-based programs, informal support could be provided as needed or on a regular basis throughout the program's life cycle (Kupersmidt et al., 2018). Monitoring could help mentors identify areas of training need while working with their mentees. The directors of STEM mentoring programs would benefit from further research that provides in-depth information about the topics covered in ongoing training, the length and timing of those pieces of training, and whether all mentors require the same level of training (Stelter et al., 2020).

Monitoring by STEM mentoring program staff is essential to the program's success. "Programme managers are failing in their responsibilities if, after matching, mentors and mentees are left to their own devices" (Miller, 2002, p. 207). Miller (2002) described the following research findings concerning the support and supervision of mentors:

> When project workers provide regular support to mentors, then pairs are more likely to meet regularly and be satisfied with the programme. When mentors are not contacted regularly by project workers there are the highest percentage of failed matches. Mentors benefit a great deal from support from programme staff in the form of ongoing monitoring, training, support-group meetings, and related practical support. (p. 207)

Program managers play an essential role in the process of monitoring and supporting mentors. Managers should have experience and training working with youth and STEM education (Kupersmidt et al., 2018). The program manager should establish methods for data collection and facilitate tracking systems for monitoring attendance and participation and to collect information from mentors about training needs and relationship-building questions (Komosa-Hawkins, 2010). Data collected should provide evidence of the program's success and identify opportunities for improvement (Dappen & Isernhagen, 2005).

Closure and Transition.

While the goal of STEM mentorship is established at the beginning of the mentoring relationship, outcomes at the program's close should be set and measured to determine the mentoring program’s success (Alper, 2017). Alper (2017) provided many scenarios for wrapping up a mentoring experience such as an end-of-program meal, the creation and presentation of an end-of-program appreciation book, a banquet with a notable speaker, or a plan for continuation at a later time such as the beginning of the following school year (p. 188). Mentors play a critical role in facilitating closure and transition through key aspects of their work. Positive examples of closure and transition facilitation include mentors who accept the end of their role with the mentee and assist the mentee with the transition, acknowledge feelings associated with that closure, and model the acceptance of a new role (Johnson & Ridley, 2018).

STEM mentoring programs encourage youth to pursue a career in a STEM field, which often means the mentor relationship might be necessary for many years beyond the defined mentoring program. As a result, the mentor/mentee relationship might continue beyond their high school education into their undergraduate and early STEM careers (Kupersmidt et al., 2018).

Learning Theories: A Framework for Mentoring

Two main learning theories provide theoretical frameworks for mentoring. Social learning theory and situated learning theory explain the essence of mentoring relationships by identifying mentoring as an essential tool for positive youth development (Bandura, 1971; Lave & Wenger, 1991). Together, these frameworks described how mentoring contributed to youths' development and STEM career preparation.

Social Learning Theory

A theory developed by Bandura in the early 1970s explained how individuals acquired behavior and regulated themselves through social learning. Bandura (1971) posited that learning is social and occurs through observation and modeling. His view of learning was it is an observation of human behavior that is connected to the acquisition and demonstration of positive and negative behavior. “In the social learning system, new patterns of behavior can be acquired through direct experience or by observing the behavior of others” (Bandura, 1971, p. 3). Bandura supported the use of models or mentors when seeking to influence others’ behaviors. “Most of the behaviors that people display are learned, either deliberately or inadvertently, through the influence of example” (Bandura, 1971, p. 5). Thus, the use of positive role models is key to steering youth toward specific goals. He also elaborated on the residual effects of mentoring when describing the transition of the observation into practice. He went on to say that a role model motivates an individual to self-evaluate in order to self-regulate when applying observed and learned behaviors in various settings. “In fact, the principal goal of social development is to transmit general standards of conduct that could serve as guides for self-regulation of behavior in a variety of activities” (Bandura, 1977, p. 138).

Situated Learning Theory

While Bandura’s (1971) theory endorsed the general use of mentoring to provide models for observation, situated learning theory offered evidence of how a specific focus, such as teaching STEM principles and content, might be utilized through the use of mentors in a social context. Situated learning theory was developed by Lave and Wenger (1991) to define learning as a social activity. According to the theory, learning is affected by the types of learning activities and modes of delivery. Lave and Wenger suggested the context of learning is communal and individuals construct their identities through relationships. The researchers defined learning as participation within a community with a shared focus. “Activities, tasks, functions, and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning” (Lave & Wenger, 1991, p. 52). Within the system of the STEM industry, mentoring is an excellent mode of delivery and knowledge transfer. According to Lave and Wenger, developing relationships is key to transferring knowledge. In their five studies of apprenticeships, the researchers found this transfer of knowledge involved replicating tasks and routines and forming relationships crucial for individual success.

A Community of Practice

Success in an industry is not only facilitated by the demonstration of tasks but also by the relationship between the expert and the apprentice. Researchers referred to this partnership as a "community of practice" in order to achieve success (Lave & Wenger, 1991, p. 79). Apprentices eventually find their identity in the community of industry. A system of relations among people emerges from and is reproduced within social communities, which are, in part, systems of relations among individuals (Lave & Wenger, 1991). The health of the STEM industry is contingent on an individual's ability to build community.

By connecting the modeling of desired behaviors to the context in which they occurred, these theories provided a framework for STEM mentoring (Bandura, 1971; Lave & Wenger, 1991). Social learning theory describes the basis for the mentoring relationship while situated learning theory provides evidence that offering it in a context such as STEM education is a theoretically sound practice (Bandura, 1971; Lave & Wenger, 1991). To understand mentors' learning activities with their mentees, it is essential to understand their mentor relationship contexts. Mentors' relationships with mentees and the contexts in which they operate are crucial to mentees' desire to follow their example.

A stronger understanding of the role of context in STEM mentoring relationships is provided by social learning theory and situated learning theory. The dynamics of relationships and negotiations between individuals are demonstrated in mentoring program settings.

> [L]earning as increasing participation in communities of practice concerns the whole person acting in the world. Conceiving of learning in terms of participation focuses attention on ways in which it is an evolving, continuously renewed set of relations; this is, of course, consistent with the relational view, of person, their actions, and the world, typical of a theory of social practice. (Lave & Wenger, 1991, pp. 49-50)

Mentees participate with their mentors in "communities of practice" (Lave & Wenger, 1991, p. 41). They benefit from the opportunity to apply prior learning in the context of the STEM industry through project teams.

> Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations. To ignore this aspect of learning is to overlook the fact that learning involves the construction of identities... Viewing learning as legitimate peripheral participation means that learning is not merely a condition for membership but is itself an evolving form of membership. We conceive of identities as long-term, living relations between persons and their place and participation in communities of practice. Thus identity, knowing, and social membership entail one another. (Lave & Wenger, p. 53, 1991)

To grow as learners, they must integrate their learning within STEM industry contexts while developing into productive industry members.

Need for Mentoring Programs in Science, Technology, Engineering, and Mathematics Educational Programming

Ample research supported the implementation and maintenance of STEM mentoring programs (Alper, 2017; DuBois et al., 2011; Kupersmidt et al., 2018). Mentoring has been identified as an intervention strategy for at-risk youth (DuBois et al., 2011). Mentoring has also shown to encourage more female youths to explore STEM as a career option (Alper, 2017). At the secondary level, educational programs should be designed to address changes in the high-tech industry. Curriculum changes should reflect industry demands on STEM professionals by providing youth with the most current information.

It is often possible for STEM industry professionals to become involved in STEM education curriculum choices through mentoring programs. Input from industry mentors could help educators stay abreast of current trends in STEM fields. Alper (2017) described how relationships between schools and industry are beneficial to the future of the high-tech industry:

> Therefore, education – meaning both skills and a highly developed capacity to apply them – is one of those factors outside the company building that will influence how well firms do in the future. So why should a private company get involved in mentoring youth? The first big reason is to serve the company's own long-term interests by adding to the pool of employable young people who possess the skills and attitudes that will make them a productive part of the workforce. (p. 5)

The benefits of partnerships are many and extend to youth, industry professionals and the industries themselves.

Statement of the Problem

Industry changes and the creation of new industries require schools to rethink their response to career readiness in the secondary school system in the United States and worldwide. Educators need support from industry professionals to provide guidance and experience with emerging technologies (Freedman, 1993; Kupersmidt et al., 2018). Industry mentors are a necessary resource for secondary schools (Miller, 2002). Adding a mentoring program to an existing curriculum requires planning, organization, and sustainable practices (Freedman, 1993). Working with children requires training and preparation. Schools are implementing STEM mentoring programs while failing to plan for and implement the support necessary for appropriate relationship-building and child development training (Freedman, 1993; Kupersmidt et al., 2018). In addition, mentors need guidelines and basic strategies for working with youth (Rhodes, 2004).

For a mentorship program to succeed, mentors must also commit to the process and demonstrate their ability to establish and maintain relationships with youth (Freedman, 1993; Rhodes, 2004). Mentoring relationships have been shown to improve student outcomes by strengthening familial relationships and leading to increased self-worth and academic achievement (Rhodes, 2004; Zand et al., 2009). However, many questions remain concerning STEM mentoring outcomes. What have youth said about why mentor relationships have positive effects on their career choices? In relation to mentor practices, what perspectives do mentees have?

Understanding how mentors can find success with youth is important. Knowing what schools need to do to improve their programs is necessary (Kupersmidt et al., 2018). However, specific information is needed from youth to understand precisely how mentoring relationships encourage youth to choose STEM careers (Kupersmidt et al., 2018; Sasson, 2019). To increase STEM workforce participation, researchers need to identify specific ways identified by youth to prepare mentors (Alper, 2017; Kupersmidt et al., 2018).

The effectiveness of mentoring programs has been investigated to determine whether youth pursue STEM careers as a result of participating in these programs. For example, Sasson (2019) conducted a research study to discover whether participants considered participation in a specific STEM mentoring program as a factor in their career choices and self-efficacy upon completion of a program. The aim of the study was to evaluate how graduates from a research apprenticeship program for 11th and 12th graders perceived their experience as affecting their choice to specialize in a STEM career and if gender differences were evident in the perceptions. The research Sasson (2019) designed and completed sought to understand whether the mentoring program contributed to the participants' career choices in STEM. Information collected in this study related to mentees' career choices and whether the program increased their comfort level and efficacy in STEM fields, especially in STEM research. However, the information gathered concerning the specific characteristics of the mentors whom students felt encouraged STEM career choices and personal efficacy in STEM fields was not directly related to mentor behaviors and methods (Sasson, 2019). The findings did not specify which mentor behaviors and methods contributed to the program's results. Furthermore, Sasson (2019), concluded the study discussion by pointing out the need for further research focusing on participants' experiences with mentors.

> Further research is also needed in order to link desired outcomes to aspects of the research apprenticeship experience. For example, more research is needed about the effect of student-mentor interactions on achieving educational goals. Mentors play a central role in apprenticeship experiences, distinguishing this program from other science programs. (Sasson, 2019, p. 479)

More research needs to be completed from the perspective of youth participating in STEM mentoring programs. A limited number of studies sought to understand the point of view of mentees and their experiences with STEM mentors. A number of positive outcomes are possible with the information mentees provide about their mentoring experiences, which could result in program improvements.

Conclusion

Mentoring has a history of providing many benefits for youth. To help students understand the complex and changing nature of the high-tech industry, STEM mentors could play an important role in introducing youth to STEM careers and assisting teachers in providing students with information about STEM careers (Alper, 2017). However, more research is needed on the specific practices employed by STEM mentors. "While the popularity of STEM mentoring has grown, the research on what makes these programs effective, either in isolation or in combination with other supports, has lagged behind" (Kupersmidt et al., 2018, p. 2).

Additional research is also needed to examine supports that enhance the efficacy of STEM mentoring programs (Kupersmidt et al., 2018; Radcliffe & Bos, 2013; Zand et al., 2009).

It is possible to find many wonderful examples of qualitative research describing how mentors encourage youth and how participants gain from mentoring experiences. However, most studies did not compare or contrast different mentor approaches, examine variations in program practice, or examine subgroup findings to discover mentoring effectiveness for certain types of youth (Kupersmidt et al., 2018; Sasson, 2019).

According to Bruce and Bridgeland (2014), mentored youth set higher educational goals, are more apt to pursue higher education, and engage in extracurricular activities beyond mentoring. Additionally, mentored youth identified the support and guidance of mentors as keys to success and healthy choices. In addition to encouraging interest in STEM, STEM mentoring could increase self-efficacy, STEM skills, and a sense of belonging to a STEM field in the future (Bruce & Bridgeland, 2014). Researchers identified the components of successful STEM mentoring programs, how to encourage participation, and how mentoring affected youth (Kupersmidt et al., 2018; Sasson, 2019).

While youth respond to mentoring in many positive ways, they are not often asked to examine the connection between the mentoring experience and their career path choices (Sasson, 2019). The purpose of this study was to investigate and identify practices that promote STEM careers among youth.

CHAPTER III

METHODOLOGY

This research study was designed to answer the following question:

Q1 What STEM mentor practices, behaviors, and roles do students identify as increasing their interest in pursuing STEM careers?

As part of the chapter, the qualitative study design is reviewed including the epistemology of constructionism, interpretivism as a theoretical perspective, and the methods I used to answer the research question. A discussion of data analysis methods and bias follows the study design.

The study was designed to examine whether youth involved in STEM mentoring programs planned to pursue STEM careers as a result of specific mentor relationship practices. Education and industry leaders could benefit from specific information about how these relationships increased participation in STEM degree programs and careers after high school.

A Qualitative Study

Qualitative research is common in the field of education (Merriam & Tisdell, 2016). This qualitative study investigated youth perspectives and interpretations of STEM mentor practices. A qualitative study seeks to answer the research question by discovering a participant's perceptions and understanding of the lived experience. These experiences are viewed through the words of participants (Merriam & Tisdell, 2016).

Identifying the specific components of the mentoring relationship that motivate youth to pursue STEM careers was the purpose of the study (Creswell, 2015). The central phenomenon was the influence of the STEM mentor relationship on a youths' decisions to pursue STEM careers after high school (Creswell, 2015). The case study method was the most effective way to answer the research question as it focuses on a bounded case or specific program. The purpose of this study was to investigate and identify practices that promote STEM careers among youth.

(Crotty, 2015). The goal of this study was to understand the mentor/mentee relationship phenomenon of influence and the reinforcement of the pursuit of a STEM career track. A case study seeks to understand one thing well (Merriam & Tisdell, 2016). In this case, the bounded system was the program selected for study.

Epistemology and Theoretical Perspective

An epistemology of constructionism was used to understand and create meaning from youth perspectives regarding mentoring. The reality of this case is constructed as the participants shared their experiences with me. Those experiences and information were gathered and categorized into themes providing information within the context of this case (Crotty, 2015). Constructionism requires meaning to be made through consciousness and interaction with real-world phenomena (Crotty, 2015). Youth were asked to provide information that provided insights into how they were influenced within a STEM mentoring program by STEM mentors.

A theoretical perspective is the philosophical perspective of the researcher (Crotty, 2015). Our theoretical perspective is "our view of the human world and social life within that world, wherein such assumptions are grounded" (Crotty, 2015, p. 7). This research study sought to discover the perceptions of youth in a public-school STEM mentoring program. The essence of these perceptions is revealed through the mentee's interpretation of their experiences with mentors (Creswell & Poth, 2018). Crotty (2015) described interpretivism as searching "for culturally derived and historically situated interpretations of the social lifeworld" (p. 67).

The information provided by study participants explains why the mentoring relationship might succeed and meet the mission or goal of the mentoring program (Crotty, 2015). Also, this theoretical perspective asks the researcher to put aside assumptions about what should work and gather information to discover the experiences of youth through their own words and interpretations (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Phenomenology is a way of viewing information through interpretivism that involves rejecting our current view or understanding of a phenomenon and embracing a new view (Crotty, 2015). Accepting the STEM mentoring relationship from the participants' perspective required me to set aside expectations and prior experiences to view the information objectively.

Study Design

This study examined a STEM mentorship program for high school youth. An understanding of the interactions between mentors and mentees was shaped by participant experiences and perceptions. It also explored ways that mentors encouraged youth to pursue STEM careers (Merriam & Tisdell, 2016). A qualitative case study defines a social setting where a specific case occurs and seeks to describe and analyze one or more cases (Creswell & Poth, 2018). In this study, a STEM mentorship program serving high school youth was the studied case. The experiences and perceptions of the mentee participants shape an understanding of ways in which youth interact with mentors that impact students' decisions to pursue STEM careers (Merriam & Tisdell, 2016). A qualitative case study is classified as an intrinsic case study when the type of study holds a specific value or interest (Creswell & Poth, 2018). This intrinsic case study focused on a specific STEM mentoring program available to high school youth.

Public schools around the country have implemented STEM mentoring programs designed to educate students about STEM careers as well as about particular skill sets required by those careers, i.e., computer programming language acquisition (Kupersmidt et al., 2018). The study's goal was to investigate one STEM mentoring program and the participants' perceptions of their mentors' influence on their decision to enter a STEM field as a career.

Program Selection and Criteria

Prior to searching for and selecting a program, Institutional Review Board (IRB) approval was obtained (see Appendix A) approval. The selection of a setting for this study required purposeful sampling. The district selected has a STEM mentoring program that has been established for at least three years. The program has had ample time from the start date to attract mentors and establish routines, schedules, and protocols. STEM-related mentoring activities were available to secondary-level education youth through the mentoring program throughout the school year. For the purposes of this study, I obtained permission from the school district by completing the district's IRB process. I sought their voluntary participation in the study while sharing the university IRB approval and study description with district professionals. Once I obtained permission (see Appendix A), I contacted the mentoring program administrator to recommend mentees in their last two years of high school. Once in contact with the recommended mentees, I provided them with a description of the study and participants indicated their interest in person or through email. They were provided with an assent form explaining the study and asked for their signatures to indicate their willingness to participate in interviews (see Appendix B). Participants under 18 years old required additional consent from their parents or guardians. I gave them the adult consent form which provided an overview of the study and obtained their guardian's consent to allow the student to participate (see Appendix C).

In addition, I asked participants to recommend others for the study and this initial contact led to the addition of mentee contacts through a snowball sampling process. The snowball sampling process required leveraging the networks of individuals participating in the program who could recommend additional participants from the STEM mentorship program (Merriam & Tisdell, 2016). This type of sampling is among the most common form (Merriam & Tisdell, 2016). A potential problem with snowball sampling is that participants not connected to the initial participant would not be included, thus narrowing access to only those with relationships with the participant (Creswell, 2015). However, snowball sampling has the advantage of occurring fairly quickly and organically while reaching a large sample size (Creswell, 2015).

In the end, 10 individuals volunteered to participate. All of the participants were attending the 11th or 12th grade, which ensured all of the participants were in the process of planning career paths in anticipation of graduation. They were able to communicate their plans for continuing education (Creswell & Poth, 2018). Their responses provided insight into possible career choices made by the mentee participants as a result of STEM mentorship (Creswell & Creswell, 2018).

Data Collection

Interviews, program artifacts, and a research journal were utilized in the data collection process. Triangulation, the use of at least three data sources, ensured the research study relied on multiple sources of data collection to provide findings deemed trustworthy (Yin, 2018). Youth were able to express themselves freely and reflect on the information they shared during the data collection interview questions.

Creswell (2015) recommended using "data recording protocols" (p. 224). Protocols for this study were developed to document information shared during interviews. The responses of participants were not shared for any purpose beyond this research project and confidentiality was maintained. All transcripts, written publications, and presentations used pseudonyms for the site and participants. Furthermore, these data, along with any digital recordings, were stored in password-protected files on my personal computer and only I and the research advisor had access. Consent forms were stored in the research advisor's office in a locked cabinet and all files and consent forms will be destroyed three years after completing this study.

Interviews

Merriam and Tisdell (2016) identified interviewing as the most common of data collection method in qualitative research. Interviewing in qualitative research tends to be more open-ended and less structured (Merriam & Tisdell, 2016). My initial goal identified in the IRB was to conduct between 10 and 12 interviews. Semi-structured interviews were conducted to gather specific information from participants. This format allowed for the opportunity to ask follow-up questions to thoroughly explore and understand participant responses. During the interviews, questions were asked and paraphrased as needed for clarification (Merriam & Tisdell, 2016).

Interviewing protocols were developed and used in this study to collect information from participants (see Appendix D). All interview responses were recorded using digital devices and kept on a password-protected digital file (Creswell, 2015). Miles et al. (2014) recommended that the researcher carefully consider the research problem when developing the questions to design an instrument that provides information relevant to answering the research question. Multiple interview questions were used to collect the same information to examine the consistency of the participants' answers. This form of questioning ensured the information was corroborated within its context by the participant, which aided in determining the trustworthiness of the responses (Yin, 2018).

Artifacts

The use of different forms of documentation often helps researchers develop a broader picture of the studied phenomenon and add to explanations provided by other sources (Yin, 2018). Merriam and Tisdell (2016) listed numerous documentation types that might be accessed at a particular site. In this study, a district website offered descriptions of STEM programming as well as provided a presentation video for each project team. Mentor/mentee relationships were contextualized by the information on the website pages and in the video presentations.

The website pages provided information that supported the responses provided in the interviews. A description of the program and the activities students participated in were included on each webpage. Students provided testimonials about the work they engaged in throughout the presentation videos. Information on the website also indicated the industry sponsors engaged with the Center for STEM Instruction and Innovation (CSII) project teams. Project team staff responsible for managing teams for the district were highlighted as well.

The first interview question asked students to describe their STEM mentoring program. Students provided information about their teams including specific information about their mentors and academic and STEM careers, which were corroborated by the website. The coding process included all the information gathered from the website pages as well as the interview responses. The axial codes represented information included in both sources.

Research Journal and Field Notes

A research journal is vital to establishing an audit trail (Merriam & Tisdell, 2016). Directly after I conducted interviews and as I reviewed artifacts, I recorded descriptive notes in my research journal. Those notes served as a data source in that they provided me with additional sources from which to analyze information contained in interview responses and artifacts. As I reviewed both sources, I recorded descriptions of the case, which provided additional contexts of the case. As I read and re-read the interview transcripts and throughout the coding process, I recorded my impressions, observations, and questions. I also analyzed artifacts obtained on the CSII website that added to my analysis of the context of the case. I highlighted words and short phrases in the transcripts and used them in a synopsis by identifying the phrases in the individual response summaries I created. In a column next to the summaries, I recorded my observations of the participants as I listened to interview responses.

While reviewing artifacts, I copied sections from the website pages that I identified as relevant to the context and mentee/mentor relationships and repeated the process of recording relevant information. I also used field notes to reflect on possible personal bias by answering a series of questions. One of the questions I used in my reflection allowed me to analyze my methods as I chose established research methods to complete the study. This question encouraged me to remain diligent in the analysis process and seek out established methods according to qualitative research experts (Creswell, 2015; Merriam & Tisdell, 2016; Miles et al., 2014).

Data Analysis

In qualitative research, data collection and analysis are ongoing as information is gathered through interviews and artifact analysis (Merriam & Tisdell, 2016). Using the field notes creation process and in vivo coding method described above, information gathered from these activities was immediately analyzed and added to existing information as codes and themes emerged. Data were analyzed using thematic analysis—an exploratory approach (Schwandt, 2015). To make sense of the information, themes were identified, and information was interpreted as opposed to reported as 'facts' (Creswell, 2015).

My coding process was modeled after an In Vivo coding method that "uses words or short phrases from participants own language in the data record as codes" (Miles et al., 2014, p. 65). The authors also pointed out this method of coding gives voice to the participants. I individually open-coded each transcript and artifact. Next, I created axial codes. Using the axial coding process, dominant codes were identified, and redundant, less essential codes were eliminated (Saldaña, 2016). Using axial coding, categories could be linked with subcategories and relationships could be examined (Saldaña, 2016). The axial codes were then collapsed into major themes through an inductive examination of the data (Schwandt, 2015). Using the themes, I elaborated on my interpretations of the meanings of the data in more detail as suggested by Saldaña (2016).

Trustworthiness

Data collection and analysis methods were carefully constructed and implemented. Designing the study process and developing and using data collection instruments provided evidence of the study's trustworthiness and its findings (Merriam & Tisdell, 2016). In addition, various strategies ensured trustworthiness and thus the accuracy and credibility of the study (Creswell, 2015; Merriam & Tisdell, 2016; Yin, 2018). To ensure trustworthiness, multiple data sources were used, member checks were conducted for validation of data collection.

Additionally, a research journal was used to explore and analyze data, and an audit trail was used to document study implementation (Merriam & Tisdell, 2016).

Triangulation of the data provided a strategy to ensure “the credibility and internal reliability” (Merriam & Tisdell, 2016, p. 245) of the interviews, artifacts, and research journal entries. Using multiple sources of data collection provided a method to support the internal reliability of information from all information sources (Miles et al., 2014). In addition to triangulation, I provided participants with a copy of the transcript after the interviews and asked them to review it for accuracy. Soliciting feedback from participants throughout the study added to the credibility of the study (Merriam & Tisdell, 2016).

Another strategy for ensuring dependability and consistency was an audit trail (Merriam & Tisdell, 2016). In the research journal, I included how the data were collected, organized, coded, and important decisions made during the process (Merriam & Tisdell, 2016). As a result of data analysis, themes and codes were developed in the research journal to document the research process (Merriam & Tisdell, 2016). My research journal contained a log detailing how I tried to keep my biases in check while collecting and analyzing data.

Researcher Positionality

Miles et al. (2014) identified a characteristic of a practical research observer as familiar with the subject and context of the site. As an educator of almost 31 years, I believe my familiarity with the educational setting helped me in collecting and analyzing data related to this study. However, familiarity must be tempered with objectivity and the ability to remain non-judgmental in my work. I also had experience in STEM education as a former fifth grade mathematics and science teacher and middle school technology elective teacher. I currently work as a STEM teacher in a middle school. I am also involved in the robotics program, which includes the use of several STEM mentors including industry professionals.

Additionally, I completed a program evaluation of an aquatics robotics team for youth offered through my school district to complete a requirement for one of my university classes. Participating in the program evaluation led me to form numerous questions concerning the use of industry mentors. I began to think about their involvement with youth, especially after a meeting I attended with the program director and several of the mentors. Following the meeting, I wondered about the ways professionals outside of the education system worked with youth at appropriate developmental levels. As a result, I became curious about how mentorship encouraged youth to participate in STEM programming.

Upon choosing a research topic, I focused my attention on understanding how STEM mentoring programs led to positive outcomes. My investigation of STEM mentoring programs helped me identify a common goal shared by school leaders and researchers. The purpose of establishing mentoring relationships is to identify young people who have a potential to become industry professionals. Mentoring relationships motivate youth to pursue STEM education and career paths after high school graduation (Alper, 2017; Kupersmidt et al., 2018; Radcliffe & Bos, 2013). The purpose of this study was to investigate and identify practices that promote STEM careers among youth. My perspective provided me with the necessary background knowledge to understand the study site and purpose. In order to understand the issue, I created instruments for data collection based on my positionality.

To ensure the process was as pure and free of bias as possible, I created goals that took into account potential judgments and preconceived ideas about the research question. Miles et al. (2014) proposed a line of questioning for researchers to promote honesty, trust, integrity, and quality: “What is my relationship with the people I am studying? Am I telling the truth? Do we trust each other?... “Is my study being conducted carefully, thoughtfully, and correctly in terms of some reasonable set of standards or established practices?” (p. 55-57). I used these questions and others to reflect on in my research journal throughout the study.

Conclusion

U.S. public schools commonly use STEM mentoring programs at the secondary level (Bruce & Bridgeland, 2014; Kupersmidt et al., 2018). The goal of these programs is to encourage youth to pursue STEM degrees upon entering college or to enter STEM career training professional programs after high school. This goal has not been achieved and the problem appears to be worsening (Cuny, 2019; Graf et al., 2018; Lister, 2017). This qualitative research study sought to understand the perspective of youth participating in a public-school STEM mentoring program. Specifically, the study explored how mentors impact their mentees’ decisions to pursue STEM careers. In order for STEM education to succeed and for high-tech industries to thrive, effective mentoring practices are crucial.

CHAPTER IV

RESULTS

> I think that everyone should have a mentor of some type, even if it's not a one-on-one thing. ... having someone who's in a workplace you want to go into, regardless of whether it's STEM, art, writing, whatever ... I think that it goes beyond what you can learn in a classroom, and I think that's important (Samuel).

This study was designed to understand how STEM mentor relationship practices motivate mentees by answering the following research question:

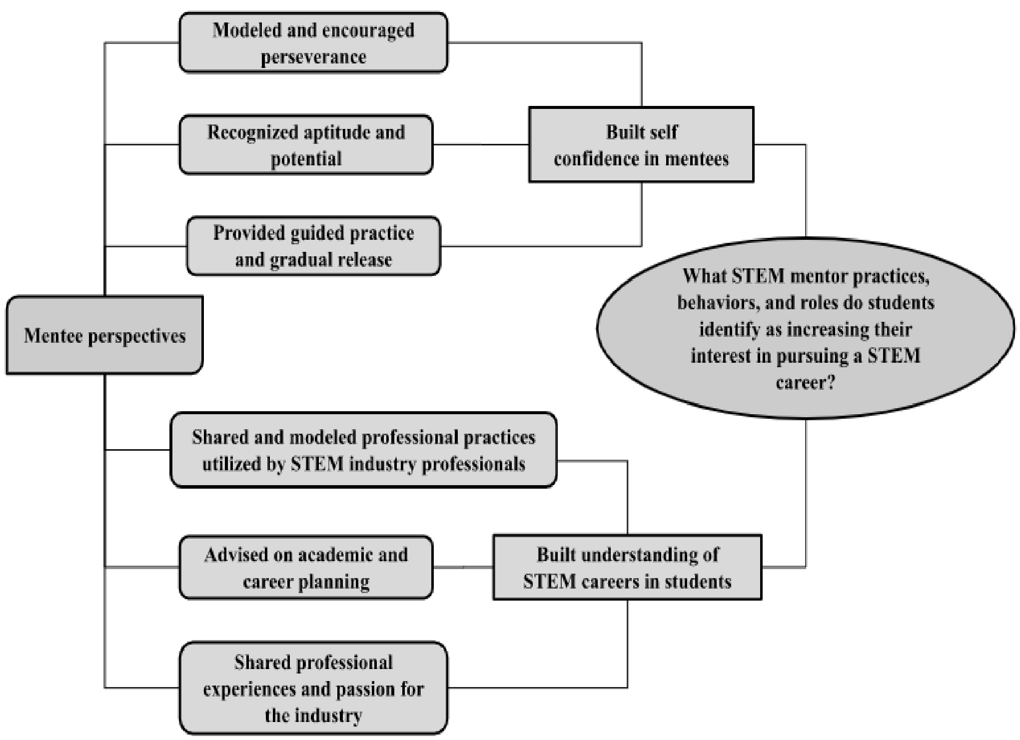
Q1 What STEM mentor practices, behaviors, and roles do students identify as increasing their interest in pursuing a STEM career?”

This chapter explains the findings from the collection and analysis of the data detailed in chapter three. Participants' responses are explored as well as the activities detailed on the website of the project team. An analysis of mentor relationship practices that encourage their mentees to pursue STEM careers was conducted in this study. Findings were organized into subthemes which evolved into themes through information analysis. Analysis of the findings revealed characteristics repeated by participants throughout the interview responses achieving saturation. Saturation of the findings reinforced the subthemes and themes as accurate representations of participant perspectives.

Various mentor characteristics and behaviors were revealed in the participants’ responses to interview questions. Subthemes emerged throughout participant responses that supported mentorship practices as increasing their interest in STEM careers. Two themes emerged from the findings regarding mentor relationships. The theme Built Self Confidence in Mentees was represented by the subthemes Modeled and Encouraged Perseverance, Recognized Aptitude and Potential, and Provided Guided Practice and Gradual Release. The theme Built an Understanding of STEM Careers in Students was represented by the subthemes Shared and Modeled Professional Practices Utilized by STEM Industry Professionals, Advised on Academic and Career Planning and Shared Professional Experiences and Passion for the Industry. The relationship between themes and subthemes is reflected in Figure 1. Representation of the themes occurred often and to varying degrees throughout the responses.

Figure 1

Science, Technology, Engineering and Mathematics Mentoring Relationship Practices



This case study provided a strong argument for the necessity of STEM mentor programs at the secondary education level as a method of increasing students' desire to pursue STEM careers. In fact, participants wondered how their project teamwork would be affected without the involvement of mentors. They speculated on the inability of the Center for STEM Instruction and Innovation (CSII) to offer many of the project team opportunities available to students without the involvement of their mentors. Also, participants questioned the existence of their project teams without their mentor's involvement.

One participant gave an example as he pointed out the importance of mentor involvement on the aeronautics-focused team: "There's a certain point where mentors are necessary…as a kid, I wouldn't set this up. ...the CSII got the funding for this airplane build...with no mentors...it wouldn't exist." There was a consensus among participants that project teams would not offer the same benefits to students without their mentor's expertise and guidance. Participants recognized the connection between their access to STEM mentors, the opportunity to develop a passion for STEM activities and projects, and their motivations and decisions to pursue STEM careers.

Setting and Context

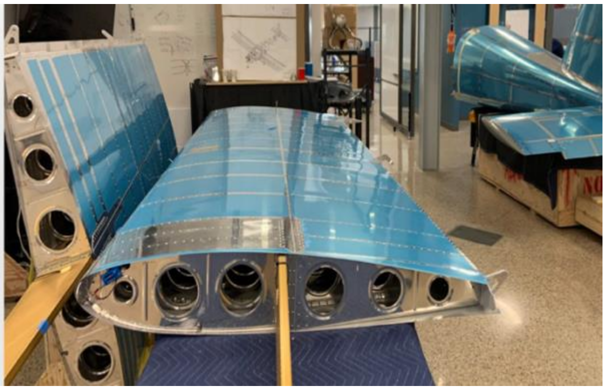
Setting

Golden Meadows is a public school district in a suburban area of the Rocky Mountain foothills. The area is located just north of a major U.S. city. Recreational and academic opportunities abound here. The region is home to a number of large STEM-focused companies that attract STEM professionals to the area. The school district serves over 30,000 public school students. Golden Meadows was in the top 10 of the largest school districts in the state. The district is responsible for over 50 schools and programs spread over 400 square miles. It consists of approximately 20 elementary schools, less than 10 middle schools, less than 10 high schools, nine charter schools, a district wide preschool program, alternative and online high schools, homeschool programming and support, a Career and Technical Education Center program (CTEC), and a CSII. The school district offers STEM secondary-level programs for high school students at the CSII. These programs include opportunities for students to engage in STEM activities with industry mentors.

The CSII is a newly built, secure education facility containing several project team spaces. Within those spaces, the district provides the necessary equipment and technology to accommodate STEM-focused learning activities. Upon entering the building, visitors are aware of the emphasis on technology education and ongoing project-based learning opportunities. An information video plays on a large screen television in the front lobby. The path leading through the building reveals a conference room, a computer lab, an aeronautics center, a laser design and production lab, and a robust robotics lab. Each area is outfitted with current STEM-related equipment designed to meet industry specifications. The aeronautics center contains cockpit simulators and manned and unmanned aircraft construction spaces. The aeronautics project team meets in the manned aircraft build space. Figure 2 is an image of their current build.

Figure 2

Manned Aircraft Build

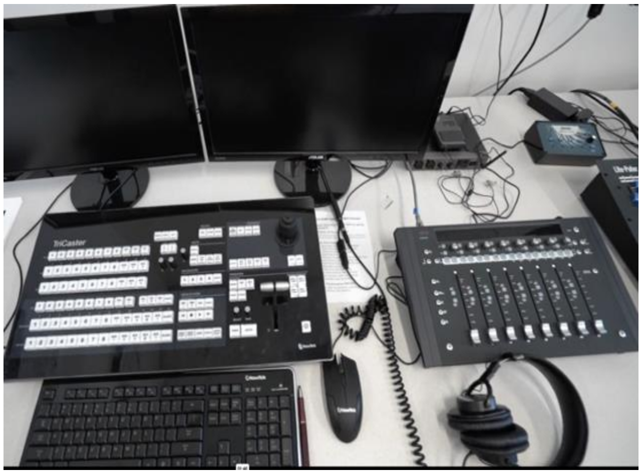


Note. Students work to assemble an RV-12; an American two-seat, single-engine, low-wing airplane.

There is a large presentation room in the center of the space three stories tall. Several offices, an additional conference room, and classroom spaces are located behind this space. On either side of the presentation room, labs with classrooms for group work contain screens and presentation equipment. In addition, a maker space classroom at the back of the building serves small professional development groups and classes from elementary schools participating in field trips. An outfitted media studio and audio production office are located on the second floor. The studio is equipped with current audio and visual technology designed to mirror the studio environment in professional videography studios. Figure 3 shows an image of the CSII studio as well as the audio mixing office.

Figure 3

Studio Project Team Space



Note. Studio spaces are used to create informational videos, commercials, and sound bites for local clients.

The staff at the CSII include an administrator, a director of innovation, two design education coordinators, a maker space coordinator, instructors for each project team, and additional staff required for programming needs. The center provided year-round program offerings. Club and project team meetings occur after school hours. Weekend classes and competition work are also part of the CSII's programming and district-wide work. Industry partners are listed on each project team's website page. Partners include STEM industry companies located in the surrounding area. Students spend school days, nights, and weekends working and building alongside mentors at the CSII throughout the year.

Adults and students gather in the CSII spaces on any given weekday, conversing and collaborating in the labs. They view presentations, complete team exercises in the computer lab, or film and edit footage in the audio/visual studio. The use of workshop tools in the aeronautics lab echo through the spaces. Metal robot engines are heard coming from the robotics lab as well. Students use the robotics lab to design programs and strategies for maneuvering robots through obstacle courses. The goal is to score points through various competition-driven challenges. Mentors and teachers look on or are consulted, interacting with mentees periodically; occasionally, a chorus of laughter or a shout of excitement is heard from among the groups. Figure 4 shows an image of the robotics-focused, project team lab.

Figure 4

Robotics Lab

Note. Robotics-focused project teams allowed students to build robots and compete in competitions.

Context

The study participants were all members of at least one of the CSII project teams. Each team worked with no less than two industry mentors. Student interviews occurred at the CSII on an agreed-upon day and time. Questions were designed to understand student perspectives about mentor relationship practices. Students were asked to describe practices, behaviors, and roles that encouraged them to consider careers in STEM. I eventually completed 10 interviews and achieved a saturation level, which was supported by an analysis of the interview transcripts.

As seen in Table 1, the participants were mixed in age and years of mentoring. I met the goal of interviewing mentees in their last two years of high school. Four of the participants attended public school in the 11th grade and six in the 12th grade. Four participants worked with the aeronautics-focused project team, one worked with the audio/visual-focused team, three worked with the cybersecurity-focused team, and two worked with the artificial intelligence (AI)-focused team. In addition, two participants worked with the robotics-focused team and three participants were involved in at least two of the teams listed.

Table 1

Participant Demographic Information

Name	Grade Level	Number of Mentor Relationship	Years Spent in Mentor Relationships	Project Team Focus
Andrea	12	2	1.5	Robotics
Adi	12	2	6.0	Cybersecurity
Atikish	11	3	3.0	Robotics and aeronautics
Jason	12	2	2.5	Cybersecurity
Nate	12	2	3	Assisted robots and AI
Tara	11	5-6	4	Robotics and aeronautics
Samuel	11	2	4	Cybersecurity and AI
Justin	11	4	1	Aeronautics
Dulce	12	2	3-4	Audio/visual production
Veda	12	1	1	Aeronautics

Participant Profiles

Andrea.

Andrea was a 12th-grade student at the time of our interview. She joined the robotics-focused project team at the CSII about a year and a half ago. Her team worked with her mentor Ezequiel from IBM, developing chatbots using an IBM Watson assistant. Ezequiel presented the team with an overview of chatbots and introduced some badges IBM offered its developers. He also invited the team to work with his IBM colleagues on a project that required problem-solving with an existing chatbot. Andrea described her mentor’s encouragement to pursue a STEM career: “I think [he]...encourages us by making it engaging and interactive instead of just listening to a lecture. And I think ... by engaging us we're more invested in it and so become ... more interested in pursuing that kind of STEM career.” She planned to pursue a computer science career with an emphasis on business management: “I would want to go into ... a high-tech company, I do wanna focus on ... business because I like talking to people and ... I don't like being pure ... technical, which I think Ezequiel has also shown.” After graduating high school, she continued with her CSII project team as a peer mentor.

Adi.

Adi, a 12th-grade student at the CSII, was a member of the cybersecurity project team. Adi’s mentor experiences spanned over a six-year period. He described the rapport he built with his mentor, Ms. Sharon:

> Our relationship has developed over the years because originally in ninth grade and 10th grade, I had her as a computer science teacher at Golden Hills high school and then she transferred ... here to the CSII. I've gotten to know her as more of a coworker than just an instructional figure. So, I think just the way how that relationship is developed and the rapport that I've developed with her has been ... really ... exciting.

Adi’s industry mentor, Dr. Mickey, began working with him in seventh grade. Adi described him as “a prominent mentor from university...who’s regularly involved with us and he’s helped us...develop our skills in cybersecurity.” His project team created a computer science competition focused on cybersecurity for middle schoolers.

Adi’s mentors have influenced his career choices through the years by educating him about the industry and various STEM careers. After high school, he will pursue a career in computer science in which he is hoping to combine his love of politics and data science. Dr.

Mickey's experiences as a university professor influenced him to consider a path in academia as well.

Atikish.

As a member of the robotics and aeronautics teams, Atikish worked with three project team mentors: Mr. Shift, Ms. Ralph, and Mr. Baker. His mentors worked with mentees on the CSII project teams and supported an aeronautics engineering certification program at his high school as well. He described the academic benefits as follows:

> [The aeronautics] program that I'm in currently at our high school...[offers] a series of STEM classes throughout your ninth, 10th, 11th, and 12th grades...you work with different levels of STEM mentors in order to create a capstone project where in the end of completing your capstone project and receiving passing marks, you'll get an engineering diploma and special certification at graduation.

During our interview, Atikish shared his initial experiences with STEM exploration and recalled the trepidation with which he approached his classes and activities. He also described the encouragement he received from his mentors:

> Mr. Baker kind of stepped in, he was like, you know what? I did that too. When I was in school...I was not good at this. There's no reason you need to be good at it. You just need to be passionate...by my 11th grade year, I ended up surpassing [my] peers because they ended up giving up.

Mentor encouragement facilitated Atikish's ability to develop a passion for science. He was in the 11th grade and had been a mentee at the CSII for three years at the time of our interview. He is planning to pursue a career as an astrophysicist after high school.

Jason.

Jason was involved in the cybersecurity team during his final year of high school. Ms. Sharon and Dr. Mickey had worked as his team mentors for over two years. His project team facilitated the cybersecurity competitions for middle schoolers and competed in district-wide computer science competitions at the secondary level. Jason spoke very highly of his mentors and shared details about their experiences and expertise. When describing Ms. Sharon, he said: “[S]he's [Ms. Sharon] also very knowledgeable about the topic... for example, for the coding competition...she does a lot of coding languages and done a lot of competitions herself. ...she's just been a really big help with the process overall.” He described Dr. Mickey as follows: “[H]e [Dr. Mickey] is a really...smart and...influential person...in the field of cybersecurity ...I know he worked at a university for a while, and I believe right now he is working for the government in some type of defense work. …he's very, very knowledgeable.”

Jason appreciated the encouragement and engagement his mentors provided. Their specific acknowledgment of mentees’ work seemed important to him. He also added at the end of the interview how much he appreciated their time and effort and got a sense that “they really care about the world of tech and cyber security.”

Although he will still be pursuing a career in the tech industry, he will not be entering the field of cybersecurity due to its intensity and complexity. He did, however, express his appreciation for the in-depth experience and was thankful he had not had to wait until college to discover it was not for him.

Nate.

As an assistive robotics and AI project team member, Nate, a senior year in high school, had participated in some impressive projects. His team designed robots that could “interact with special needs students" as well as an "underwater camera that uses machine learning to count an endangered fish population." He had a lot to say about the benefit of working with a mentor who is also a full-time engineer:

> He's been immensely helpful…cuz a lot of the kids in that project team have more experience along the lines of programming and artificial intelligence. …there's been a bit of a learning curve around the physical hardware implementation. He's been really helpful with…just the experience he brings to the table.

Nate also shared that his mentors had given him advice concerning high school subjects to study as well as a wealth of information concerning industry equipment, client communication and collaboration, emerging technology, and application of skills. When asked about future plans, Nate said he wanted to pursue a profession that "allows me to work with computer science, mathematics as well as just science in general." After high school, Nate would like to become an experimental physicist.

Tara.

At the time of her interview, Tara was in 11th grade and working on the robotics and aeronautics-focused project teams. Her robotics team was made up of 80 students and 20 mentors. She shared that the team was broken into sub-teams and her team was responsible for assembling and wiring the robot. Team members also completed prototyping and testing, and Tara drove the robot. She described her aeronautics team as follows:

> [F]or the RV build, [we have] probably 10 students and five or six mentors. … we're just building a two-person airplane from scratch. … I work with them to figure out what we're doing on the plane and what the instructions are telling us and how to do that and use all the tools.

Tara shared that learning a universal problem-solving process from her mentor was very helpful and an important experience for her. She also felt her mentors encouraged her by "opening my eyes to the STEM field and showing me how cool it is and all the different things you can do with a STEM career. I just find engineering fascinating and I love it." Her mentors had written letters of recommendation and given her advice about college, job interviews, and engineering disciplines.

After high school, Tara will major in mechanical engineering with a minor in electrical and computer science at a university. In her interview, she described one of her mentors' prototyping abilities as "ingenious." Tara said, "I want to do that when I grow up."

Samuel.

Samuel participates in two teams: the cyber security team as well as the AI team. He added his own perspectives about Dr. Mickey as well as the IBM professional working with the Watson development team. He has been a mentee for four years and began working with mentors in middle school through cybersecurity competitions. He is currently in his 11th year of high school. Sam reported that he appreciated his current mentors' approach to mentoring and described his preferred learning style:

> I'm just kind of like that stubborn coder guy who just does his own thing. …I just really need…a 15-second rundown of why this is important and why I care about this and then gimme an article, a textbook, whatever, and I'll do it on my own, I guess. Um, so I learn a lot more efficiently that way.

He also described the positive experiences he had with mentors such as discussions he engaged with during project team sessions. He recalled how much he enjoyed individual conversations he had about his interests and the questions he asked about various concepts he was curious about. He characterized his mentor, Ian, as a father figure of sorts. At one point, he made the connection between his mentors' current professions to his future plans. He recognized the value of the opportunity to work with mentors who were industry professionals in the following: "…in a few years cause I'm going into their fields…it's interesting to learn about…what actual professionals are doing in their job. …it gives me an insight on what I'm gonna need to do and what I need to do outside of…an educational standpoint." Samuel is planning to major in electrical and computer engineering, which combines computer science with electrical engineering.

Justin.

Justin is a member of the aeronautics-focused project team and was finishing his junior year of high school when he participated in our interview. He began describing his experiences learning about the equipment and shared insight into the direction mentors provided as students learned procedures:

> Today they [were] doing a quick sweep and they came over to where I was working, and they saw that I had a rivet that wasn't completely sealed. …he [mentor] said, 'You know, you wanna take a look at that.' …obviously, it was kind of too late, so you had to figure out a whole way around that. …they let us analyze what we're doing and figure out what's wrong before they actually say it.

Justin shared he was encouraged by his mentors due to the dedication they modeled to their disciplines by committing to mentoring and volunteering their time. He felt that just by being there they were showing how much they "love engineering." He shared he wanted to develop a similar passion for engineering through his future profession: "I want a job I love." Justin is planning to pursue a degree in engineering and is considering optical engineering but has also expressed an interest in biomedical engineering. He was already considering a specific university based on his research of academic institutions that offer the degree. He offered that he wanted to choose a program that had a reputation for being a top program.

Dulce.

Dulce, a senior in high school, was the only participant who worked with the audio/visual-focused project team. She had been working with two mentors on the team for almost four years. Dulce's experience was unique as her work was focused on completing jobs for clients in teams that required students to fulfill their roles in a hierarchical system. Eventually, as a veteran member of her team, Dulce was responsible for the initial planning meetings with clients and the management of the project deliverables. She described her initiation to the work and the risks and rewards of learning new skills all while describing her mentors' influence on her use of audio/visual technology and management projects for local clients: "It was my first year here…my mentor was like, 'Hey, let's run a camera.' …I'm like, 'No, …I don't know how to do that' and he [said], 'No, you'll do fine'. I really did learn a lot. …It was pretty cool. I had a lot of fun. …You find out you're good at something."

Dulce's mentors gave her increasingly difficult roles while rewarding her by praising her work and sharing their opinions with others. Shortly before our interview, Dulce planned an open house event for Latino families at which she said her mentors took the time to share their admiration for her talent and work ethic with those in attendance. She recalled the sense of pride and accomplishment she felt. She said, "...they really encouraged me to become someone and…really be proud of myself."

Dulce described the value of the problem-solving and communication skills she acquired through her work with mentors. Although she will not be pursuing a career in broadcasting, she shared how the work she participated in with her mentors helped to shape her understanding of professional practices. Dulce has dreamed of being a doctor from the time she was in elementary school. She plans on pursuing a career in medicine. At the end of her interview, when asked if she had anything to add, she took the opportunity to express her appreciation for her mentor's influence. She said, "I would like to add that...[they] opened many doors for me."

Veda.

Veda was another aeronautics-focused team member interviewed for this study and was in his last year of high school. Veda had the least amount of mentee experience among the study participants. As a result, his interview responses as a fairly new mentee offered a slightly different perspective. When asked about the activities he participated in with his mentors, he immediately shared the opportunities to ask about internships, college prep, and workforce readiness. He also shared that he did not know anything about planes before joining the aeronautics-focused project team.

Veda is interested in engineering, specifically aerospace and biomedical disciplines. He described his experiences as hands-on and fun. He liked using tools and working with friends and teammates. He shared the team's reaction to putting the final touches on the first airplane wing they completed:

> A positive experience I've had is just completing a wing, which was a huge step. ...it took almost an entire semester to just get one wing done and putting in that final rivet was like a milestone, cuz that just leaves another wing. ...We celebrated by...clapping, but then we kind of just moved on to the next part. ...time is like valuable cuz we only have four hours a week to work on it.

Veda responded to a question about his mentor's encouragement to pursue a STEM career by sharing more advice he received about internships. His mentors described the benefits of internships for students who are interested in understanding different STEM professions through work experience and apprenticeship. Veda will pursue a degree in engineering and is considering biomedical engineering and aerospace engineering.

Project Teams

Each CSII project team fit the description provided in chapter three of a STEM-focused program. Programs offering mentor partnerships provided participants willing to be interviewed for this study. Each team had an informational website with descriptions of the programs. The CSII workspaces and project team websites were evaluated as artifacts for triangulation. The team website pages added to the understanding of the context mentees and mentors collaborated in and the backgrounds and expertise of project team mentors. The website pages described course offerings, project goals, and objectives of teams. Websites also described the work of project teams through presentation videos highlighting their work as well as profiles of sponsoring staff members and their contact information and project team mentors.

The project teams all met at various times and days at the CSII. Teams were spread throughout the building in the labs created for their work. The groups met after school and some of this work required late hours and work on the weekends. Participants described involvement in evening community events as well. Students were involved in competition teams with their mentors. Cybersecurity-focused teams competed in statewide events, and robotic teams often advanced to international competitions through their success in regional and state competitions.

Many teams worked on projects that involved external clients such as local organizations or businesses outside of the CSII. These customers were sponsors and supporters of the CSII and its STEM project teams. The audio/visual team often created informational videos for local government agencies as well as promotional videos for local businesses. The aeronautics team worked with local pilots to complete physical and tech-based deliverables. One of their original collaborations focused on creating an underwater roving robot that helped local officials complete various wildlife studies.

Science, Technology, Engineering and Math Industry Mentors

Teams at the CSII often onboarded industry mentors to project teams through word of mouth within the companies where they worked. Mentors were also occasionally contacted by CSII staff such as the innovation director or various CSII project team staff. Mentors involved at the CSII are sought-after members of their STEM disciplines such as computer science, robotics, and aeronautics. These members play a pivotal role in the ability of mentees to obtain the background knowledge and skill sets required to complete projects. Often teams worked with multiple mentors who fulfilled varying roles in their STEM field. The aeronautics-focused team relied on pilots and engineers to assist them in their work. Teams with a robotics focus required engineers and computer science professionals to complete projects involving chatbots as well as assistive technology projects for individuals with disabilities.

Mentors helped participants learn more about the hardware and technical expertise needed to complete their project work. They also brought valuable opportunities to their mentees in the form of internships and certifications. One student shared the importance of these opportunities and the advantages they provided mentees at the CSII. He said, “Getting certifications is huge for getting into college... (Certifications and courses) help with applying to job internships.” Another student related how the coursework offered at the CSII encouraged him to pursue a STEM career: “I took this class and now I want to do this as a career.” Mentors’ professional experience and academic background information were included on project team webpages as well. Mentors worked in high-level positions in their industries in aeronautics and computer science fields such as cybersecurity, artificial intelligence, mechanical, electrical, and structural engineering. Participant responses included descriptions of their levels of expertise. Many mentors held positions requiring highly specialized advanced degrees in engineering, biology, or computer science. A few of the secondary education professionals who managed the project teams held professional, STEM-focused, higher education degrees. The CSII staff members acting as STEM mentors were employed in the industry prior to entering the education profession. Those staff members relied on their academic and professional experience in STEM disciplines to assist mentees in their project teamwork.

Findings: The Mentee Experience

Throughout the interview process, participants shared detailed insight about their work with mentors. They described increased self-confidence as mentors facilitated an in-depth understanding of STEM careers. Participants described several experiences with their mentors that reinforced their intentions to pursue academic pathways and STEM careers. As a result of their interactions with their STEM mentors, all 10 participants shared their plans to pursue STEM-focused academic programs after graduating high school.

Website presentations, course descriptions, and mentor profiles served to reinforce participant activities and added details regarding mentor backgrounds as well as levels of expertise. Presentation videos featured student testimonials about the project teamwork and its value. Students described project teamwork and skill acquisition opportunities while expressing gratitude for the variety and availability of CSII program offerings. The students' descriptions reinforced the complexity of the content offered and clearly supported the need for the involvement of qualified staff and industry professionals. One student shared her opinion as follows: "A lot of what we do here at the CSII could not be possible without mentors." This information added to student perspectives concerning the influence of mentors on the research. Students shared how these experiences reinforced their intentions toward preparing for a STEM career. The STEM courses and project team descriptions added context to the roles mentors played in project teams. This information also provided more detail about the levels of industry knowledge and skill required of mentors in their work with project teams.

Through analysis of the responses and project team webpage content, it was clear the mentors employed a number of practices that encouraged their mentees to pursue STEM careers. Mentors modeled and encouraged perseverance, made an effort to recognize ability and potential, and openly encouraged mentees to take on new challenges. Mentors also provided essential guidance regarding professional practices. In addition, mentors encouraged mentees to practice new skills and work toward mastery. Through their work with mentors, participants reported increased confidence in their ability to participate in and eventually accept leadership roles in various STEM discipline project teams. They also indicated increased confidence in their ability to apply acquired knowledge and skills to project work. As a result, mentees accepted increasing responsibility on project teams and engaged with mentors in planning for their futures in the STEM industry.

Built Self-Confidence in Mentees

Throughout their time together, mentors had several opportunities to influence their mentees' ability to successfully participate in design tasks while acquiring technical skills and applying those skills in their project teamwork. These experiences created an environment in which their mentees built self-confidence and a skill base that allowed them to find more success in their project teamwork. Participants gave many examples of mentors modeling problem-solving methods for students in their work together. Tara observed and later replicated a universally applied problem-solving strategy modeled by her mentor on the aeronautics-focused team:

> My main mentor has taught me the whole process of how you...systematically identify and isolate where the problem is so you can figure out what it is and how to solve it...and that really applies to everything. You can use that with everything in life, but that's been really helpful.

Mentors also influenced mentees by recognizing their progress and increased skill levels. This type of recognition resulted in their mentee's increased self-awareness and confidence. Anecdotal examples shared in participants' interviews revealed the influence mentors had on their mentee's actual and perceived abilities. They gave examples of moments in which they accepted increased responsibility based on their mentor's encouragement. Andrea shared a moment her mentor encouraged her to sign up for the role of an architect on a sub-team for a client deliverable:

> That was the moment...a clear moment where he [said]...'Put your name down next to the architect. I know you can handle the technical things. So, I'm going to assign you to that role.'...to me, that was like, 'I know you can handle the technical things. So, I'm going to...assign you to that role.'

Although participants described initial misgivings, mentors often offered participants their opinions on their readiness for increased responsibility. This demonstration of confidence increased their mentees' engagement with new challenges and available leadership opportunities. Mentor encouragement added to mentees' ability to comfortably, albeit cautiously, accept more complicated challenges and leadership roles.

Modeled and Encouraged Perseverance

Participants provided examples of mentors who modeled problem-solving organizational strategies, productive failure, and perseverance in their work together. Mr. Baker, a mentor from the aeronautics-focused team, inspired Atikish to give his best effort while prototyping. He encouraged him to continue his work while setting aside any doubts about the results:

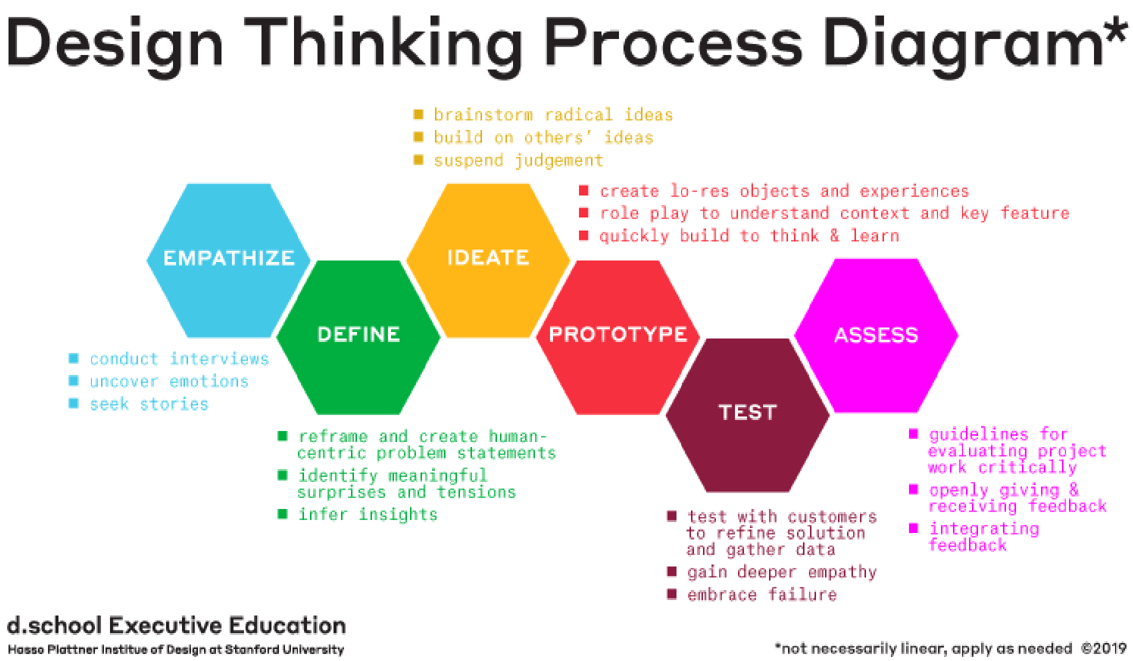
> So, the one thing that really helped me with my mentor, Mr. Baker, was that he would just keep pushing me to try it no matter how bad of a technical grade I thought I would get...[it] never ended up being that bad when I genuinely tried to do it.

Mentors maintained a positive attitude when experiencing failures and frustrating circumstances as they worked on project teams with their mentees. Participants were inspired by their mentor's ability to approach problems with confidence and draw on their expertise to find solutions.

Much of the work participants engaged in with their mentors involved the use of a variety of problem-solving strategies. Mentees described moments their mentors led them in prototype testing and redesign sessions and how these experiences increased their desire to join the STEM field. Tara, a member of the robotics-focused project team, described a moment her mentor modeled prototyping in their work on the robotics-focused project team and that experience inspired her: "He'll walk you through the process of how to prototype everything and just come up with ingenious designs that can make the robot work in a few minutes. ...want to do that when I grow up." The design process required the ability to recognize the adjustments needed to improve a prototype in response to performance tests. Industry professionals consistently engaged in design in their STEM fields and each CSII project team utilized the process as they collaborated on projects. Successfully applying the process was important to students developing an understanding of the importance of perseverance during problem-solving. Much of the work completed in project teams involved utilizing the stages of a design process used by STEM professionals, especially in a variety of engineering disciplines. Golden Meadows school district used the process shown in Figure 5 as part of its STEM curriculum district wide.

Figure 5

The Design Process



Note. The design process model from Stanford University is used by Golden Meadows public school district.

In their work with mentees, mentors identified opportunities resulting from productive failure as examples of the need to model perseverance. Professionals such as engineers and programmers used productive failure in their professions as they engaged in trial-and-error-based design projects while seeking solutions to problems. Solutions were tested and revised as often as needed until a suitable one met project goals. Throughout the interview responses, participants offered their observations of mentors as problem solvers. These experiences served to increase problem-solving stamina. Tara shared her experiences:

> We have tons of things go wrong...things break, and you just have no idea where to start looking. My main mentor has taught me the whole process of how you systematically identify and isolate where the problem is so you can figure out what it is and how to solve it.

Mentees often recognized and emulated strategies employed by mentors when approaching design flaws and planning the next steps. Another example provided by Atikish, a member of the aeronautics team, involved his mentor Ms. Ralph intentionally modeling strategies for writing and revising programming code. She shared a strategy with him after recognizing the need to intervene and redirect him in his work. The method she shared with him allowed him to account for changes he needed to make in his code by making notes along the way. Initially, he chose not to follow her advice but after a few frustrating experiences, he allowed her to revisit the method with him. He described this exchange:

> One really helpful tool that I learned from her is to put comments...in my code. I would refuse to do it because I would think...I don't need it. I just I'm too good for that. ...later I would go look and...I have no clue what I'm doing. So, she kind of just introduced that [strategy]...slowly.

It was clear he appreciated her patience with his hesitancy and eventually saw the value of the strategy.

As they participated with team members, mentors provided positive reinforcement when mentees attempted to deal with setbacks or failure. As previously described in this section, mentors encouraged their mentees to persevere using strategies employed by engineers and professionals in the field. Atikish offered his thoughts on the effect another mentor, Mr. Baker, had on his understanding of perseverance and how it increased his interest in STEM. He said, "I learned through his coaching and help. ...I just needed to know how to keep going. And it was that kind of perseverance aspect that got me way more into STEM." An increased interest in STEM led Atikish to plan for a career in the STEM industry.

Mentors also shared examples of setbacks they encountered in their experiences in the industry as they pursued and entered STEM careers. In addition to his thoughts on perseverance, Atikish added more in his interview about his mentor, Mr. Baker, who described his early experiences as a physicist at NASA. He viewed himself as an awful student in the beginning, who did things his own way, much to the chagrin of his coworkers and supervisors. However, as time passed, he was able to demonstrate the value of his natural ability and commitment to persevere by surpassing his coworkers and excelling in his division. Atikish recalled:

> He was an awful student and...he would not do things the way...people wanted him to and...everyone would get mad for it. ...a few years later he was the one who was excelling at the top of...the division because in the end...he would...get the job done beyond anybody else.

This story helped Atikish develop a deeper understanding of his mentor's career path and increased his level of comfort in pursuing his own. The mentor encouraged his mentee to work through feelings of inadequacy and criticism in moments like these.

Mentors connected their experiences with those of their mentees by commiserating with their mentees when they shared feelings of inadequacy or doubts in their abilities. Many mentors told stories similar to the previous one describing frustration or feeling unsure of their ability to complete the work. Mentors shared that their own passion for their work often led them to develop the confidence to move forward in their career pursuits. They shared their own uncertainty when starting out and many followed less traditional paths than others in similar roles.

Mentors also shared that their family members often caused them to question their own career interests. Mentors who initially chose other career paths eventually overcame doubts from family and found their way to their current positions and success in their field by following their passion. A member of the audio/visual production-focused project team, Dulce, described her mentor's ability to persevere when he felt unsure about what profession he wanted to pursue. In his search for a meaningful career, he developed a passion for film production. Dulce related the following conversation they had as they discussed academic paths:

> He told me...'I went to school for something I didn't like, because my parents were.., go do this so you can become someone. But then as I was in school...I saw that I wanted something different.' When I heard that, I was like, okay, then I need to do something I want.

Her mentor shared with her that his family encouraged him to seek a profession they considered more stable, which might provide more security. Eventually, he followed his passion and moved on to a career in Hollywood for a production company and found a level of success they eventually celebrated. His example inspired her to explore the possibilities she was considering and gave her the confidence to stay true to her passion. In commiserating with mentees, mentors helped to build their student's comfort level with their choices.

Participants also shared conversations they had with their mentors as they discussed problems in design, or the frustration participants felt at times. Throughout the interview responses, participants shared their appreciation for their mentor's assistance and influence.

They offered examples in which they worked to acquire and improve industry-required skills. With the help of their mentors, participants connected motivation and self-confidence as a result of the exploration of STEM careers. Adi participated in mentor-facilitated cybersecurity competitions with his mentors and shared his appreciation for the opportunity to practice solving computer science industry problems. He recognized that the preparation for competitions added to his ability to apply skills required for computer science careers:

> They prepare you for...the workforce because the problems in those competitions that you have to solve are very similar to...technical interview questions that...software engineers or data scientists are asked. So, it really helps...just being prepared for the workforce. ...it also...provides you a lot of motivation to better your skills in...computer science.

As they completed work in their project teams, mentors also encouraged students during times when they realized they had made a mistake or initially failed to solve a problem. They reminded their mentees that new skills could be developed only through the processes of acquiring new knowledge, application of new learnings, and trial and error. Students' experiences with trial and error were especially trying. On the day of our interview, one member of the aeronautics-focused team, Justin, had repeatedly made mistakes as he worked on a project. He shared his frustration often throughout the interview. His mentor approached him when he noticed a problem and provided an opportunity for him to recognize that something was wrong by suggesting he might need to check his work. He described the experience as follows:

> I didn't see what I was doing wrong initially. ... he said, you know, you wanna take a look at that. Um, and obviously it was kind of too late, so you had to figure out a whole way around that... I like how they let us figure out what's wrong first cuz it teaches us...and I think it...helps us learn to do better next time.

He recognized the value of this approach and appreciated that his mentor gave him the opportunity to find it and fix it on his own.

Atikish also recognized the importance of failure when seeking to learn more about a problem and possible solutions. He shared, "It's about being able to take failure and then learning from that." Atikish also recalled a moment his mentor encouraged him to follow his passion and be patient with himself in the learning process. He also described how the new experiences he had with STEM in his project teamwork challenged him in a way he had not experienced up to this point. He also pointed out that his mentor practiced patience in their work together while continuing to maintain high expectations. He said, "I hadn't really experienced something where I was failing... I never had someone try to genuinely push me beyond what I knew." Atikish went on to explain how his mentor reinforced the idea that he did not have to demonstrate mastery right away; he just needed to maintain a passion for his work. Many other participants described similar experiences in their work with mentors. A common theme among mentees was failure was important to their growth and essential to their understanding and proficiency in STEM disciplines.

Recognized Aptitude and Potential

Mentors motivated students with encouragement and praise as they worked side by side on their project teams. They created an environment of trust by recognizing mentee aptitude and potential as they engaged in STEM-focused work together. Participants said their mentors recognized their potential often before the mentees themselves did. Mentors demonstrated confidence in mentees by encouraging them to share their project teamwork even when they were unsure of the finished product. This act required mentors to share their belief in a mentee's ability to successfully complete a task or take on leadership roles within their project teams.

Dulce described that, at first, it was difficult to share her work: "When we did the first video, I told him [my mentor]... 'I'm gonna show you this, but I don't like it.' ...My mentor said 'You really...need to stop...doubting yourself. You need to believe in yourself.'" She went on to describe the effort her mentor made to share more of her accomplishments with others. Her description was as follows:

> We did a Latino family night here, and I planned the whole event and...invited the guests and the clients and everyone else. After that event, ...my mentor has been telling everyone... 'She's really awesome. She did the whole thing. She did the speech in Spanish and English. You, you can hire her now.'

This type of reinforcement from mentors helped mentees feel less hesitant to share their work with others.

Mentors often increased mentees' abilities by providing a mix of redirection and recognition. Participants expressed appreciation for their mentor's candor as well as praise in response to their work. They recognized their mentor's efforts to include both forms of feedback as a way to acknowledge mentee potential. The effort mentors gave to their work with students was a clear indication of their belief in their mentee's potential. Participants offered specific examples of their mentor's efforts to balance constructive criticism with recognition of their accomplishments.

On the day of our interview, Justin had been struggling with riveting a wing on the airplane the aeronautics-focused project team was building. He expressed frustration with himself more than once throughout the interview. He also shared that his mentors tried to mix constructive criticism with recognition and praise. He explained, "I messed up three times, and those three were the ones that stood out...[and] sometimes they congratulate us for stuff that we've...figured out...to solve a problem." Justin was clearly frustrated with himself for ignoring his mentor's earlier advice to be more mindful and double-check his work. He revealed his frustration with his mistakes with a mix of relief and appreciation for his mentor's response. He also recognized his mentor's effort to offer congratulations at other moments when he found success in solving problems in his work on the project team.

Mentors also demonstrated confidence in their mentees' potential by bringing industry certification opportunities to their project teams. Under their mentors' tutelage, mentees were encouraged to obtain STEM industry credits and endorsements relevant to their project teamwork. These programs, made available through a partnership between the CSII and IBM, provided students with training that added to their ability and readiness for STEM industry careers.

Mentors worked with their mentees to choose and complete classes through a "badging" system created by the company for its employees. Participants responded to questions regarding activities they participated in with their mentors with descriptions of these systems. Andrea, a member of the AI-focused team, shared:

> So, we took...a minicourse, and those were all badges that he introduced to us through IBM. He also gave us presentations about...what makes a good chatbot and about...the cycle that IBM goes through as kind of a guideline for us when we develop our own chatbot.

As mentees earned badges, they began to develop the confidence to apply their increased ability to project teamwork. Sam, another member of the AI-focused team, described the value of this system: "We get...the same...certifications as IBM employees do, and that can carry throughout jobs. Cause they're...internationally recognized." Access to industry certifications that transfer to future work in the STEM industry motivated participants to pursue STEM academic and career paths.

Acquisition of badges would not have been possible or had the same impact without the involvement and guidance of mentors. The CSII obtained access to the badging system through their work with IBM mentors who managed the project team students. While the CSII provided the spaces needed for project team activities, mentors played an essential role in acquiring the skills required to earn certification badges. Mentors were essential to their mentees' understanding of the badging system and its applications to STEM-focused work and problem-solving.

In addition to badging certification opportunities, participants described other work-related projects brought to their teams by their mentors that demonstrated their mentors' confidence in their aptitude for the work. Including students in their own workplace projects was a clear indication of their mentors' belief in their mentees' abilities. Andrea described the introduction of a project brought to her team by one of her mentors: "Recently, we've been working on helping his team...fix a chatbot that isn't really working well. He was introducing us to his project that he's working on and asking us for help. ...we helped him sort through everything and organize it." Her mentor approached the team with this opportunity as an option to increase their ability for the work required of STEM industry professionals. The experience encouraged Andrea to explore computer science as a possible career path.

Another instance in which mentors recognized potential and increased the ability of their mentees was in connecting their teams with real-world project work. They helped project teams attract clients who required work connected to the focus area of their project teams. Participants could accept project work from local organizations and businesses while their mentors coached them from conception through delivery.

Dulce shared her involvement in projects her mentor brought to her team. Her mentor coached mentees as they participated in training and began to assume responsibilities. According to the CSII website, students initially learned how to operate camera equipment, interview clients, develop storyboards, and shoot and edit audio and video. Eventually, the project team mentees were asked to complete additional projects for clients who became repeat customers. Dulce described a project as follows: “We've been producing a video. It has been already...three films and we're producing it to...to show people that the city of Langley has a lot of safety.” Mentees recognized that, through work with their mentors, they were developing skill sets that could be directly applied to STEM industry careers.

Provided Guided Practice and Gradual Release

Participants recalled specific moments they were motivated by their mentor’s style of providing guidance through observing and consulting with mentees. They reported that when problems arose or mistakes were made, their mentors began their counsel with questions or advice. Mentors refrained from jumping in to solve problems or taking over projects. Tara shared, “If you ask them for help, they’re always there, but they’re not overbearing, trying to do it for you.” Participants also reported that mentors added to their understanding of problems by explaining the reasons for their mistakes and how to fix them. They reported that their mentors’ approach to their questions or need for feedback led to increased confidence and made them feel more empowered.

Mentees identified how their mentors helped them find and fix mistakes in their work. They reported more positive emotional reactions to mentor guidance in the form of questioning strategies or advice after they had recognized a problem and asked for assistance. Nate described an experience his team had with mentor feedback and guidance:

> When we first presented our idea to him and what we had so far...he was able to ask questions...we didn't really have the answer for yet. That helped us to then develop a better understanding of what exactly we wanted to do and how we wanted to achieve it. ...we definitely have made a lot more progress since he joined.

Creating a supportive work environment helped students develop a comfort level with STEM industry work, which led to an increased desire to pursue STEM careers.

Due to their mentors' patient demeanor, students reported they felt comfortable accepting guidance from them. Interview responses revealed that mentees valued their mentors' show of restraint when working through mistakes and problems with them. In a classroom environment, guided practice was often used by an instructor during the initial stages of learning. In this instance, mentors provided instruction and assistance as students acquired new skills and problem-solving strategies.

Study participants recalled feeling more open to the assistance and support they received from their mentors due to this style of support. Mentors trusted students to arrive at solutions and complete projects with guidance and support when they sensed mentees were open to it. As a result, mentees were able to advocate for themselves when needed. Tara gave an example of an experience with her mentor's use of guided practice and how she encouraged her to be more comfortable advocating for herself when she needed assistance:

> So, if you ask them for help, they're always there, but they're not like overbearing trying to do it for you, which is really encouraging. Cuz a lot of people, when they see you're doing something wrong, they just take it outta your hands and do it themselves. But

when they actually explain why you're doing it wrong and how to do it differently, it makes you feel a lot better.

Participants described how their mentors' positive influence helped them understand how to move forward when encountering obstacles by creating a plan for the next steps.

Mentors encouraged their mentees to begin to engage independently in activities that were more rigorous and required advanced knowledge of STEM applications and concepts. This type of gradual release toward increased responsibility and independence was key to students' ability to explore STEM careers in which they could find success. Instances in which mentors employed gradual release practices allowed students to develop comfort with their roles throughout a project which resulted in student independence as they completed their work. Their independence was eventually achieved through skill acquisition and problem-solving experiences.

Guided practice allowed mentors to acknowledge their mentee's potential while patiently providing support. As a result, mentees began to feel comfortable taking on more responsibility. As mentees progressed, mentors recognized a decreasing need to direct their mentees' work. Students found success and improved their skill levels in this supportive environment. Tara shared the following example of her mentor's assistance and the confidence he demonstrated in her potential: "He was at every meeting helping us out…then as I became more confident and learned more things...[he] let me run everything…which really improved my leadership skills along with my engineering skills."

It was clear the participants not only valued the coaching provided by their mentors in these moments but also their mentors' confidence in their ability to take over leadership roles.

Mentees' willingness to take risks was an important outcome of the trusting relationships which mentors fostered with their mentees as they encouraged them to take increasing responsibility for their project teamwork. Trust was an important part of mentees' acceptance of their mentors' belief that they would eventually take over leadership roles on their project teams. Participants described their hesitation toward accepting increasing responsibility in project team roles.

In response to the question of how mentors encouraged mentees in their work together, Tara provided an example of her mentor's use of gradual release during her project teamwork: "As I became more confident and learned more things, he kind of stepped out...and let me run everything. ...which really improved my leadership skills along with my...engineering skills." This response was indicative of the effect this type of recognition had on a mentee's motivation to consider a STEM career path. As a result of experiences such as these, mentees reported increased confidence in their ability to fulfill increasingly complex roles. They found success in the tasks offered to them by mentors, which increased their desire to explore and pursue STEM career options available to them through various academic pathways.

Built Understanding of Science, Technology, Engineering and Math Careers

Participants described the impact mentors had on their levels of skill work and industry knowledge. They increased their mentees' understanding of STEM careers by connecting them with industry internships and professionals. Mentors also coached their mentees as they participated in STEM-focused competitions involving real-world industry scenarios. In addition, mentors shared their experiences from STEM-focused conferences and inspired students by sharing new information. Participants appreciated the effort their mentors put into educating them about the industry as well.

Mentees often shared conversations they had with their mentors as they worked on project teams together. In those conversations, mentors encouraged their mentees to share their interests and plans for their future by asking questions and offering opinions and advice. Mentors' effort to respond to their mentees' interest in STEM careers was evident as they connected their mentees with meaningful industry experiences. As a result of these exchanges, mentors introduced their mentees to various internships and industry opportunities.

Mentors also advised students on academic and career planning paths. Participants often sought advice from their mentors as they considered various academic avenues. They valued their mentor’s opinion and felt increased confidence in their ability to make informed decisions as a result. Students sought answers to questions about the types of STEM engineering degrees. The students participating in the aeronautics-focused team described the different types of engineering-focused academic paths they discovered from their conversations with mentors. Other participants wanted to know more about choosing computer science programming and cybersecurity-focused careers. Mentors often inspired students by providing specific examples from their work in various STEM fields. One mentor offered a number of scenarios demonstrating the need for increased security in the computer science field.

Mentors shared professional experiences as well as their passion for the industry. At times, participants described these experiences with enthusiasm and expressed their excitement at the possibility of having similar opportunities. Sam offered his thoughts:

> I get to see…what day-to-day life in his job looks like. And he's pretty high up in IBM. Like he's someone who gets to travel to London just over a weekend to talk to some people because why not? ...I guess it gives me sort of a, not really a goal, but...something I could look forward to if I get to his position.

Shared and Modeled Professional Practices Utilized by Industry Professionals

Mentors influenced their mentees' desire to pursue STEM careers by building on their understanding of the STEM professions connected to their project team focus. STEM industry professional practices such as the use of design process methods, methods of organization, and the application of skills and content knowledge were shared and modeled by mentors often in project teams. In response to a question about the tools his mentors had shared with him, Nate described his mentor's guidance while building and applying a knowledge base to the application of new forms of hardware and software. Nate described an example of this type of guidance: "He introduces us to a lot of the hardware [and] software that...is widely applicable ...also the general ideas behind how these systems work. ...helping to build a foundation of knowledge for each of us where previously we might have not known very much." They reported that mentor interactions and discussions with their mentees added to mentees' skill levels as well.

According to their mentees, mentors shared the STEM industry tools, strategies, and practices often required of STEM professionals in their industry work. Interview responses and webpage student testimonials made it clear that mentors played a crucial role in their mentee's growth and understanding of their project team's STEM focus. Industry examples and scenarios shared by mentors in project teamwork often added context to problem-solving routines participants might be required to utilize in their work in the STEM industry. Participants recalled developing a deeper understanding of the work they might engage in as STEM professionals. Jason, a member of the cyber security-focused project team, shared this example in our interview: "[Dr. Mickey]...works for the government...[he] can't always talk about everything, but he has given us a lot of...interesting stories about...the differences between other...kinds of [STEM] careers and [a] career in cybersecurity." Jason also shared that his increased understanding of cybersecurity careers led him to begin planning for a career in the STEM industry.

Participants shared design process tools they learned from mentors on their project teams. Mentors modeled ways to identify problems by asking themselves a series of questions. They modeled a thorough investigation of problems, often by methodically reviewing their work. Adi, a member of the cybersecurity-focused team, shared a valuable experience with his mentor at a project team meeting:

> I had difficulty...automating...a Lennox, cybersecurity... I spent a lot of time on it. So, I decided to bring it up at the [project team] meeting. We [my mentor and I] just went through the script line by line, uh, looked through the problems I was having. And I remember walking out of that meeting...learning so much from just that short time we were there. ...we hadn't finished the process obviously, but...I finished it like two days after...I learned so much from that...practice.

It was this approach to problem-solving that mentees recognized as necessary to their understanding of a number of possible solutions to design flaws or mechanical issues as they completed tasks.

According to their mentees, mentors often engaged in problem-solving as needed throughout project work. Tara described her work with her mentors, explaining, "We work closely coming up with ideas, learning how to use tools and how to assemble things and do all of the wiring...and learn engineering process and techniques that involve go along with that." Mentors modeled methods of organization STEM professionals often employed as they planned and implemented specific stages of projects. They coached students in the appropriate procedures for constructing equipment required for project teamwork.

Participants expressed gratitude for their mentor's direction. Veda, a member of the aeronautics-focused team, shared an example of a task he and his peers were preparing for in their project team. Before they attempted to assemble new equipment, his mentor intervened by stressing the importance of thoroughly reviewing and understanding a technical instruction manual. His mentor explained the format, how to interpret diagrams, and some technical language contained in the assembly directions. Veda said:

> It's [reading the instruction manual] the key to a build kit for an airplane. They [mentors] teach me what the parts mean and how to take the image and the words that you see and translate it to actually prepping the part...which is really important to building an airplane.

Veda reported that the advice he received from his mentor prior to beginning their task significantly contributed to their success. He also described his relief at the outcome and recognized the possibility that the task could have hit several roadblocks without direction from his mentor. It was clear his mentor anticipated the need for direction and recognized an opportunity to share a professional practice he utilized in his own work.

Participants recalled instances when mentors offered new information as needed during project work. Mentors could anticipate the need to prepare students as they approached various stages of project work. They paused the team's work and provided instruction when needed. Participants recalled these moments and shared how important this was to their project work. They reported that the additional instruction was necessary for their work and often made it possible to move forward with projects. Andrea described a moment where this strategy was necessary and helpful to the AI-focused project team, saying, "...when we hit that wall, ... confused about...the technical things, ...he addresses them by giving us...a real-world [example], or he'll kinda...review the concepts in another presentation."

Mentors encouraged mentees to take advantage of opportunities offered in the STEM industry by local companies and organizations. They shared information about STEM-focused conferences, internships, and competitions. Many of the opportunities students described were those the mentors brought to the teams based on conversations. Mentors took the initiative to provide mentees with industry connections and those provided through the CSII. They often recognized the need for mentees to be proactive in pursuing their own interests and offered them a starting point in the industry. Mentors provided their mentees with industry contacts in the form of internship opportunities. Veda recalled conversations with his mentor about local engineering internships:

> I've talked to a mentor, and they've actually tried to help me, ...talked to me about internships locally, even...anything engineering related, 'cuz they all have the connections and work with...the CSII and CDC. So, their connections help me and my…future.

Mentors also encouraged connections as a way to help students begin to explore their academic interests, especially when mentees were not sure how to initiate this type of inquiry. Dulce recalled the encouragement her mentor gave her to visit college recruiters at a higher education information night at the CSII. She had expressed interest in the medical field but was shy and unsure of how to proceed. He encouraged her to approach recruiters and ask for information about available programs.

Dulce shared her mentor's help during her interview as she described a conversation they had:

> At first, I was like, ...I'll just figure something out, and he's like, no, we have to look for something because you're not just gonna be thrown on the outside world. ...so, he's pretty much preparing me...to search for the answer and trying to, to look for...for advice or try to look for places that are gonna help me.

She had been struggling to seek more information from colleges and reported an increased level of confidence from this experience.

Participants valued their mentors' willingness to relate their experiences from industry conferences and share relevant information. They also related the enthusiasm mentors demonstrated as they recalled those experiences. A mentor involved in a cybersecurity-focused project team often brought back information she acquired at conferences to her team. Adi recounted how his mentor, Ms. Sharon, shared her conference experiences:

> Ms. Sharon usually talks about various conferences that she's...been involved with...recently she was at an NCWT conference, ...as well as a cyber conference, before that. She always likes to share what she learned in those conferences and how they might be relevant to the tasks that we're focusing on or just general things to be aware of.

Ms. Sharon shared this information in project team discussions with her mentees and provided sources and names of authors and experts in the field.

In addition to connecting mentees to specific industry workplace opportunities, mentors also encouraged students to participate in STEM academic competitions. These competitions simulated specific problems mentees might encounter in a STEM career and often asked students to apply strategies and skills developed in their work in project teams. STEM cybersecurity competitions not only allowed CSII mentees to compete on their own teams but also to educate and train younger students to compete on middle school teams. Competitions offered the opportunity for students to solve problems involving real-world scenarios developed by industry professionals specifically for competitions. Mentors acted as team coaches by preparing teams for competitions, scheduling and planning for team participation, and organizing involvement with younger students in the district.

Mentors facilitated student involvement in computer programming competitions. These competitions provided students with opportunities to apply their skills to real-world problems and prepare for careers in the industry. Adi also described his experiences with Ms. Sharon in cybersecurity competitions that allowed him to practice answering potential interview questions he might encounter when applying for a position:

> [Our mentor] takes us on...competitions across the state for us to compete. They're always really interesting because...they prepare you for the workforce because the problems in those competitions that you have to solve, they are very similar to interview questions, technical interview questions that aspiring software engineers or data scientists are asked.

Participants were motivated and appreciative of mentors who connected them directly with their workplace. Often these projects were brought to them organically through the work they completed with their mentors on project teams.

Mentors provided an important show of confidence when they introduced projects and industry certification programs to mentees. They often brought opportunities to mentees from their workplaces or connections in the industry. Andrea described a project her mentor brought to her project team: “Recently, ...we've been working on helping his [mentor’s] [work] team kind of like fixing a chatbot that isn't really working well. And so...he also shows us how their team approaches, like being able to fix the problem." Mentees were somewhat pleasantly surprised, although apprehensive, when their mentors approached them with these opportunities. They reported an increase in confidence as they performed industry work in their roles on project teams.

Participants described a few of the projects brought to them by mentors. The audio/visual team created informative videos for local clients with their mentors' guidance. Also, the team working with IBM was able to take advantage of certification systems used by employees of the company to obtain endorsements in STEM applications.

Advised on Academic and Career Planning

Mentors often advised mentees on academic and career planning. They offered their opinions about STEM career paths and shared what they knew about the academic requirements needed to obtain various positions in the STEM industry. They also engaged in productive conversations about the future by sharing detailed information about career options in various STEM fields.

Each participant reported they actively sought the advice of their mentors about academic considerations and decisions. One mentor shared her academic experiences and advice with her students at a project team meeting. Adi shared that "Ms. Sharon...was taking a few graduate level cybersecurity courses at university. [She] provided a lot of reflection and explanation of you know, how those classes were run, what she was learning in those classes." Participants reported that mentors described their own experiences often and described this type of sharing as helpful to their understanding of STEM academic opportunities.

Participants seemed to be encouraged by their mentors' personal stories and the factors that led them to follow their own paths. Dr. Mickey shared his experiences working for government agencies that led to consulting jobs. Ms. Sharon and Ms. Ralph transitioned from industry jobs to teaching positions. Some of the mentors described their careers as pilots or engineers. Veda offered background information about some of the aeronautics mentors' roles in the STEM industry:

> We have multiple mentors that are...certified pilots and...fly for fun. So, they...tell us cool stories about...places they've traveled and flown to. So, we get to see pictures...where he landed his plane and...cool stuff like that. Also, we have mentors who are teachers, and they just tell us about...their way of getting there cuz not all our mentors are pilots.

Mentors recognized opportunities during project work to educate their mentees about different types of academic paths and majors they might pursue and how they applied to the work they were doing.

Participants described how the increased understanding of possible areas of study helped them to focus their interests and research certain academic paths in more detail. They often discovered they did not have all the information they needed to understand how certain academic paths connected to their interests. For example, mentors offered descriptions of various types of engineering disciplines and how they differed. Tara described how her mentors helped her choose an engineering academic focus based on her interests in the following:

> I decided mechanical engineering over something else because I wanted to...specifically do...all of the different parts of engineering and talking to my mentors, most of them were mechanical engineers and that gave them...a really broad perspective on all of engineering. So that's how I decided on mechanical.

Participants valued their mentor's input concerning STEM careers. Veda shared his appreciation for his mentor's input and availability. He said, "They're good to have just as people to talk to for the future, for connections and...building relationships for going into college and then eventually the workforce." Mentors also supported participants' educational pursuits by writing letters of recommendation. Tara appreciated the help her mentors gave her as she made plans to pursue a career in engineering. She said, "They've written letters of recommendation and...given me advice on school and college and job interviews and...what kind of engineering I want to do. So that's really been helpful." Mentees also described moments their mentors challenged their choices and beliefs about STEM careers.

Mentors questioned participants when discussing interests and career options. They encouraged students to do their research and strive to gain more of an understanding of certain disciplines. Justin shared the following example of this type of guidance:

> I was looking at aerospace engineering, but then [my] mentors have started to lead me away from that. ...they lead you to the right path, I guess...aerospace engineering is...a great field...but it's not...applicable to too many things like optical engineering [is].
>
> It's...in the phones, it's in the, it's in the airplanes as well. So [they've] guided me.

Mentors honored their mentee's resolve by assisting them in pursuing their passions as well. At one point, Dulce's mentor challenged her career plans during a conversation about her strengths and talent for the audio/visual production industry. In the end, she decided to continue her path and as a show of support, he offered his guidance in her search for information about medical school. She said:

> At first, he [said] "Are you sure you want to be a doctor?" ...that's what I wanted to be since I was a kid. ...he made me think about it...because with some of the projects that we did, he's like, "You're really good at business. ...you're really good at talking to people. And you're really good at ... the planning of the events. So, are you sure you want

> to be a doctor?" ...I [said], "Yes!" and [he said], "Okay, then we're gonna go for the doctor." ...He helped me. ... "If you want to be a doctor, let's look for places that you...can go to. ...We had a job fair here, and he said, "Okay, go talk to [university] health."

She shared that she felt this type of discussion with her mentor actually helped her to feel more confident about her decision.

Shared Professional Experiences and Passion for the Industry

Participants shared examples of their mentor's work ethic and longevity in their field. Their mentors shared the jobs they had had over the years and how they came to be involved in their current positions. In fact, one mentor, Dr, Mickey, was well into retirement and working as an industry consultant when he agreed to mentor CSII students. They told their mentees about projects they worked on that were important to their professional growth. They also shared how the industry had changed over time.

Participants shared stories from mentors about times they sacrificed their time to complete a project or meet a deadline. For example, mentors shared that they worked through weekends for a project when needed. Mentors who worked as computer science programmers described projects that required their constant attention through completion due to deadlines and company expectations. Mentors also shared stories of the physical labor and often tedious work required of them. Many of their projects required additional work, which was often uncomfortable and physically demanding.

Students on the aeronautics-focused team heard many stories from their mentors about the physical demands involved in airplane builds. Their mentors shared honest descriptions of the challenges their careers presented at times. There was an appreciation among participants for their mentor’s openness and honesty about the pros and cons of industry work. Andrea expressed her appreciation as follows:

> It's definitely really helpful to see, you know, ...the other parts of his job that you probably wouldn't get just from...a job description. I think...it's definitely given me a very real sense about what a career in the STEM field is like. ...He didn't sugarcoat anything. I think that's helped my understanding. If I do wanna go into this field, you know, maybe I will have to put in some hours over the weekend. And I think it's very, very realistic which is really helpful.

Participants recalled opportunities mentors shared that they had taken advantage of in their field of work. They enjoyed stories mentors shared from their time in the industry. Many of those opportunities involved travel to interesting places around the world. Mentees were inspired by mentors who shared stories of visits to other countries and described interesting project work. Their mentors sometimes shared pictures of destinations they traveled to. Andrea gave examples of her mentor’s experiences as he traveled for work: “He'll...show us pictures...he...visited something in Britain or London that had to do with IBM, and he shows us...pictures of cool things. ...how what he's doing is...actually in the real world.” It was evident throughout the interviews that these stories motivated mentees to look forward to working in the STEM industry and the opportunity to travel it might provide.

Participants described mentors who were not only dedicated but passionate about their work. Mentors modeled enthusiasm by participating alongside students in project builds involving robotics and aeronautics. Mentors shared stories of experiences they had had as government consultants or as members of teams tasked with important cybersecurity projects. They described work they completed for agencies such as NASA or companies such as IBM.

All of these experiences motivated students to explore STEM career possibilities. Participants admired their mentors and expressed the desire to follow in their footsteps. Participants responded to interview questions with hopes of finding the type of career that would allow them to follow their passion. Justin described his mentor's influence and how it encouraged him. He said, "They love being an engineer and...obviously coming in here and showing that appreciation, I guess, and wanting to do more than they're actually already doing...it makes me wanna, you know, have that same thing." The passion mentors modeled in their work together increased participants' desire to experience the same. For the mentees, this was all the more reason to pursue a STEM career upon graduating high school.

Participants appreciated their mentor's willingness to share their time with mentees. One student stated he appreciated that his mentors volunteered to spend their time at the CSII with students. Justin shared his appreciation for his mentors: "They [mentors] don't have to be here, but it shows that they want to do more engineering, which I think is pretty cool. You know, I want a job that I love." Justin clearly made the connection between his mentor's willingness to volunteer at the CSII and his passion for his job. Mentors were showing students how much they enjoyed their industry work and were genuinely motivated by their interests to engage in STEM-focused activities outside of work.

Conclusion

This chapter provided a detailed summary of findings that evolved into two main themes as well as a discussion of contextual factors relevant to this case study. Mentoring contexts facilitated an enhanced understanding of the activities in which the mentors and mentees engaged. In addition, a description of the CSII facility added to an understanding of the STEM project team environment. Project teams provided the context of the opportunities for the STEM-focused work of mentors and their apprentices.

This study was designed to capture and analyze the perspectives of mentees as they interacted with their mentors. As mentees worked with mentors, they formed important impressions and opinions about the benefits of mentoring. Participants provided insight into the world of mentoring as they knew it and how their experiences had encouraged them to pursue a STEM career after high school. I was inspired by the stories they told and the appreciation they shared for their mentors. All the participants expressed their admiration for their mentors and their passion for their industry. They clearly held their mentors in high esteem and appreciated the effect of mentors on their work. As participants told their stories and shared examples, it appeared they often considered the negative impact the absence of mentors would have had on their STEM education and career choices.

Participants valued their mentor's advice and shared their perspectives about the importance of including mentors in their project teams. Each example and shared experience in some way led to their desire to follow in their mentor's footsteps. The self-confidence they developed as a result of their work with mentors was key to their willingness to continue to improve and engage in their project work. Participants recognized the value of the insight they developed into STEM industry professions. Mentors provided important context for their mentees as they shared the pros and cons of their careers, the level of expertise STEM professions require, and the patience and skill required to design and prototype.

There was also a sense that mentors trusted their mentees to value all the facets of STEM professions, good and bad, and continue to follow their passion. As mentors modeled their passion for their STEM professions, participants observed true dedication to their profession, thus benefitting from their mentors' example. A clear result of the inspiration participants felt as they interacted with their mentors was the pursuit of similar experiences in their own career aspirations. Participants' work with industry mentors in project teams appeared to greatly influence decisions about their future and encourage them to pursue careers in the STEM industry.

CHAPTER V

DISCUSSIONS AND CONCLUSIONS

As a result of STEM mentoring, students develop a deeper understanding of STEM disciplines such as engineering and computer sciences, as well as the STEM industry careers available to them (Alper, 2017; Kastrenakes, 2016; Kupersmidt et al., 2018; Stelter et al., 2020). Prior research has uncovered effective mentor program activities as well as specific STEM education experiences. However, more research is needed to understand mentor influence and practices that inspire mentees' career choice. In order to explore mentor influence, this case study was designed to examine the perspective of a single stakeholder in the mentoring relationship: the mentee. The following research question was created to guide the study:

Q1 What STEM mentor practices, behaviors, and roles do students identify as increasing their interest in pursuing STEM careers?

The findings presented in chapter four supported the use of industry mentors in STEM education programs to add to the STEM industry workforce. The school district and the industry partners employed mentoring as a solution to the decline in individuals pursuing STEM careers (Kupersmidt et al., 2018; Radcliffe & Bos, 2013).

This qualitative case study was grounded in an epistemology of constructionism which in this bounded case, a STEM mentoring program, relied on the interpretation of the phenomenon, the STEM mentoring relationship (Crotty, 2015). STEM mentoring relationships were investigated through the perspectives of STEM mentees participating in a school district's STEM education program.

I interviewed 10 mentees in the 11th and 12th grades about their mentor relationships. Mentees were asked to reflect on the mentor practices and roles that encouraged them to pursue a STEM career. As a result of this study, I gained a deeper understanding of mentor practices and their contexts. Through the analysis of the interview responses, a shared mentee experience emerged, and common themes were found among the responses. As a result of the study design, responses and artifacts were collected, and a research journal was created throughout the process. I used the journal to document my observations and impressions, while exploring any biases I discovered as I reviewed information collected in the study. Through analysis of the data, I developed the subthemes from which two major themes emerged. The themes representing the scope of mentee perspectives were Built Self Confidence in Mentees and Built an Understanding of STEM Careers in Students. Each theme was represented by subthemes detailing the specific practices used by mentors as they built relationships with their mentees. In chapter four, an analysis of the results of the study was presented through a discussion of mentee perspectives and the practices they identified that influenced their career choices.

This chapter connects this study's findings with prior STEM mentoring research. The implications of the findings are explored as they relate to STEM mentors, mentor program administrators and industry partners. The limitations of the study will be discussed along with suggestions for future research. Recommendations for mentors and program administrators are presented as they pertain to mentor practices.

Interpretation of Findings

The themes of this study are supported by the findings in existing mentor-focused research. This section will explore the influence mentors have on career choice and connect the study findings to prior research supporting the use of mentors to promote industry professions.

According to the literature review, mentoring promotes interest in industry careers by connecting young people with industry professionals (Alper, 2017; Kupersmidt et al., 2018).

Study participants' responses reinforced the research supported mentor practices of guiding STEM instruction and skill practice, recognizing achievements, raising expectations for student participation, and encouraging risk taking (Alper, 2017; Kupersmidt et al., 2018; Miller, 2002; Rhodes, 2004). In this study, industry mentors increased participants' comfort levels with industry focused activities by periodically providing instruction. As Tara practiced skills and accepted increasingly challenging roles suggested by her mentors, she received guidance and support.

Kupersmidt et al. (2018) reinforced the use of mentors to engage their mentees in STEM-focused activities, while monitoring their progress. As the cybersecurity team developed scripts in preparation for a competition, Adi sought assistance from his mentor. He recalled a meeting in which his mentor guided the team in a trouble shooting session. His mentor's guidance allowed him to finish the script in a matter of days. Participants also shared that their mentors acknowledged their progress by initiating celebrations as mentees acquired new skills and successfully navigated project team responsibilities. Veda shared another example of mentor support. He appreciated that his mentors initiated a celebration of the completion of an airplane wing.

Another finding supported by prior research revealed that mentors challenged mentees to raise their personal standards as they engaged in design and problem-solving methods (Alper, 2017; Kupersmidt et al., 2018; Miller, 2002). Participants said that mentors pushed them to take risks. Mentors encouraged Dulce and Andrea to accept increasingly challenging project team roles similar to those they might encounter in the workplace. Alper (2017) promotes the use of mentor relationships to increase mentees' capacity for careers by providing guidance and continuing support.

Mentees also gained confidence as they participated in STEM-focused projects with the guidance their mentors provided at various stages of their work. Mentors in this study were purposeful in their assistance, and careful not to intervene. Their mentees appreciated the opportunities this practice provided to them as they isolated problems and developed solutions. Mentors guided study participants through failures and encouraged them to persevere while problem solving as well. They pushed mentees to continue working through the design process by emphasizing the need to make improvements even as they anticipated some level of failure.

Prior research suggests that mentoring benefits include an increase in mentees' employability, motivation to engage in STEM activities and desire to achieve (Alper, 2017; Bruce & Bridgeland, 2014; Freedman, 1993; Halim et al., 2018; Miller, 2002; Rhodes, 2004). In this study, participants reported that their mentors' efforts to introduce and model professional practices, openly share the pros and cons of their professions, and willingness to provide industry certifications and contacts encouraged them to pursue STEM careers. Alongside their mentors, study participants gained work related experience while implementing the school district's adopted design process as they built robots, programmed chatbots, constructed airplane parts, produced videos for public information campaigns, etc.. Dulce led a team responsible for creating informational videos for the town where the CSII was located. She shared that the communication skills she developed interacting with clients will benefit her in a career as a medical doctor.

Through his mentor's guidance, Nate increased his STEM career potential by learning about software and hardware systems used in the computer science industry. The mentors described in this study also aimed to ensure their mentees' employability by offering them opportunities to apprentice for their companies through workplace projects and opportunities. Earning industry certifications and completing deliverables for clients gave students real-world experience. Andrea's mentor included his mentees in a project from his workplace and asked them to work with his colleagues at IBM to trouble shoot an issue with a chatbot. Her experience motivated her to consider a career in computer science.

Other participants described the value of mentor-provided industry badging systems and internships. Mentors also found opportunities to model the organizational and trouble shooting skills they developed as needed in their professions. Tara and Atikish confirmed that their mentors' introduction to professional practices increased their interest in STEM and possible career avenues. Atikish's mentor taught him a programming notation process to use as he wrote programs. Tara's mentor taught her how to isolate and solve design problems while building her robot.

Another example of mentor influence involved Sam's work with his mentor, Ian from IBM. Sam plans to pursue a career in electrical and computer engineering due to the insight he gained from working with an industry professional like Ian. Sam was motivated to ask questions and discuss industry specifics with Ian such as the benefits and drawbacks of his profession. Consistent with the literature, mentee career choices were influenced by their mentors' ability to provide valuable workplace experience while offering and cultivating the expertise required of STEM professionals (Alper, 2017; Kupersmidt et al., 2018).

In this study, the "communities of practice" Lave and Wenger (1991, p. 79) observed within apprenticeships were formed through the STEM-focused project teams. Mentees described how participation in these teams allowed them to build networks that increased their interest in STEM and encouraged their plans to pursue STEM careers. Miller (2002), supported the use of mentors to advise their mentees on academic and career choices. Participants in this study reported that their mentors engaged in discussions confirming or questioning mentee career choices, all while encouraging mentees to raise their expectations by developing loftier career goals. Furthermore, some mentees changed career choices due to their mentors' influence (Miller, 2002). Mentees reported that they often engaged in discussions about various academic and career pursuits with mentors. They shared that mentor advice either reinforced or discouraged them from certain aspirations. Their mentors' advice often renewed their confidence in their choices.

Mentor advice also served to clarify the differences between STEM disciplines in order to help mentees make informed decisions. A few participants reported that their mentor disagreed with their career aspirations which helped mentees reflect on their motivation for certain career paths. Although Dulce's mentor questioned her decision to pursue a medical degree based on his observations of her project teamwork, she continued her pursuit. The findings of this interpretivist case study are supported by the literature included in chapter two. Mentees in this study had much to say about the practices mentors implemented in the context of the relationships that led to research supported benefits.

Implications for Mentor Programs

For the purposes of this study, mentee perceptions were explored and analyzed in the context of STEM education. Those perceptions revealed specific mentor practices employed in mentoring relationships that led mentees to develop an interest in pursuing a career in a STEM profession. The findings offer implications for mentors as well as mentor program administrators and industry partners with the shared goal of producing STEM professionals. As a result of this study, STEM mentors, program administrators and industry partners have access to mentor practices that build mentee interest in STEM professions.

Participants in this case study identified the relationship practices mentors used to build self-confidence. Specifically, participants revealed that their mentors modeled the ability to see difficult problems thru and continue their work despite setbacks. They encouraged mentees to persevere through failures and frustrations by example. Mentors demonstrated their belief in mentees' ability to do the work, even as mentees continued to express doubts. While encouraging their mentees to accept increasingly difficult roles on their teams, they offered mentees new roles and responsibilities when appropriate. They also made efforts to recognize mentee accomplishments and milestones in their project teamwork.

Other practices shared by mentees served to build an understanding of STEM careers among students. Participants reported that mentors built an understanding of STEM careers when they introduced and facilitated students' use of professional practices. Mentees also valued their mentors' academic and career advice. Mentors who purposefully shared their industry connections facilitated students' early introduction to future employers. Mentees in this study actively sought their mentors' counsel concerning academic pathways and a deeper understanding of aspects of certain STEM professions.

Industry Mentors

Employ Mentee Identified Practices

Mentors with the goal of building mentee interest in STEM careers should be compelled to use the mentee identified practices listed above. Entering into a mentoring relationship requires mentors to prepare to form relationships and utilize effective practices. As the STEM industry grows, mentor relationship goals will most likely remain focused on encouraging mentees to enter the workforce needed to sustain the expansion of the industry.

Mentors who aspire to build mentees' self-confidence might want to consider how comfortable they are with failure. Mentor reactions to frustrating circumstances will have positive or negative consequences for their mentees willingness to participate challenging STEM activities. Mentee participation in STEM education builds self-confidence. Mentors may ponder additional ways to build mentee self-confidence such as recognizing mentee potential as well as accomplishments. Also, due to their mentees' need for feedback, mentors might plan to purposefully observe their mentees capacity for industry work in an effort to recognize opportunities for encouragement.

Mentors who seek to encourage mentees might consider the methods listed above that were used to empower mentees as they acquire new skills. Mentor guidance, done well, can foster a mentees' ability to apply new learnings with hands on tasks. Mentors should consider how mentees respond to their attempts at support and guidance. As mentees worked with the mentors in this study, they were more empowered when mentors refrained from intervening directly while still pointing out the need to identify mistakes. Mentors might want to investigate the application of guided practice, a method often employed by classroom teachers, in their interactions with mentees. Guided practice methods empower mentors to remain aware of their mentee's need for independence while occasionally interjecting to reteach or offer additional information and advice.

Mentors who seek to build mentee understanding of the STEM industry may want to ascertain how their industry experience can benefit their mentees. Experienced mentors may want to consider how they can access resources such as industry certification and badging programs, professional conference opportunities, internships and STEM-focused competitions. Their industry contacts should be examined as well, to ascertain important professionals whose expertise might benefit their mentees. New mentors should consider securing resources from their professional network and creating a list of current contacts to ensure they can provide industry access to their mentees.

Industry mentors can also prepare to use mentee identified practices by planning to offer academic and career advice to mentees. Knowledge of academic pathways and career opportunities will allow mentors to add to their mentees understanding of STEM career options. Also, based on participant responses, mentors may want to develop a comfort level with sharing industry experiences to inspire their mentees. Mentors who aspire to build mentees understanding of the industry may want to consider ways they might demonstrate passion for their industry and plan to share the benefits of their profession.

Mentor Program Administrators

Improve Mentee Relationship Outcomes

Focused and organized leadership is key to successful mentoring programs in school systems (Komosa-Hawkins, 2010). Intentional use of mentor relationship practices can improve the program outcomes desired by mentors, mentor program administrators and industry partners. Program administrators can leverage the information provided by participants in their search for potential mentors as well in mentor training modules.

Program administrators impact the success of mentoring relationships through their search for potential mentors. The practices identified in this study could help administrators recognize a mentor's capacity to use those practices that encourage mentees to enter the STEM workplace. By creating recruiting tools to ascertain mentor potential, administrators could seek to evaluate mentors' current or potential use of study identified mentor practices.

Additional consideration should be given to implications for mentor training. Mentor preparation that produces relationship outcomes such as the ones described in this study would benefit all stakeholders. As a result of the study findings, program administrators may recognize opportunities to incorporate effective mentor practices into training sessions. Comprehensive mentor training serves to improve the chances that mentors will successfully apply those the mentor practices identified by study participants.

Science, Technology, Engineering and Mathematics Industry Partners

Supply Industry Professionals and Resources

The ability of STEM mentors to encourage mentees to choose STEM careers has implications for the STEM industry as a whole. Mentors who employ the practices outlined in this study, specifically those that built mentee understanding of industry practices, benefit STEM corporations by educating and increasing their hiring pool and potentially expanding their industry. All 10 study participants revealed their plans to pursue STEM careers as a result of the practices used by their project team mentors.

The increased possibility of accessing a workplace-ready hiring pool due to successful mentoring relationships is a study implication for STEM corporations. Mentor practices that include sharing industry connections and professional resources serve to prepare mentees for STEM careers within the companies that offer these opportunities. Companies who provide STEM professionals as well as industry certifications and badging systems to local mentoring programs similar to those offered at the CSII have been shown in this study to positively impact mentees. Mentees described several industry partnerships they took advantage of due to their mentors' connections. In fact, mentees were given opportunities to earn certifications and engage in skill badging programs as a result of their mentor relationships. Mentees reported that these resources built their understanding of industry professional practices and motivated them to continue their STEM education. Industry partners who supply mentors and give them the ability to facilitate these opportunities with mentees provide the impetus for a mentor's ability to build an understanding of STEM careers in their mentees. The acquisition of STEM certifications and advanced credits in high school provided mentees with early access to STEM career paths. Mentees increase their ability to perform specific industry related tasks through mentorship, and as a result increase their employability and value to STEM corporations.

Limitations and Recommendations for Future Research

This case study was intended to explore STEM program mentees' perspectives in their last two years of secondary education at a public school district. Golden Meadows school district dedicated time, funding, and certified staff to offer students extensive STEM programming. In addition, the district has obtained grant funding to build and outfit its educational spaces with the latest STEM technologies. As a result, the findings are limited to public school students in a specific demographic who benefit from well-funded, specialized STEM programming. Additional studies should seek perspectives from students in school districts with varying characteristics such as available STEM funding, student socioeconomic status, mentor and mentor program longevity, as well as district access to technology industry partners. Along with this list of contextual characteristics, factors that may impact mentor/mentee relationships are race and gender, along with other variables such as behavioral and mental health issues, grade point averages, and school attendance (Kupersmidt et al., 2018).

Conducting additional studies to understand the impact of these factors on their mentees' career choices may offer important information needed to understand how mentors can develop effective relationships under a variety of circumstances. Additional research should investigate relationship practices that encourage mentees with the potential to pursue STEM careers, regardless of the obstacles they might face. There are several research studies supporting mentoring for at-risk and marginalized populations. However, additional research is needed to reveal the successful mentor relationship practices identified by those mentees (Alper, 2017; DuBois et al., 2011; Kupersmidt et al., 2018; Rhodes, 2004;).

Another limitation of the study lies within the scope of the research question. In response to the interview questions, participants shared the practices and behaviors which motivated them to pursue STEM careers. Additional studies could focus on mentees' perspectives concerning improvements needed to meet their needs more efficiently. More information about the effect of mentor behaviors and program components on mentees' career pursuits is needed. Freedman (1993) offered several challenges faced by mentoring programs which may be resolved or eliminated with input from mentees.

Mentor program delivery, frequency, involvement, maintenance, and ongoing support are all program components that affect mentor influence and mentee career choices (Freedman, 1993). An understanding of the effect of these components on mentees could be enhanced by studies focusing on mentees' input about current experiences which relate to each program characteristic. Additional studies exploring mentee experiences on a continuum of mentee outcomes could provide a much broader context to the dynamics of the mentor/mentee relationship and the influence of mentoring experiences (Komosa-Hawkins, 2010). Studies of this nature might reveal the impact of mentor programs as a whole on mentee career choices as a result of their participation.

The STEM project teams included in this case study involved at least three stakeholders—the mentee, the supervising staff managing the project teams, and the participating mentors. The study's research question focused solely on mentee perspectives, excluding additional stakeholders' opinions in the case. Research questions focusing on mentor perspectives may provide important information regarding mentoring experiences as they seek to influence their mentees. Mentoring program factors such as contact frequency, availability of STEM projects, training, and monitoring are program expectations created for effective mentor participation (DuBois et al., 2011). All mentoring activities provide opportunities for mentor reflection and feedback. Komosa-Hawkins (2010) revealed that lack and frequency of mentor training adversely affected mentor-mentee relationships often resulting in limited mentor influence. Mentor perspectives can be sought to investigate the inability of some mentors to encourage mentees to pursue STEM careers. Mentors' perspectives of their experiences could offer a greater understanding of various context and program settings. Perspectives could also identify changes that need to be made to meet the goal of producing STEM industry professionals.

Recommendations for Mentor Program Administrators

The study findings encourage school districts to evaluate their current use of STEM mentors and the mentor practices they employ with their mentees. Providing mentor program administrators with the effective mentor practices found in this study could inspire administrators to complete a program evaluation. In fact, this study was inspired by a project team program evaluation which happened to include industry mentors. The evaluation was completed as a course requirement prior to developing the research question. In addition, the themes and sub-themes included in the findings of this study provide essential information for program administrators to employ in mentor recruitment and training and support.

Recruitment

The perspectives offered by study participants encourage school districts to search for mentors who have the potential to build mentee self-confidence through encouragement and efforts to educate them about their industries. The study findings offer recommendations for mentor recruitment. Program administrators have the opportunity to find mentors who have the potential to use the specific relationship practices identified by the study's participants. Using a survey or questionnaire to gather information from mentor prospects will provide program administrators additional information about their potential. Komosa-Hawkins (2010) recommended certain pre-match activities to ensure the appropriateness of individual mentor participation. The purpose of the survey would be to discover practices a mentor is willing to engage in as well as prior mentor experiences employing the practices described in the findings.

Alper (2017) offered that the discovery of mentor expertise and potential should be central to the recruiting plan of any STEM-based organization seeking mentor participation. Rangel, et al. (2021) described the advantages of this type of assistance, "...a better understanding of the motivations of STEM mentors can help SBM [School Based Mentoring] programs recruit and retain high-quality mentors as well as foster more mutually beneficial mentor/mentee interactions" (p. 354). Research findings that reveal methods of efficiently discovering potentially effective mentors can assist STEM mentoring program recruiters in their search for mentors with the potential to influence students toward STEM career exploration.

Miller (2002) advocated for developing a plan to organize mentor recruitment. Utilizing a survey as part of that plan gathers specific information concerning a potential mentor's aptitude for successfully meeting the goal of facilitating mentee STEM career exploration and pursuit. Districts should develop surveys that measure a mentor's willingness to adhere to the practices described in this study's themes and findings. This information could make the recruiting process more efficient. In addition, it could lead to discovering a few initial unknowns about a mentor's potential to utilize the relationship practices identified in this study.

Discovering a mentor's capacity for using the relationship practices outlined through mentee perspectives leads to a more efficient process of finding mentors who will influence a mentee's career aspirations. "Mentoring relationships are more likely to endure when mentors and mentees are matched along certain dimensions" (Komosa-Hawkins, 2010, pp. 130-131). For example, it is possible that a potential mentor does not value utilizing gradual release and guided practice in their work with students. In addition, perhaps a mentor is not comfortable sharing their work experience and industry connections with their mentees. Therefore, a survey based on the study findings is best utilized in the early stages of the recruitment process. Appendix E provides an example of a mentor recruiting survey organized by the sub-themes identified in the findings.

Another recruiting strategy could employ a mentor job description designed to highlight desired mentor qualities and practices. "When recruiting a mentor, the organization should adhere to the best practice of developing clear expectations, even if there is no pay involved. These expectations include a job description..." (Anastasia et al., 2012, p. 41). A mentor job description employs a more efficient recruiting process by producing appropriate matches. "Developing a job description for your mentors solidifies the characteristics and qualifications you are looking for and gives you a useful tool in your recruitment arsenal" (Garringer, 2006, p. 15). In this case, a job description focused on the practices valued by mentees in this study could provide potential mentors with a detailed outline of mentor relationship expectations. Incorporating the findings of this study in recruitment efforts would demonstrate a mentoring program's commitment to integrating empirical data as they seek to recruit mentors with the potential to positively influence their mentees to pursue careers in the STEM industry.

Training

Mentor training is a program component that may improve as a result of the study findings. Training could be designed to educate mentors on the potential of the practices identified by mentees in this study. Study findings impact a mentor's general understanding by shedding light on practices that have the potential to positively impact their mentees' attitudes toward STEM careers. Mentoring experts recommend that program administrators use best practices, such as designing mentor training around empirical findings (Kupersmidt et al., 2018). Mentors receive specific direction from program administrators about effective relationship practices. Mentor training and support activities based on these findings, could result in positive outcomes for program administrators as well as the STEM industry.

Relationship training based on research will facilitate the focused preparation of mentors (Rhodes & DuBois, 2006). Through an introduction to effective mentor practices, mentors develop a deeper understanding of the purpose of STEM mentoring relationships. Mentor training curriculum could explore the mentee perspectives analyzed in this study. Efforts to train mentors may benefit from mentee input and inclusion while mentor training is designed and implemented (Komosa-Hawkins, 2010).

Training aids mentors in developing a comprehensive understanding of the potential to influence their mentees and the decision-making skills required to effectively employ relationship practices. The findings of this study encourage training methods that incorporate mentee perspectives. Mentor training that focuses on the importance of modeling rather than directing professional practices, design processes and problem-solving methods may benefit mentees. Training could also include program administrator led discussions about the importance of modeling perseverance. Training based on the study findings might provide mentors with opportunities to hear from mentees about the value of maintaining their independence while benefiting from guidance and advice.

Conclusion

STEM mentoring programs are used to educate students about STEM concepts and disciplines. Programs also provide mentor-directed experiential learning opportunities to students that have, provided STEM professionals to an industry facing workforce shortages (Alper, 2017; Kastrenakes, 2016; Kupersmidt et al., 2018; Stelter et al., 2020). This case study investigated the perspectives of mentees concerning their mentors' relationship practices and influence on career choice. Through the discovery of the mentee perspectives, themes identifying mentor influence emerged explaining the relationship practices they connected with their desire to explore STEM career pathways. The knowledge of such effective mentor practices can provide mentors and mentor program administrators with the opportunity to evaluate their current program outcomes and ability to produce STEM professionals as a result of their program structures.

As supported by prior research, the study findings contribute to the improvement of the program components described in the literature review such as mentor recruitment, training, and ongoing support efforts. Suggestions outlining enhancements to these components include ways program organizers can evaluate their current programs while considering the relationship practice findings offered by study participants. Mentees who seek to explore STEM industry professions through mentor relationships stand to benefit from informed mentor practices. Andrea's reflection on her mentoring experience sums up the importance of industry mentor influence on a mentee's understanding of the industry. At the end of her interview, she said:

> It's a really good...experience. I think it's definitely...very helpful to have...someone guide you, especially someone that is in the workforce. ... it's definitely given me a very...real sense about what a career in the STEM field is like.

Integrating research-based practices based on mentee perspectives into new or existing mentor programs can provide mentors with strategies that may build mentee self-confidence and their understanding of STEM careers and thus encouraging them to enter a STEM profession.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
NORTHERN COLORADO
Institutional Review Board

Date:	02/02/2022
Principal Investigator:	Bonnie Palmer
Committee Action:	**IRB EXEMPT DETERMINATION – New Protocol**
Action Date:	02/02/2022
Protocol Number:	2104024587
Protocol Title:	CHARACTERISTICS OF STEM MENTORING RELATIONSHIP PRACTICES IN SECONDARY EDUCATION SETTINGS: A CASE STUDY
Expiration Date:	

The University of Northern Colorado Institutional Review Board has reviewed your protocol and determined your project to be exempt under 45 CFR 46.104(d)(701) for research involving

Category 1 (2018): RESEARCH CONDUCTED IN EDUCATIONAL SETTINGS. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

You may begin conducting your research as outlined in your protocol. Your study does not require further review from the IRB, unless changes need to be made to your approved protocol.

As the Principal Investigator (PI), you are still responsible for contacting the UNC IRB office if and when:

- You wish to deviate from the described protocol and would like to formally submit a modification request. Prior IRB approval must be obtained before any changes can be implemented (except to eliminate an immediate hazard to research participants).
- You make changes to the research personnel working on this study (add or drop research staff on this protocol).

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

- At the end of the study or before you leave The University of Northern Colorado and are no longer a student or employee, to request your protocol be closed. *You cannot continue to reference UNC on any documents (including the informed consent form) or conduct the study under the auspices of UNC if you are no longer a student/employee of this university.
- You have received or have been made aware of any complaints, problems, or adverse events that are related or possibly related to participation in the research.

If you have any questions, please contact the Research Compliance Manager, Nicole Morse, at 970-351-1910 or via e-mail at nicole.morse@unco.edu. Additional information concerning the requirements for the protection of human subjects may be found at the Office of Human Research Protection website - http://hhs.gov/ohrp/ and https://www.unco.edu/research/research-integrity-and-compliance/institutional-review-board/.

Sincerely,

Nicole Morse

Nicole Morse
Research Compliance Manager

University of Northern Colorado: FWA00000784

APPENDIX B

ASSENT FORM

ASSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Characteristics of STEM Mentoring Relationship Practices in Secondary Education Settings
Researcher: Bonnie Jeanne Palmer
Research Advisor: Dr. Linda Vogel

Purpose and Description: The primary purpose of this study is to investigate the mentor practices, behaviors, and roles youth identify as increasing their interest in pursuing STEM career paths. The researcher would like to interview youths and observe mentee/mentor interactions within a STEM mentoring program serving secondary education age youth. The researcher will observe the mentoring program setting as well as meet with youth participants only at a place and time convenient for them for the interview, and the interviews will last approximately one-half hour. The interview questions will be open-ended and will require the participants to reflect on the practices, behaviors, and roles youth identify as increasing their interest in pursuing STEM careers. The interview questions will be the same for every participant, but I may ask you follow-up questions or ask for clarifying information when needed throughout the interview. You will be allowed to take as much time as you need to think about your responses before answering.
At the end of the study, I will be happy to share the final report with you at your request, and you will have the opportunity to read your transcript for accuracy. The researcher will take every precaution to ensure the protection of your confidentiality as a participant. You will be assigned a pseudonym, and only the research advisor and the researcher will have access to the actual name connected to the pseudonym. Only pseudonyms will be used in transcripts and any reports resulting from this study. Any reference to your school, district, or other individuals will also be changed to pseudonyms in the transcript or any reports of the study's findings. Files associated with this study will be stored on the researcher's personal computer in a password-locked folder. Consent forms will remain on file at the University of Colorado in a research advisor's locked file cabinet in a locked office for three years following the conclusion of the study, as per human participant research regulations.

The risks associated with participating in this study are minimal and not outside common conversations about STEM mentoring effectiveness. You will be asked to reflect on the qualities and behaviors your mentor has demonstrated that encourage your desire to pursue a STEM career path.

The opportunity to provide your opinions and perceptions about mentor qualities within the mentor environment will be one benefit of participation. In addition, the information you provide may be used to improve STEM mentor training practices and programs and therefore STEM mentoring experiences for future youth. Also, the information you will be asked to provide will only reflect the positive practices of your mentor and other positive aspects of the mentoring relationship you share.

There are no costs to you other than the time you choose to commit to the interviews. The researcher will make every effort to schedule the interview at a time most convenient to you. There will be no other compensation for your time.

Participation is voluntary. You may decide not to participate in this study and if you begin participation, you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, UNC Research Compliance Manager, 970-351-1910 nicole.morse@unco.edu.

____

Participant’s Signature Date

____

Researcher’s Signature Date

APPENDIX C

CONSENT FORM

UNIVERSITY OF NORTHERN COLORADO
CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Characteristics of STEM Mentoring Relationship Practices in Secondary Education Settings
Researcher: Bonnie Jeanne Palmer
Research Advisor: Dr. Linda Vogel

Purpose and Description: The primary purpose of this study is to investigate the mentor practices, behaviors and roles youth identify as increasing their interest in pursuing STEM career paths. The researcher would like to interview and observe mentee/mentor interactions within a STEM mentoring program serving secondary education age youth. The researcher will observe the mentoring program setting as well as meet with youth participants only at a place and time convenient for them for the interview, and the interviews will last approximately one-half hour. The interview questions will be open-ended and will require the participants to reflect on the practices, behaviors and roles youth identify as increasing their interest in pursuing STEM careers. The interview questions will be the same for every participant, but we may ask follow-up questions or ask for clarifying information when needed throughout the interview. Your child will be allowed to take as much time as needed to think about responses before answering. Following the interview and mentoring observation, your child will be asked to complete a questionnaire about mentor practices, behaviors and roles that youth identify as increasing and encouraging their interest in pursuing STEM careers.

If you grant permission and if your child indicates to us a willingness to participate, we will speak with your child and ask him/her approximately 15-20 open ended questions about his/her experience with school. The interview questions will be the same for every participant, but I may ask follow-up questions or ask for clarification when needed throughout the interview. Your child will be allowed to take as much time as needed to think about his/her responses before answering.

The risks associated with participating in this study are minimal and not outside common conversations about STEM mentoring effectiveness. Your child will be asked to reflect on the qualities and behaviors your child's mentor has demonstrated that encourage your child's desire to pursue a STEM career path.

The researchers will take every precaution to ensure the protection of your child's confidentiality as a participant. Your child will be assigned a pseudonym, and only the research advisors and the researchers will have access to the actual name connected to the pseudonym. Only pseudonyms will be used in transcripts and any reports resulting from this study. Any reference to your school, district, or other individuals will also be changed to pseudonyms in the transcript or any reports of the study's findings. Files associated with this study will be stored on the researchers' personal computers in a password-locked folder. Consent forms will remain on file at the University of Colorado in a research advisor's locked file cabinet in a locked office for three years following the conclusion of the study, as per human participant research regulations. The names of subjects will not appear in any professional report of this research. We foresee no risks to participants beyond those that are normally encountered talking about school. There are no costs to you other than the time you choose to commit to the interviews. The researchers will make every effort to schedule the interview at a time most convenient to you. There will be no other compensation for your time.

The opportunity for your child to provide their opinions and perceptions about mentor qualities within the mentor environment will be one benefit of participation. In addition, the information provided may be used to improve STEM mentor training practices and programs and therefore STEM mentoring experiences for future youth. Also, the information provided will only reflect the positive practices of your child's mentor and other positive aspects of the mentoring relationship.

A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Nicole Morse, UNC Research Compliance Manager, 970-351-1910 nicole.morse@unco.edu.
Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research.

There are no costs to you other than the time you choose to commit to the interviews. The researcher will make every effort to schedule the interview at a time most convenient to you. There will be no other compensation for your time.

Participation is voluntary. You may decide not to participate in this study and if you begin participation, you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research.

Page 2 of 3 ________ please initial, continue to third page.

... if you have any questions or concerns about this research. Please retain a copy of this letter for your records.

Thank you for assisting us with my research.

Child's Full Name (please print)	Child's Date of Birth
Parent/Guardian Signature	Date
Researcher's Signature	Date

APPENDIX D

INTERVIEW PROTOCOL

Project Title:
Time of Interview:
Date:
Place:
Interviewer:
Interviewee:
Position of Interviewee:

The researcher will introduce herself to the participant and describe the nature of the study.

Script: *"This study was developed to address the research question, 'What STEM mentor practices, behaviors and roles do students identify as increasing their interest in pursuing STEM careers? The researcher will be youth who are participating in a STEM mentoring program at the secondary education level. As a researcher, I will take every precaution to ensure the protection of your right to confidentiality as a participant. You will be assigned a pseudonym, and only the research advisors and the researcher will have access to the actual name connected to the pseudonym. Files associated with this study will be stored on the researchers' personal computers in a password-locked folder. Consent forms will remain on file at the University of Northern Colorado for three years following the conclusion of the study, as per human participant research regulations. The risks associated with participating in this study are minimal and not outside common conversations about educational experiences. You will be asked to reflect on your experiences with your STEM mentor. The interview could take up to two hours." Review consent documents and ask the interviewee to read and initial and sign the consent form.*

Test the recording device - check the battery life of the device if low, plug-in charger.
Recording - State your name, the name of the school, the time of the interview, the name and position of the interviewee, "Do I have your permission to record this interview?" (yes)

Interview Questions:

1. Please describe the STEM mentoring program you are involved in.
2. How long have you known your mentor and what types of activities do you participate in with your mentor?
3. Please describe a positive experience you have had with your mentor in this program.
4. What does your mentor say about his or her job or past experiences in the STEM industry?
5. What tools has your mentor introduced you to that might be important to your understanding of careers in the STEM industry?
6. How does your mentor encourage you to pursue a STEM career?
7. What career path do you think you want to pursue? Why?
8. What does your mentor do to encourage a career path in a STEM career?
9. How does your mentor encourage you in the work you do together?

APPENDIX E

MENTOR RECRUITING QUESTIONAIRE

Mentor Recruiting Questionnaire

As you work with mentees, you will be asked to engage in relationship practices that encourage your mentee to explore STEM professions. Please provide your comfort level with the following:

Please indicate your comfort level with the following practices:

Modeling and encouraging perseverance as you engage in project design and deliverables with your mentees.

1 2 3 4 5 6 7 8 9 10

Recognizing your mentees' aptitude and potential by articulating successful outcomes as well as areas for improvement throughout project work.

1 2 3 4 5 6 7 8 9 10

Providing guided practice to mentees as they acquire new skills and engage in trial and error to increase their capacity to participate in project work.

1 2 3 4 5 6 7 8 9 10

Engaging in gradual release over the life of project as mentees become more proficient and demonstrate readiness for certain project work roles and responsibilities.

1 2 3 4 5 6 7 8 9 10

Sharing and modeling professional practices you utilized in your work in the STEM industry.

1 2 3 4 5 6 7 8 9 10

Advising mentees as they plan academic and career paths for STEM industry professions

1 2 3 4 5 6 7 8 9 10

Sharing professional experiences and passion for the STEM industry.

1 2 3 4 5 6 7 8 9 10

Please list any prior mentoring experiences, include the context within which they occurred and add any examples that connect with the above mentoring practices.