Developing Engineering Career Pathway Perceptions for Students Interacting with Near-Peer Mentors in an Informal Learning Environment

Deidre Horne Mangin

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DEVELOPING ENGINEERING CAREER PATHWAY PERCEPTIONS FOR STUDENTS
INTERACTING WITH NEAR-PEER MENTORS IN AN INFORMAL LEARNING ENVIRONMENT

Deidre Horne Mangin

A Dissertation Submitted in Partial Fulfillment of the
Requirements for IDT 8230
Doctor of Education

Major: Instruction and Curriculum Leadership

The University of Memphis
May 2024
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Dedication/ Acknowledgement

This research is dedicated to future engineers who will break barriers and innovate a better future for all people. I appreciate the participating school community, which allowed me to implement all I have learned in my studies.

I want to thank my family, especially my incredible husband, who supported me through this doctoral journey. I am grateful every day for their patience and unconditional love.

Three years ago, I was fortunate to become part of a cohort of extraordinary peers. They provided support and encouragement that helped me persevere and grow in my skills. Finally, I want to close with my deepest gratitude to my dissertation committee, Dr. Amanda Rockinson-Szapkiw, Dr. Stephanie Ivey, Dr. Craig Shepherd, and Dr. Andrew Tawfik, who guided and encouraged me along the way.
Abstract

Given the worldwide shortfall of engineers that threatens innovation and global stewardship, educators and industry must find ways to engage and prepare the next generation of engineers. To attract and train candidates to fill global needs, researchers need to expand engineering career pathway perceptions for students of all ages. Engineering education programming, whether formal or informal, not only encourages students to hone soft skills such as design thinking, communication, emotional intelligence, and evaluation but also promotes traditional technical skills. Fostering engineering self-efficacy and thus promoting engineering career pathways is an emerging area of study that has the potential to mitigate the current deficit of engineers, while simultaneously equipping future generations of problem-solvers for the workforce. Informal learning environments that incorporate authentic inquiry experiences with role models, near-peer mentors, and engineering-related connections have positively impacted engineering identity development in students of all ages. As such, the purpose of this study was to explore the impact of an informal engineering program with near-peer mentors on the mentees’ perceptions of engineering career pathways, as well as to investigate this informal engineering program’s influence on self-efficacy in elementary students. Findings indicate that the use of near-peer mentors positively impacted intervention participants in measurable outcomes as measured by the STEM Future Career Interest Survey. Near-peer mentors supported students as consultants, advisors, and helping hands.

Keywords: engineering career pathways, self-efficacy, informal education, role models, near-peer mentors, engineering education, inquiry experiences
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**List of Abbreviations**

Black, Indigenous, or Other People of Color (BIPOC)

International Technology and Engineering Educators Association (ITEEA)

National Academies of Sciences, Engineering, and Medicine (NASEM)

National Science Foundation (NSF)

National Science Teachers Association (NSTA)

Next Generation Science Standards (NGSS)

Science and Engineering (S&E)

Science, Technology, Engineering, and Mathematics (STEM)

Social Cognitive Career Theory (SCCT)

STEM Career Interest Survey (STEM-CIS)

STEM Future-Career Interest Survey (STEM Future-CIS)
CHAPTER ONE: INTRODUCTION

The science, technology, engineering, and mathematics (STEM) labor force accounts for almost one-quarter of the workers in the U.S. (National Science Board, National Science Foundation, 2022). However, in 2022, the National Science Foundation (NSF) reported concerns regarding the science and engineering (S&E) workforce pathways. The number of individuals entering the S&E sector of the United States (U.S.) is not keeping pace with industry growth and needs (NSF, 2022). Maintaining and increasing the STEM workforce pathway is imperative for the U.S. to retain its global standing in research, development, and national security (NFS, 2022).

Engineers are vital to the economy; as such, they are in great demand (Graddick, 2023). This need for engineers is expected to continue to rise even though educational institutes are not producing enough qualified engineers to fill new positions and replace engineers leaving the workforce (Browne, 2023; Graddick, 2023; Mannan, 2021; Society for Women Engineers, 2023). Engineering jobs are often unfilled for months before qualified personnel can be located and hired (Browne, 2023; Mannan, 2021). According to the U.S. Bureau of Labor Statistics, the field is expected to experience a deficit of six million engineers by 2024 (Graddick, 2023; Roman, 2021; Society for Women Engineers, 2023). The projected shortfall of engineers impacts the worldwide economy and the quality of life (Rodriguez et al., 2017; Roman, 2021).

Engineering, represented by the letter $E$ in STEM, impacts the daily lives of every individual. From clean water and air to efficient transportation and communication, engineers solve problems in all industries (National Society of Professional Engineers, 2023). Engineers possess a unique skill set that extends beyond mathematics and science content to design thinking, collaboration, leadership, and problem-solving (Times Higher Education, 2022).
Moreover, trained engineers are valued beyond their own industry as they are also needed in academia, government agencies, business, finance, and security (Roman, 2021; Times Higher Education, 2022).

The NSF (2022) recommends “building, broadening, and diversifying S&E capacity” (Conclusion section, para. 2) to meet future workforce challenges. In this building effort, recruitment must target students of all ages and demographic groups, especially women and traditionally underrepresented racial and ethnic groups (i.e., black, indigenous, or other people of color [BIPOC]) who have been historically alienated in engineering education and the workplace (Graham et al., 2022; NSF, 2022; Orrell & Cox, 2020; Xue & Larson, 2015). When introducing the White House’s, *You Belong in STEM* campaign, Cindy Marten, the U.S. Deputy Secretary of Education, stated that all students “belong in STEM and that they deserve to have rigorous and relevant educational experiences that inspire and empower them to reach their full potential as productive, contributing members of our nation’s workforce” (U.S. Department of Education, 2022, para. 2).

Recruitment of all students, particularly those from underrepresented groups, is thwarted by systemic barriers that must be recognized and addressed by educational institutions and industry (Orrell & Cox, 2020; Xue & Larson, 2015). Examples of engineering career pathway barriers include a lack of educational opportunities, the “White Male” stereotypes, societal norms, social class, and non-supportive environments (Cohen et al., 2020; Henderson et al., 2021; Xue & Larson, 2015). While the reasons that underrepresented populations (including women) do not develop an interest, pursue, and persist in engineering education and careers are complex, the literature consistently has identified a lack of engineering career interest, negative recognition, and an absence of self-efficacy as primary reasons (Carlone & Johnson, 2007). The
promotion of engineering career pathway perceptions through the development of engineering career interests, expectations, and self-efficacy begins with exposure to career opportunities, role models, and mentors at strategic career developmental milestones. Gottfredson (1981) findings pointed to the formation of gender perceptions about appropriate careers that develop in early elementary grades, first through third grades, and the establishment of social class perceptions about suitable careers that develop in later elementary and middle grades, fourth through eighth grades as such milestones. This exposure during the formative years is essential for students to develop interests, positive expectations, and a healthy self-efficacy in engineering careers that could ultimately lead them to pursue and persist in engineering education and career pathways (Falco, 2016; Paul et al., 2020).

Even though students of all ages benefit from exposure to engineering career options, elementary students are often overlooked in research (Falco & Summers, 2017; Hazari et al., 2022; Paul et al., 2020). While this trend needs to change in order to mitigate barriers to career pathways during formative years, presently this lack of focus on elementary exposure is evident in the scarcity of STEM intervention research for children and adolescents. In systemic reviews, researchers have estimated that fewer than 20% of STEM education studies have focused on elementary-age student development (Simpson & Bouhafa, 2020; Wagner, 2023).

Although early exposure to STEM education has a lasting impact on career choice, many elementary students receive few opportunities for engagement (Anand & Dogan, 2021). A dearth of research exists in engineering education, both formal and informal, at the elementary level. The negligible number of existing research has shown that elementary students in the first through fifth grades profit from engineering education to maintain career interests and to prevent stereotypical misconceptions about engineering (Yoon et al., 2014). Engineering education has
also been found to support the mastery of STEM content in science and math for students in the elementary grades (Yoon et al., 2014). Additionally, Ling and Hamzaid (2019) found that engineering education allows students to utilize higher order thinking and to develop soft skills such as creativity, collaboration, and teamwork.

Engineering interventions that intentionally address the sources of self-efficacy have the potential to enhance career pathway perceptions through interest development in girls and other underrepresented populations in STEM (Aguirre-Munoz et al., 2021; Falco & Summers, 2017). Introduced by Bandura (1977), self-efficacy theory, found that student adaptability, perseverance, and achievement emanate from four sources: performance accomplishment, vicarious experiences, social persuasion, and physiological states (Bandura, 1997; Falco, 2016). STEM and engineering intervention research in the performance accomplishments sources of self-efficacy, such as the opportunity to perform related tasks and experience success, has further indicated that repeated opportunities for students to see themselves succeed in real-world tasks are highly influential in promoting engineering career pathways (Kinkopf & Dack, 2023). The second source of Bandura’s theory of self-efficacy, vicarious experiences, can be seen as interactions with role models who resemble the students in some way; these impactful sources of self-efficacy allow students to visualize their place of belonging in the workforce (Falco, 2016). Granted, social persuasion and physiological states are valuable sources of self-efficacy; however, research has found that they do not exert the same influence as performance accomplishment and vicarious experiences when developing an interest in engineering career pathways for early adolescents (Britner & Pajares, 2006; Kinkopf & Dack, 2023).

Therefore, this study is designed to examine the influence of mentors, specifically near-peer mentors (i.e., vicarious experience), during a STEM club intervention experience (i.e.,
performance accomplishment), on elementary (2nd through 5th grades) students’ perceptions of engineering pathways: engineering career interests, expectations, and self-efficacy. Near-peer mentors are defined as students who resemble their mentees in age, position, and experience (National Academies of Science, Engineering, and Medicine, 2019). It is hypothesized that because near-peer mentors and mentees have a common identity, near-peer mentors may provide emotional support through shared connections (Al-Thani et al., 2023). Interaction with near-peer mentors may also provide students with vicarious sources of self-efficacy through guidance, feedback, and personal rapport (Tenenbaum et al., 2014).

The Social Cognitive Career Theory (SCCT) framework provides the lens to examine the sample population's perceptions of engineering career pathways as defined by the constructs of SCCT, particularly self-efficacy, outcome expectations, interests, personal goals, personal inputs, and contextual supports (Lent et al., 2016). Lent, Brown, and Hackett (1994) purported that inputs, contextual affordances, and sociocognitive variables affect the formation of career interests, goals, and actions. Thus, the SCCT framework functions as a model for predicting interest and actions surrounding educational and career pathways (Kier et al., 2013). In addition to its central constructs, SCCT modeling considers the variables of social context, environment, specific skill sets (i.e., computer skills, mechanical knowledge, leadership, or organizational skills), personal goals, contextual factors, and cognitive abilities (Lent et al., 2006). SCCT provides an integrated perspective of self-efficacy and has been found to be an effective predictor of career pathways, career success, and career identity in several studies that investigate the impact of educational programs (Luo et al., 2021; Paul et al., 2020). For these reasons, numerous researchers have used SCCT as a lens to examine the impacts of and on STEM career pathways over the last two decades (Lent & Brown, 2013).
**Problem of Practice Statement**

With a projected shortfall of six million engineers, local, national, and international projects will face dramatic challenges (Mannan, 2021). As a result, engineering fields must attract and maintain workers to support the U.S. economy and quality of life (Browne, 2023; National Society of Professional Engineers, 2023; Society of Women Engineers, 2023). This recruitment to engineering career pathways must be fostered in elementary school as career interest, expectations, and self-efficacy begin to form as early as kindergarten (Capobianco et al., 2012; Gottfredson, 1981; McLean et al., 2020). Unfortunately, most programs developed to attract students to the field target middle-school, high-school, and college-aged students (Capobianco et al., 2012; Gottfredson, 1981; Pantoya et al., 2015; Paul et al., 2020).

Although research has indicated that engineering career interests have already formed by the time students enter high school and college (Cohen et al., 2021; Global Strategy Group, 2023), studies have also highlighted that engineering-related experiences in later years, high school and college, positively impact the persistence and success of students who already have an interest in engineering (Hughes et al., 2019; Skrentny & Lewis, 2022; Zaniewski & Reinholz, 2016). Additionally, interventions designed for students in middle grades, sixth through eighth, have been found to impact the career interests, expectations, and self-efficacy of participants (Henderson et al., 2021). The ego ideals of adolescents in this age group are still pliable, and career preferences are moderately open to the influence of vicarious experiences in the form of role models and mentors, as well as performance accomplishments that are rooted in real-world engineering design (Falco, 2016; Gottfredson, 1981).

Many engineering interventions take place in the context of an informal learning experience. These informal experiences include workshops, internships, field trips, and clubs.
centered around acquiring knowledge and skills (Morelock, 2017). Building an engineering network of personal experiences enhances informal learning environments; these experiences include vicarious interactions with professional networks, role models, peers, mentors, and near-peer mentors (Capobianco et al., 2012; Henderson et al., 2021; Morelock, 2017; Trujillo et al., 2015). Moreover, research has demonstrated that performance accomplishments in real-world situations and authentic problems enhance engineering career interest, expectations, and self-efficacy development (Maiorca et al., 2021; Morelock, 2017; Turner et al., 2016; Vanderbilt University Collaborative for STEM Education and Outreach, 2023; Yoon et al., 2014).

Therefore, exposure to quality, informal STEM programs in the elementary grades, specifically in programs designed to promote engineering career pathway perceptions through the development of engineering career interest, expectations, and self-efficacy in second through fifth-grade students has the potential to assist younger students in developing engineering career interest and self-efficacy (Capobianco et al., 2012, Pantoya et al., 2015). Providing elementary students with constructive performance accomplishment and vicarious experience relationships supports their desire to pursue engineering career pathways. Based on previous research focused on high-school and middle-school students, it is conjectured that both informal learning opportunities, defined as any opportunity to gain knowledge and skills outside of classrooms, as well as formal training, allow elementary students to apply engineering skills during design-based inquiry activities in a low-risk environment (Henderson et al., 2021; Kekelis et al., 2014; Martinez & Whiting, 2021). Elementary students’ exposure to role models and near-peer mentors in informal environments supports the development of engineering-related connections that further promote engineering career interests, expectations, and self-efficacy (Henderson et al., 2021; Koenig & Hanson, 2008; Manuel et al., 2018; Trujillo et al., 2016). Mentoring may avail
elementary students of psychosocial support and skill development to encourage further pursuit of an engineering career pathway (Zaniewski & Reinholz, 2016). Thus, this research will examine the impact of near-peer mentors in an informal learning setting (e.g. an after-school STEM club) for second through fifth-grade students.

Purpose Statement

This quasi-experimental, pretest-posttest non-equivalent control group study aims to examine what influence, if any, a near-peer mentor intervention during a STEM Club has on the perceptions about the engineering career pathways of elementary students in grades two through five at a suburban parochial school controlling for the previous engineering career pathway perceptions. Perceptions about engineering career pathways, both the dependent variable (i.e., posttest) and covariate (i.e., pretest), are defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports (Kier et al., 2013; Playton et al., 2023). Engineering career pathways are operationally defined and will be measured by a pretest and posttest using the STEM Career Interest Survey (STEM-CIS) (Kier et al., 2013) and the STEM Future Career Interest Survey (STEM Future-CIS) (Playton et al., 2023) instruments.

The independent variable is interaction with a near-peer mentor in the STEM Club. In the study context, STEM Club is defined as an extra-curricular activity taking place in an informal learning environment. Extracurricular activities are structured and take place outside of the school day. Informal learning environments are places of engagement where students acquire knowledge and skills in a non-coursework related time or space (e.g. maker spaces, libraries, museums, and extracurricular programming). The STEM Club met weekly for four weeks for ninety-minute sessions. During this time, the students engaged in the engineering design process
with real-world inquiry experiences featuring problem-based learning activities and were introduced to professional engineer role models of diverse backgrounds. The STEM Club meeting design of inquiry experiences, problem-based engineering design challenges rooted in real-world experiences, and the inclusion of role models were inspired by the self-efficacy, outcome expectations, and personal goals of SCCT (Brickhouse, 2001; Capobianco et al., 2012; Carlone & Johnson, 2007; Maiorca et al., 2021). By pairing low-risk, high-engagement opportunities to explore types of engineering with exposure to diverse role models, students were given repeated opportunities to identify with engineers and to develop an affinity for engineering as they determined their own capabilities (Hazari et al., 2022; Morelock, 2017).

The covariate dependent variable of perceptions about engineering career pathways, defined by the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports, was measured prior to and after participation in the program using the STEM Future-CIS (Playton et al., 2023) (see Appendix A for STEM Future-CIS questions). The STEM Future-CIS, designed for second through fourth graders, measures the impact of interventions designed to encourage awareness and interest in STEM careers as measured by the SCCT constructs of self-efficacy, personal goals, outcome expectations, interest, contextual supports, and personal input (Playton et al., 2023). Focusing on career pathways encourages practitioners to consider the knowledge and skills needed to support the S&E workforce (National Science and Technology Council, 2021). Individuals are more likely to be interested in activities with high-expectation outcomes, which are ones in which they see themselves assimilating socially, academically, and professionally (Brown & Lent, 2019; Dziak, 2020). Early interventions stimulate students’ thoughts about future plans, which lays the
groundwork for course planning and college mapping that may lead to the highest level of success in career pathway pursuits (Blanchard et al., 2023).

The comparison group in this study participated in the STEM club without near-peer mentors. The control group did not participate in the STEM Club; instead, these students learned only from the school's standard STEM curriculum. All participants engaged in the same standard STEM curriculum at the school during the school day. The treatment group had near-peer mentors who provided vicarious learning experiences during the STEM Club. Near-peer mentors, students in eighth grade, worked with the treatment group to guide and encourage the students in the second through fifth grades. Students in the comparison group participated in identical activities and were exposed to the same role models, but they did not have near-peer mentors in their groups. Table 1 identifies the groups and the STEM engagements of each group.
Table 1

Group Design

<table>
<thead>
<tr>
<th></th>
<th>STEM Curriculum</th>
<th>STEM Club</th>
<th>Near-peer mentor in STEM Club</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(Group A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison Group</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(Group B)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Control Group</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Group C)</td>
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</table>

Note: The sample population received up to three interventions based on the self-selected groups of the study.

Moreover, an ex-post facto, causal-comparative study examined the possible influence of near-peer mentors on the engineering career pathway perceptions of students who identify as girls and BIPOC groups, traditionally underrepresented in engineering careers. The independent variables in this portion of the study are gender and racial/ethnic identities, as they cannot be manipulated. The dependent variable is engineering career pathway perceptions of the gender and racial/ethnic groups in the test population of students who participated in the STEM club. The comparison of outcomes for girls and boys is essential to this study as research has demonstrated that girls and boys respond differently to the learning environment, which leads to differing impacts of educational interventions (Cohen et al., 2020; Gottfredson, 1981). Likewise, research has found that peer groups heavily influence students who identify BIPOC and help to build a stronger sense of belonging through interpersonal relationships (Graham et al., 2022).

Theoretical Framework

Social cognitive career theory (SCCT) guided this study and was introduced by Lent, Brown, and Hackett in 1994 as a framework for understanding the conditions that encourage and
limit individual career development choices (Lent et al., 1994). Lent, Brown, and Hackett (1994), building on Bandura’s work in self-efficacy (1977) and social cognitive theory (1989), identified a diverse set of social-cognitive mechanisms that influence individual decision-making. SCCT focused on the interplay of variables that construct an individual’s interest, choice, and performance in educational and career endeavors (Brown & Lent, 2019; Lent, 2005; Lent et al., 1994, 2006; Lent & Brown, 2013; Lent & Brown, 2019). SCCT has provided a psychological and social lens to explore self-efficacy, personal goals, outcome expectations, and other variables that impact career choice (Brown & Lent, 2019; Lent, 2005; Lent et al., 1994, 2006; Lent & Brown, 2013; Lent & Brown, 2019).

Self-efficacy refers to individuals’ confidence and belief that they have the capacity to drive their own performance through motivation, behavior, and reaction to their environment (Lent et al., 1994). This personal agency addresses people’s individual confidence in their ability to perform in a manner that allows them to achieve a specific goal. Self-efficacy grows from performance accomplishments, vicarious experiences, social persuasions, and physiological states and can influence the amount of effort and persistence an individual will invest in activities (Bandura, 1977; Lent et al., 1994). Self-efficacy is the central variable in SCCT and determines the choice of activities and interests in academic, social, and workplace environments (Brown & Lent, 2019; Lent, 2005; Lent et al., 1994, 2006; Lent & Brown, 2013).

SCCT also explored the interplay of self-efficacy with other variables, including outcome expectations, personal goals, cognitive abilities, specific skill sets, social context, environment, and interest development (Dziak, 2020; Brown & Lent, 2019). These internal and external factors impact individuals independently and in concert to provide models for understanding and predicting the decisions and development of individuals in both academic and career
contexts (Lent, 2005; Lent et al., 1994; Brown & Lent, 2019; Lent & Brown, 2019). By exploring self-efficacy, interest, and choice, SCCT can provide insight into the variables impacting the development of engineering career interest, expectations, and self-efficacy in elementary students (Brown & Lent, 2019; Capobianco et al., 2012; Kier et al., 2013; Lent et al., 1994; Lent & Brown, 2019; Pantoya et al., 2015).
Table 2

SCCT Constructs and Definitions Aligned with Intervention Sources in the Study

<table>
<thead>
<tr>
<th>SCCT construct</th>
<th>Definition</th>
<th>Intervention sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy</td>
<td>Self-efficacy is an individual’s belief in their capacity to perform and produce desired results (Bandura, 1977).</td>
<td>Groups A, B, &amp; C: Engaged in hands-on, real-world engineering activities (PA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group A: Engagement with near-peer mentors (VE, SP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups A &amp; B: Engagement with diverse role models (VE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups A &amp; B: Participation in a low-risk environment with self-selection opportunities (PS)</td>
</tr>
<tr>
<td>Outcome expectation</td>
<td>Outcome expectations address the individual’s expected consequences. (Lent et al., 1994).</td>
<td>Groups A, B, &amp; C: Real-world problem-solving activities (PS)</td>
</tr>
</tbody>
</table>
### Table 2 continued

**SCCT Constructs and Definitions Aligned with Intervention Sources in the Study**

<table>
<thead>
<tr>
<th>SCCT construct</th>
<th>Definition</th>
<th>Intervention sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest</strong></td>
<td>This construct defines an individual's desire or curiosity to learn about a subject (Paul et al., 2020).</td>
<td>Groups A, B, &amp; C: Engagement with engineering activities (PA) Groups A &amp; B: Interaction with role models and career exposure materials (VE)</td>
</tr>
<tr>
<td><strong>Personal goals</strong></td>
<td>Personal goals define an individual’s intention to participate in activities and to invest the effort to achieve a particular level of performance. (Roller et al., 2020).</td>
<td>Groups A, B, &amp; C: Exposure to engineering careers (SP) Groups A, B, &amp; C: Engagement in challenging activities (PA)</td>
</tr>
<tr>
<td><strong>Personal input</strong></td>
<td>A person’s tendency to identify in a particular way based on gender, background, abilities, disabilities, and age (Lent, 2005; Tomperi et al., 2022).</td>
<td>Group A: Opportunities to seek support from near-peer mentor (PS) Groups A, B, &amp; C: Engagement in high-interest activities (PS)</td>
</tr>
</tbody>
</table>
### Table 2 continued

**SCCT Constructs and Definitions Aligned with Intervention Sources in the Study**

<table>
<thead>
<tr>
<th>SCCT construct</th>
<th>Definition</th>
<th>Intervention sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contextual support</td>
<td>Proximal influences that impact experiences such as exposure to role models or family involvement. Encouragement and discouragement by influential persons also fall into this category (Lent et al., 2000).</td>
<td>Group A: Engagement with near-peer mentors (VE, SP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups A &amp; B: Engagement with diverse role models (VE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups A &amp; B: Exposure to intentional positive messages from facilitators (SP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups A &amp; B: Participation is self-selected and encouraged by parents (SP)</td>
</tr>
</tbody>
</table>

**Note:** The following abbreviations have been used to help identify the sources of self-efficacy as they relate to the interventions of the study: performance accomplishments (PA), vicarious experiences (VE), social persuasions (SP), and physiological states (PS) (Bandura, 1977). The study included three student groups: Group A, STEM Club participants who received the treatment and work with near-peer mentors; Group B, STEM Club participants without near-peer mentorship (i.e., comparison group); and Group C, students who do not participate in STEM Club (i.e., control group).

**Questions**

The research questions for this study are as follows:
**Research Question 1.** To what extent, if any, does suburban parochial students’ participation in a near-peer mentor experience during STEM Club influence second-fifth grade students’ perceptions about their engineering career pathways, defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports, controlling for the previous engineering career pathway perceptions with pre-intervention scale surveys, as measured by the STEM Future-CIS instrument?

**Research Question 2.** While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of girls and boys after engagement with near-peer mentors during STEM Club?

**Research Question 3.** While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of students who identify as BIPOC and those who identify as white after engagement with near-peer mentors during STEM Club?

**Null Hypotheses**

The null hypotheses for this study are as follows:

Null Hypothesis 1: A near-peer mentor experience during STEM Club will have no impact on suburban parochial students’ perceptions of their engineering career pathway, defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports.

Null Hypothesis 2: There will be no statistically significant difference between the engineering career pathway perceptions of girls and boys after engagement with near-peer mentors during STEM Club.
Null Hypothesis 3: There will be no statistically significant difference between the engineering career pathway perceptions of students who identify as BIPOC and those who identify as white after engagement with near-peer mentors during STEM Club.

Definitions

**Contextual Inputs.** Proximal influences that impact experiences such as exposure to role models or family involvement. Encouragement and discouragement by influential people also fall into this category (Lent et al., 2000).

**Design Thinking.** A human-centered process of innovation and creative problem-solving that guides users through the phases of empathy define, ideate, prototype, and test (Anand & Dogan, 2021; ITEEA, 2018). (See Appendix B for the Design Thinking Framework).

**Engineering Design Process.** An iterative process, sometimes called design thinking, which involves identifying a problem, brainstorming possible solutions, creating models and prototypes, and evaluating, iterating, or refining the solution. (ITEEA, 2020; McLean et al., 2020).

**Extra-curricular Activity.** Structured out-of-school activities such as clubs (Main et al., 2022; Ozis et al., 2018).

**Informal Learning Environment.** Engagement opportunities that occur outside of school, in which students acquire knowledge and skills in a less structured environment (Henderson et al., 2021). Informal learning is often interest-driven and non-coursework-related (Johri et al., 2016). Informal learning environments include maker spaces, libraries, museums, and extracurricular programming (Ozis et al., 2018).

**Inquiry Experiences.** Inquiry experiences engage students in scientific and engineering activities that simulate real-world workplace experiences (Ghattas & Carver, 2017). Often
inquiry-based activities follow a model of engagement, exploration, explanation, elaboration, and evaluation (Manuel et al., 2018). Inquiry experiences require active, cooperative, hands-on, and collaborative learning (Brown et al., 2020).

**Interest.** This construct is defined as an individual's desire or curiosity to learn about a subject (Paul et al., 2020).

**Mentor.** A person designated to support and advise someone with less experience in a field or institution. A mentor does not need to identify with a mentee in the areas of gender, ethnicity, age, or background (Wu et al., 2021).

**Near-Peer Mentor.** A mentor relationship in which the near-peer mentor is close to the social, professional, or age level of the person being mentored (Frances et al., 2022). Near-peer relationships provide mentees with a coach who is approachable academically and socially (Zaniewski & Reinholz, 2016).

**Outcome Expectations.** Outcome expectations address the individual’s expected consequences. (Lent et al., 1994).

**Performance Accomplishments.** Challenging educational experiences in which students perform tasks and experience success (Brown et al., 2016).

**Personal Goals.** Personal goals are defined as an individual’s intention to participate in activities and to invest the effort to achieve a particular level of performance (Lent et al., 1994).

**Personal Inputs.** A person’s tendency to identify in a particular way based on gender, background, abilities, disabilities, and age (Lent, 2005; Tomperi et al., 2022).

**Physiological States.** The emotional and physical state of the participants. These states can be positive, energetic, optimistic, and engaged. They can also be stressed, fatigued, anxious, and negative (Yusoff et al., 2019).
**Problem-Based Learning.** Constructivist learning activities that tackle societal problems which can be solved with the engineering design process (National Science and Technology Council, 2018; Robinson-Hill, 2022).

**Project-Based Learning.** A cooperative learning technique employing student collaboration in an interdisciplinary project (Beier et al., 2019; United States Department of Education, 2019).

**Role Model.** A person who has achieved an academic or social goal similar to another person who is aspiring to achieve the same aim. Similarities are typically gender, race, or ethnicity, but similarities may extend to background, socioeconomic factors, and interests (Henderson et al., 2021).

**Self-Efficacy.** Self-efficacy is an individual’s belief in his/her capacity to perform and produce desired results (Bandura, 1977).

**Social Cognitive Career Theory.** Social cognitive career theory (SCCT) is a rich theoretical framework that considers the variables of self-efficacy, interest, and outcome expectation in reference to individual decision-making and the dynamics of career choice (Lent et al., 1994).

**Social Persuasion.** Messages of affirmation or discouragement from influential persons (Bandura, 1977).

**Vicarious Experiences.** Interactions with role models and mentors, as well as professional networking opportunities (Kinkopf & Dack, 2023).
CHAPTER TWO: REVIEW OF THE LITERATURE

According to Mettler (2023), Albert Einstein once remarked, “Scientists investigate that which already is; engineers create that which has never been.” Engineers touch every facet of life, from cellphones to cellophane wrap, from hydroelectric dams to clean water (American Society of Mechanical Engineers, 2023). The word *engineer* is rooted in the Latin word for ingenuity and has been used to describe the craft since the Roman era, when engineers built aqueducts and the Colosseum (Smith, 2022). Like the engineers of old, today’s engineers are finding solutions to problems that impact individuals, communities, and nations of the world (National Society of Professional Engineers, 2023).

Engineers are in great demand in the current economy, and the demand is only expected to rise in the future (Graddick, 2023). Most engineering jobs remain unfilled for months because there are not enough engineers to meet the need for local, national, and international investments (Browne, 2023; Mannan, 2021). In addition to new positions, fields, and technologies, existing positions are also left unfilled because the population of STEM graduates is outstripped by those leaving the workforce (Society for Women Engineers, 2023). The projected shortfall of engineers impacts the worldwide economy and quality of life for all people (Rodriguez et al., 2017; Roman, 2021). In public understanding of engineering report, the National Academy of Engineering (2008) iterated the value of engineering when it stated: No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas
Engineering not only positively impacts communities, but the career also significantly impacts those who pursue the field. As previously noted, engineering talent is highly sought (Graddick, 2023; Weber, 2011). Thus, individuals in this field receive many positive benefits. Engineers are well compensated, with a median annual wage over $90,000 (US Bureau of Labor Statistics, 2018). Engineering education provides workers with a unique skill set encompassing science and math content, as well as problem-solving, design thinking, collaboration, and leadership (Times Higher Education, 2022). Unlike other professions, trained engineers are welcomed in many non-engineering industries, such as academia, government agencies, business, and finance (Roman, 2021; Times Higher Education, 2022).

With the benefits that engineering education provides personally and communally, the question is, what can be done to develop engineering career pathways for students? The answer may lie in programs designed to build engineering self-efficacy through early elementary student engagement with near-peer mentors during real-world engineering projects.

**Engineering Career Pathway Perceptions**

Internal and external factors influence perceptions of engineering career pathways, creating an impression in students as early as kindergarten (National Academy of Engineers, 2018). External factors, such as exposure to the diversity of engineering careers convey to students the idea that engineering is for everyone (National Academy of Engineers, 2008). Personal interactions, support systems, and networking opportunities play an external role in students' perception of engineering career pathways (Lunn et al., 2022). Internal factors such as self-efficacy, outcome expectations, and socialization profoundly impact students at
developmental milestones as they journey from adolescence to the workforce (National Academy of Engineers, 2018).

**Avenues to Engineering Career Pathway Perceptions**

The field of engineering encompasses electronics to materials and everything in between. The array of engineering opportunities available to today’s workers, as well as future workers, is limitless (National Academy of Engineers, 2018). It has been estimated that most job titles projected for 2030 do not exist today (Institute for the Future, 2019); therefore, it is incumbent on educators to expose and prepare students for an assortment of pathways in and out of the classroom (National Academy of Engineers, 2018). Experiencing engineering careers through workplace visits, college visits, field trips, and opportunities to perform authentic engineering activities illuminates diverse opportunities for students (Kuchnya et al., 2022).

While active engagement in engineering provides students with an avenue to explore their talents, strengths, and interests (Johri et al., 2016), leadership, entrepreneurial, and problem-solving skills developed from authentic engineering activities prepare students for the workplace of 2030 (National Academy of Engineers, 2018). Participation in engineering activities leads to higher self-confidence in students, which may establish engineering careers as viable options for developing adolescents (National Academy of Engineers, 2018).

**Barriers to Engineering Career Pathway Perceptions**

Despite differing definitions, researchers agree that students will not pursue a field of study in which they personally feel as though they do not belong, or they feel that they are not perceived by others as belonging members (Capobianco et al., 2009; Godwin, 2016; Henderson et al., 2021; Rodriguez et al., 2018). Cultural influences, stereotypes, discrimination, social group, and socio-economic status are merely a few of the barriers that students must overcome in
order to follow engineering career pathways (Brown & Lent, 2019; Falco & Summers, 2017; Henderson et al., 2021). Although barriers affect each student individually, collective research can predict how groups of students will respond to barriers such as cultural stereotypes (Falco & Summers, 2017). Women often experience barriers to engineering career pathways in the form of cultural stereotypes about their academic ability (or lack thereof) in math and science (Deemer et al., 2014; Falco, 2017). Underrepresented populations, especially African Americans and Latinx, rarely see engineers who look like them or have similar backgrounds to theirs (Henderson et al., 2021; Morelock, 2017). These barriers may lead to students to feel as if they will fail and do not belong in engineering endeavors (Henderson et al., 2021).

Social Cognitive Career Theory and Student Perceptions of Engineering Career Pathways

Perceptions of engineering career pathways are best understood in the context of a theoretical framework that can help predict career choice through self-efficacy, interest, and outcome expectations (National Academy of Engineering, 2018). SCCT is one such framework that focuses on individual decision-making and the dynamics of career choice (Lent, 2005; Lent et al., 1994; Lent et al., 2006; Lent & Brown, 2013). Introduced by Lent, Brown, and Hackett (1994), SCCT allows researchers to investigate internal and external factors impacting engineering self-efficacy and interest development (Brown & Lent, 2019; Lent, 2005; Lent et al., 1994; Lent et al., 2006; Lent et al., 2016; Lent & Brown, 2013). SCCT’s foundation is self-efficacy, a concept first introduced by Albert Bandura in the 1970s (Lent & Brown, 2013).

Self-Efficacy

Self-efficacy refers to individuals’ confidence and belief that they have the capacity to drive their own performance through motivation, behavior, and reaction to their environment (Bandura, 1977). It is confidence in one’s own ability to control situations and reach personal
goals (Lent et al., 1994). This perception influences the effort and persistence an individual will expend in pursuing a goal (Lent et al., 1944). Self-efficacy also determines the interests of individuals and the choices they make in activities socially, vocationally, and academically (Brown & Lent, 2019; Lent, 2005; Lent et al., 1994; Lent et al., 2006; Lent & Brown, 2013).

Self-efficacy accumulates from four sources: performance accomplishments, vicarious experiences, social persuasion, and psychological states (Bandura, 1977; Kinkopf & Dack, 2023). Concerning building engineering self-efficacy, opportunities for students to successfully engineer solutions would be described as performance accomplishments (Kinkopf & Dack, 2023). Vicarious engineering experiences result when students are exposed to role models, especially role models who highlight successful engineering achievement among underrepresented populations (Kinkopf & Dack, 2023; Steinke et al., 2022). Self-efficacy emanating from social persuasion falls into the categories of positive feedback and the recognition of others as a result of success in engineering endeavors (Kinkopf & Dack, 2023).

The final source of self-efficacy, psychological states, refers to students’ management of their emotional and physical reactions when engaging in engineering challenges (e.g., persistence or frustration) (Kinkopf & Dack, 2023). Research has indicated that performance accomplishments have the most significant impact on the four ways self-efficacy is developed (Brown et al., 2016; Kinkopf & Dack, 2023; Krishnamurthi et al., 2014). Research also has shown that vicarious experiences are powerful contributors to self-efficacy development in STEM activities (Kinkopf & Dack, 2023; Steinke et al., 2022).

**Performance Accomplishments**

The most influential source of self-efficacy, performance accomplishment, is challenging educational experience in which students perform authentic tasks and experience success (Brown
Engineering-related experiences, which can be classified as performance accomplishments, can be formal or informal educational experiences characterized by the acquisition of knowledge and skills; other experiences include workshops, internships, field trips, etc. (Morelock, 2017).

As the opportunity to perform real-world engineering tasks enables students to persist in realizing a goal individually or in collaboration with others, these performance accomplishments support the development of self-confidence and mitigate self-doubt (Bandura, 1977). Repeated instances of performance success facilitate an increase in self-efficacy, leading to more extensive resilience stores for future challenges (Falco & Summers, 2017).

The interactions with experiences and relationships that impact the formation of engineering identity range in exposure from single, one-off events to long-term experiences (Archer et al., 2021; Patrick & Borrego, 2016). Although favorable results occur from one-off interactions, long-term exposures have the most lasting influence on students (Archer et al., 2021). Repeated exposure to varied methods, such as relevant inquiry experiences, field trips, authentic problems, collaborations, etc., have the most enduring impact on expanding engineering career pathway perceptions (Archer et al., 2017; Maiorca et al., 2021).

**Vicarious Experiences**

As adolescents develop their self-view, networking opportunities with professionals, as well as interactions with role models and mentors provide vicarious experiences for developing self-efficacy (Kinkopf & Dack, 2023). Success in engineering, whether personally experienced or observed in another, bolsters students' belief in their own capacity to problem-solve, design, create, or invent (Kinkopf & Dack, 2023). Introducing students to diverse role models and creating opportunities for interaction with mentors offer students concrete examples of success
through sustained effort (Falco, 2016). Frequent and sustained vicarious interactions build a cache of positive reflections that students can retrieve when barriers to engineering career pathways are encountered (Kinkopf & Dack, 2023). Additionally, research has shown that mentorships have the potential to increase self-efficacy in both the mentee and the mentor (Trujillo et al., 2015).

**Social Persuasion**

Messages of affirmation from influential persons support the development of self-efficacy (Bandura, 1977). Encouragement, feedback, constructive criticism, and interaction provide lasting impacts on student perceptions of themselves and their future careers (Playton et al., 2023). Additionally, positive relationships (including modeling) both in and out of the classroom also provide the benefits of social persuasion in mentoring environments (National Academy of Engineering, 2018; Unlu & Dokme, 2018). Although social persuasion offers affirming sources of self-efficacy, many barriers to its development can also fall into this category (Unlu & Dokme, 2018). Stereotypes, negative feedback, cultural influences, and attention received due to failure are detrimental to student perceptions of engineering career pathways (Graham et al., 2022).

**Physiological States**

Physiological states can be described as the emotional and physical state of the participants. These states can be positive, energetic, optimistic, and engaged. They can also be stressed, fatigued, anxious, and negative (Yusoff et al., 2019). Physiological states play an influential role in the development of self-efficacy since they provide students with a measurement of their level of confidence with an activity (Britner & Pajares, 2006). Educators and influential adults can contribute to the positive effect of physiological states by helping
students learn to manage anxiety and draw on experiences of positive states when faced with adversity (Britner & Pajares, 2006).

**Other Variables of Social Cognitive Career Theory**

Although self-efficacy is a central variable in SCCT, it is only through consideration of additional variables in interrelated models that predictive analysis can best be viewed (Lent et al., 2008). The personal variables of outcome expectation, interest, and personal goals, as well as environmental variables, such personal inputs and contextual support, allow researchers to explore impacts on a career pathway perception (Lent et al., 2000).

**Outcome Expectation**

Outcome expectations address the expected consequences an individual anticipates based on personal efforts (Lent et al., 2016). Individuals who foresee peer approval, substantial reward, quality work conditions, and pride in themselves are more likely to invest effort in activities and behaviors with greater persistence (Lent et al., 1994). This invested effort impacts interest since a student will work harder to achieve a goal that promises an efficacious result, such as happy parents or future career benefits (Kier et al., 2013). As such, outcome expectations are valuable predictors of behavior and influence the goals and efforts of students (Lent, 2005).

**Interest**

Interest development is ever-evolving and is influenced by numerous factors including education, family, community, social interaction, culture, and socioeconomic factors (Brown & Lent, 2019). Interests, a person’s preferences and curiosities, are crucial to career interest development as they provide motivation and desire to pursue activities and learning (Godwin, 2016). Individual interest increases when the outcome expectations are favorable socially, academically, and vocationally (Brown & Lent, 2019; Maiorca et al., 2021). As interest drives
active learning, it also promotes the perceptions of career pathways through frequent engagement in engineering performance accomplishments and vicarious experience interactions with role models (Major & Kim, 2017; Playton et al., 2023).

**Personal Goals**

Personal goals are defined as an individual’s intention to participate in activities and to invest the necessary effort to achieve a particular level of performance (Lent et al., 1994). While goals organize, guide, and sustain actions (Playton et al., 2023), they also impact persistence in the face of setbacks and delayed feedback (Roller et al., 2020). Personal goals tend to be tied to self-perceptions of personal capabilities and can be used to predict student attitudes toward career goals (Lent et al., 2000).

**Personal Input**

Personal inputs are described as a tendency to identify in a particular way based on gender, background, abilities, disabilities, and age (Lent, 2005; Tomperi et al., 2022). They are socially constructed factors that impact feelings of self-efficacy, interest, goals, and actions (Kier et al., 2013; Tomperi et al., 2022). For example, phrases such as, “I would feel comfortable” in a given situation reflect personal inputs (Kier et al., 2013, p. 468). According to Donmez and Idin (2020), both positive and negative environments and interactions influence the personal input associations of students.

**Contextual Support**

Contextual supports are proximal influences that impact experiences, such as exposure to role models or family involvement (Lent et al., 2008). Encouragement and discouragement by influential persons also fall into this category (Lent et al., 2000). Contextual support can
positively impact and facilitate student perceptions of career pathways; likewise, it can impact and stifle student development negatively (Kier et al., 2013).

**Existing Research**

Existing research on educational interventions meant to influence student self-efficacy, interest, and perceptions of engineering career pathways is plentiful and recent (Simpson & Bouhafa, 2020). Many studies have narrowed the scope of research to investigate underrepresented populations such as females, as well as both males and females among Black, Indigenous, and People of Color (BIPOC) (Morelock, 2017; Patrick & Borrego, 2016; Simpson & Bouhafa, 2020). However, the bulk of these studies profile middle grades, high school, and secondary-grade students (Henderson et al., 2021; Playton et al., 2023; Simpson & Bouhafa, 2020; Tenenbaum et al., 2014; van den Hurk et al., 2019). Amidst the research, intervention commonalities that meet both performance accomplishments and vicarious experiences criteria can be found (Henderson et al., 2021; Simpson & Bouhafa, 2020).

**Self-Efficacy and Interest in STEM Careers**

**Instruments to Assess Self-Efficacy and Stem Career Interest**

Several survey instruments targeting self-efficacy and interest have been developed to measure STEM career interest for different age groups. In the area of STEM, early tools such as the STEM Semantic Survey, Career Interest Questionnaire, Student Attitudes Toward STEM, and the STEM Career Questionnaire targeted middle grades and high school students with questions pertaining to attitudes toward the STEM disciplines (Kier et al., 2013; Roller et al., 2020). The Role Identity Survey in STEM (RIS-STEM), which was adapted from an earlier Role Identity Survey in Engineering (RIS-E), is focused on identity, self-efficacy, confidence, and interest indicators specifically for students in grades three and up, although researchers have
noted that the tool would yield quality data through the high school years (Paul et al., 2020). The Student Interest and Choice in STEM (SIC-STEM) Survey 2.0 is a tool designed for middle grades students that integrates the constructs of self-efficacy, outcome expectations, and interest with the attitudes toward STEM disciplines (Roller et al., 2020).

The STEM Career Interest Survey (STEM-CIS) is another instrument focused on middle-grade students. The development of this assessment tool was funded through a NSF grant which funded research in STEM career awareness (Kier et al., 2013). Foundationally, the STEM-CIS measures and predicts student career interest through the constructs of self-efficacy, personal goals, outcome expectations, interest, personal inputs, and contextual supports (Kier et al., 2013). The STEM-CIS is considered psychometrically sound for fifth-grade students and older and can be administered as a whole or as four separate subscales: science, mathematics, technology, and engineering (Kier et al., 2013).

As educational institutions began to focus on STEM intervention in younger elementary school students, the need for an age-appropriate instrument became apparent; as such, the STEM Future Career Interest Survey (STEM Future-CIS) was developed (Playton et al., 2023). The STEM Future-CIS was based on the STEM-CIS and was likewise founded on the constructs of SCCT (Playton et al., 2023). However, the instrument differs from the STEM-CIS in length, scope, and administration as necessitated by the target audience of second through fourth grades (Playton et al., 2023).

**Building Self-Efficacy: Performance Accomplishments and Vicarious Experiences**

A national collaboration dedicated to providing high-quality STEM experiences for students led to the publication of the Next Generation Science Standards (NGSS) in 2013. These standards harness the best practices in STEM education and could potentially result in
constructive experiences for students (NGSS Lead States, 2013; Turner et al., 2016). Developing in-depth content knowledge, conceptual understanding, and practical skills for science and engineering are at the center of NGSS design (NGSS Lead States, 2013). One central content and practice area in the NGSS is engineering, which is essential to workforce development (Bush et al., 2018; Turner et al., 2016). Using the NGSS guidelines drives students to ask questions, develop models, argue from evidence, work within constraints, evaluate the efficacy of solutions, and harness technology to develop solutions in both formal and informal settings (NGSS Lead States, 2013; Turner et al., 2016). The NGSS engineering standards can be found in Appendix D.

Research into the impact of robust performance accomplishments in the form of integrated STEM experiences has shown that real-world connections and authentic problems enhance the engineering experiences of adolescent and pre-adolescent students (Maiorca et al., 2021; Morelock, 2017; Turner et al., 2016; Vanderbilt University Collaborative for STEM Education and Outreach, 2023; Yoon et al., 2014). A group culture of innovation fostered through adult training, but centered on student agency, nurtures constructive experiences and relationships (Vanderbilt University Collaborative for STEM Education and Outreach, 2023). Design thinking and the engineering design process stimulate learning by shifting the student’s focus to a problem that is solved by transdisciplinary knowledge acquisition and skill usage (Bush et al., 2018; Vanderbilt University Collaborative for STEM Education and Outreach, 2023). Other research has shown that vicarious experiences such as in-person exposure to role models as guest speakers, as well as through media in books, videos, and online platforms positively impact STEM and engineering self-efficacy (Hutton, 2019; Lent, 2005; Steinke et al., 2021). Portfolio construction, mentors, and interaction during informal engineering activities also provide constructive engineering identity gains (Morelock, 2017). Recent studies of mentor
interactions with students who are close in age and situation to mentees have led to programs of near-peer mentorship (Frances et al., 2022; Lunn et al., 2022). These relationships have been found to support the development of self-confidence, camaraderie, and a sense of belonging in mentees, which positively influence student interest in and perceptions of engineering career pathways (Frances et al., 2022).

**Vicarious Experiences**

Falco (2016) found that vicarious experiences support the development of self-efficacy and influence perceptions of engineering career pathways by observing and interacting with a role model, be it an adult or near-peer, who has successfully navigated the environment and sustained the necessary effort to achieve acceptance as an engineer. Witnessing attitudes and behaviors that have led to desirable outcomes, vicarious interactions facilitate both awareness and acceptance of a crucial belief: role models or mentors can be emulated. This realization helps to promote successful outcomes through vicarious experiences (Brown et al., 2016; Kinkopf & Dack, 2023). Underrepresented populations are particularly impacted by interactions and enriching experiences in which they see, interact, and emulate a role model (Sun & Clark-Midura, 2022).

**Near-Peer Mentors.** Near-peer mentors are people who resemble mentees in age, status, skills, and interests, provide psychosocial support and guidance to mentees (Al-thani et al., 2023; Clarke-Midura et al., 2018; Kuchynka et al., 2022). Although there are inconsistencies in the application of resemblance in age and status, studies define near-peer mentors as having skill levels that fall between that of the mentee and that of experts (Clarke-Midura et al., 2018, Tenenbaum et al., 2014, Trujillo et al., 2016).
A plethora of studies have highlighted the importance of these near-peer mentors (Al-thani et al., 2023; Clarke-Midura et al., 2018; Kuchynka et al., 2022; Trujillo et al., 2016; Zaniewski & Renholz, 2016). Research has shown these credible role models promote the development of engineering self-efficacy in their mentees through shared experiences, navigation of institutions, and skill development (Clarke-Midura et al., 2018; Trujillo et al., 2016; Zaniewski & Renholz, 2016). While Frances et al. (2021) found that mentors provide mentees with valuable insights into struggles and strategies to overcome obstacles based on the mentors’ recent experiences in a similar environment (), other research showed that mentees benefit from the encouraging, personalized, timely feedback that they receive from mentors (Henderson et al., 2021; Martinez & Whiting, 2021).

Sun and Clarke-Midura's (2022) findings suggested vicarious modeling of solutions by near-peer mentors also serves to provide collaborative situations to mentees offering success and mitigating the effects of previous failures. The relationship between mentees and near-peer mentors provides the protégés with a visible trajectory toward success in engineering and STEM endeavors (Kuchynka et al., 2022). While frequent and repeated interactions with near-peer mentors have been found to positively influence self-efficacy and academic success (National Academies of Science, Engineering, and Medicine, 2019), other studies indicated a positive impact on engineering self-efficacy, not only for the mentee, but also for the near-peer mentor (Clarke-Midura et al., 2018; Trujillo et al., 2016). For example, near-peer mentors have shown increased skill development because of perceived empowerment, practice in articulating knowledge, and skill development in their mentees (Frances et al., 2021; Rockinson-Szapkiw et al., 2020; Tenenbaum et al., 2014).
Role Models. Role models are constructive factors in the development of engineering self-efficacy because they provide students with a concrete opportunity to envision engineering and STEM careers (Henderson et al., 2021). Role models are tangible examples of the perseverance and success necessary to promote engineering career pathways and develop engineering self-efficacy (Steinke et al., 2021). Additionally, exposure to role models mitigates the impact of cultural stereotypes and enhances a sense of belonging in underrepresented groups (Gonzalez-Perez et al., 2020). Personal interactions with role models also allow students to meet people who are passionate about their careers yet also share real-life struggles and successes as inspiration (Robinson-Hill, 2022). According to Crane et al. (2022) live interaction is unnecessary for successful role model exposure; they found that role model interaction can include the study of historical figures and notable engineers. Role models can also be everyday engineers who provide testimony via recorded videos or visits to students to promote interactive experiences (Steinke et al., 2021).

Performance Accomplishments

A best practice in science and engineering education is the use of hands-on, real-world inquiry-based experiences in formal and informal environments (NGSS, 2013). Robust performance accomplishments designed around inquiry lead to meaningful engagements with open-ended, relevant opportunities for students (Bier et al., 2018; Ghattas & Carver, 2017; Martinez & Whiting, 2021). Inquiry experiences focused on design thinking and the engineering design process provide students the opportunity to develop collaboration skills, critical thinking, and communication skills as they navigate authentic solutions to global concerns (Bush et al., 2018; Razzouk & Shute, 2012; Robinson-Hill, 2022; U.S. Department of Education, 2019) (See Appendix B for the Design Thinking Framework). As students act and think like engineers, they
experience performance accomplishments, which facilitates the development of self-efficacy and positive perceptions of the engineering career pathways (Birney & McNamara, 2022).

**Informal Learning.** Learning happens everywhere (Ozis et al., 2018). Informal learning environments and non-traditional learning activities range from clubs and field trips to museum experiences (Hazari et al., 2022). The term *informal* relates to the setting, interaction, activity, or presentation in which knowledge and skills are acquired (Martinez & Whiting, 2021). Informal learning environments are typically low-risk, high-engagement opportunities that allow students to explore interests and determine their own capabilities (Hazari et al., 2022; Morelock, 2017). Research has indicated that students participating in informal STEM activities are more likely to have increased self-assuredness, positively contributing to the psychological state leading to self-efficacy (Kinkopf & Dack, 2023; Ozis et al., 2018). The non-compulsory nature of informal learning encourages underrepresented populations to feel more at ease and in control of their outcomes (Blanchard et al., 2023). After-school clubs change the learning dynamic and encourage joyful participation (Blanchard et al., 2017; Krishnamurthi et al., 2014). Participants in informal learning environments have greater agency to learn at their own pace and interest level (Martinez & Whiting, 2021).

**Extracurricular activities.** Participation in extracurricular activities has been found to foster interest in STEM disciplines due to increased exposure and depth of experience (Johri et al., 2016; Ozis et al., 2018). By definition, extracurricular activities occur outside of the core academic experience and include sports, arts, and clubs; these extracurricular activities are not graded and often feature a level of self-direction (Ozis et al., 2018). Another advantage of extracurricular activities is that they foster a sense of belonging and community as participants share unique experiences and interact meaningfully to develop interpersonal skills (Johri et al.,
Extracurricular activities also provide students access to people, places, and pursuits that influence the development of engineering self-efficacy and interest in engineering career pathways (Main et al., 2016).

**Strengths and Weaknesses of Existing Research**

Several strengths can be found in the existing research as it is both current and plentiful. Much research has investigated a variety of groups, especially underrepresented populations in STEM. The extensive research in the middle grades, high school, and college provides insight into the development of students over time. The variety of interventions used in existing research highlights the impact of different environments, activity types, durations, and interactions, offering educators a plethora of variations to explore.

A weakness in the research exists in the limited number of studies focused on pre-adolescent students, particularly early elementary students, which is most likely due to the long-held belief that career interests emerge in adolescence. Another unexplored area of research is the impact of varying types of role models; in most of the studies, the adults are amassed together instead of being viewed by the role they play as parent, near-peer or older mentor, etc.

**Conclusion**

Based upon existing research, numerous conclusions support this present study’s foundation. Student perceptions of engineering career pathways are impacted by constructive performance accomplishments and vicarious relationship experiences (Kinkopf & Dack, 2023; Morelock, 2017). Career self-efficacy begins to form in pre-adolescents and continues to evolve, impacted by age, circumstance, community, and career (Falco & Summers, 2017). Early exposure to robust, authentic engineering experiences through programs of some duration may encourage career interest development in young people (Archer et al., 2021). Role models,
mentors, near-peer mentors, and parents also impact perceptions of engineering career pathways (Steinke et al., 2021). To mitigate the global shortfall of engineers, formal and informal educators should engage students in constructive programming to encourage the future pursuit of engineering careers (Society of Women Engineers, 2023). Elementary grades are an opportune time to foster career pathway perceptions (Capobianco et al., 2012).

Engineering education encourages students to hone soft and technical skills (Times Higher Education, 2022). The benefits of proficiency in design thinking, communication, emotional intelligence, and evaluation extend far beyond engineering careers (Times Higher Education, 2022). Robust engineering programming affects all disciplines and all areas of the workforce; additionally, high caliber engineering programming prepares future workers to be highly skilled problem-solvers (Times Higher Education, 2022). Clearly, the importance of this research cannot be understated.
CHAPTER THREE: METHODOLOGY

Innovation and quality of life depend upon engineers, yet there is a shortfall of qualified people to meet global needs (Graddick, 2023). To build the engineering sector, young people, especially women and historically underrepresented racial and ethnic populations, must be attracted to engineering education programs (National Science Foundation, 2022). Most current programs designed to attract prospective engineers target middle school, high school, and college-aged students despite research positing that engineering identity begins to develop in the elementary years (Capobianco et al., 2012; Pantoya et al., 2015; Paul et al., 2020).

The primary aim of this quantitative, quasi-experimental, pretest-posttest non-equivalent control group designed study was to examine what influence, if any, near-peer mentor intervention during a STEM Club had on the perceptions of engineering career pathways of elementary students in grades two through five at a suburban parochial school, controlling for the previous engineering career pathway perceptions with pre-intervention scale surveys. Perceptions about engineering career pathways were defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports (Kier et al., 2013; Playton et al., 2023), which were examined as a mean score in this study.

The secondary aim was to examine the possible influence of near-peer mentors on the engineering career pathways of students who identify as girls and BIPOC, which are traditionally underrepresented populations in engineering careers. An ex-post facto, causal-comparative study of the treatment group viewed the dependent variable of engineering career pathways through the lens of gender and racial/ethnic identities, the independent variable.
Research Design

This quantitative study, a quasi-experimental, pretest-posttest non-equivalent control group design, explored the influence of interaction with a near-peer mentor during a STEM Club, which was an informal learning experience, specifically an extracurricular activity, on the perceptions about the engineering career pathways of elementary students, in grades two through five, at a suburban parochial school. According to Cresswell and Cresswell (2023), a quantitative quasi-experimental design focuses on manipulating and measuring variables when a control group is present. This design offers the benefits of good internal validity with the presence of a control variable and group (Bandalos, 2018). Moreover, a quasi-experimental design is the most rigorous design when randomization for a true experimental design cannot be achieved (Cresswell & Cresswell, 2023).

Parents of students in second through fifth grades at the test site self-selected to participate in an informal learning experience, a STEM club focused on engineering. Within the study, three student groups were examined: 1) Group A, STEM Club participants who received the treatment and worked with near-peer mentors; 2) Group B, students who participate in STEM Club without near-peer mentorship (i.e., comparison group); and 3) Group C, students who did not participate in STEM Club (i.e., control group). Although the parents opted to have their child participate and chose the day of the week for participation, the parents did not know whether their child was in the treatment or comparison group at the point of participation. Across the three groups, the sample population consisted of 66 students in second through fifth grades: 36 of whom were girls, and 21 of whom identify as BIPOC. Table 3 shows the sample population as categorized by grade level, gender, and BIPOC identity.
Table 3

*Test Site Sample Population Demographic Table*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of Students</th>
<th>Girls</th>
<th>BIPOC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>%</td>
<td>$n$</td>
</tr>
<tr>
<td>2nd</td>
<td>13</td>
<td>19.7</td>
<td>5</td>
</tr>
<tr>
<td>3rd</td>
<td>17</td>
<td>25.8</td>
<td>10</td>
</tr>
<tr>
<td>4th</td>
<td>15</td>
<td>22.7</td>
<td>8</td>
</tr>
<tr>
<td>5th</td>
<td>21</td>
<td>31.8</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>36</td>
<td>54.5</td>
</tr>
</tbody>
</table>

*Note.* Racial and ethnic identities were self-reported. Families had the option to indicate Hispanic or non-Hispanic ethnicity in addition to other race options.

Although the sample population included 66 students, participation in the STEM club was self-selected for 51.5% of the sample population, as only 34 students chose to participate. Table 4 shows the sample population categorized by study group. It is significant to note that the composition of the groups was not homogeneous in regards to grade-level and race, as such these variables were considered as additional covariates for research question one.
Table 4

Study Group Demographic Table

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>35.9</td>
<td>15</td>
</tr>
<tr>
<td>2nd</td>
<td>3</td>
<td>23.1</td>
<td>5</td>
</tr>
<tr>
<td>3rd</td>
<td>6</td>
<td>46.2</td>
<td>4</td>
</tr>
<tr>
<td>4th</td>
<td>4</td>
<td>30.8</td>
<td>5</td>
</tr>
<tr>
<td>5th</td>
<td>6</td>
<td>42.9</td>
<td>1</td>
</tr>
<tr>
<td>Girls</td>
<td>9</td>
<td>47.4</td>
<td>8</td>
</tr>
<tr>
<td>BIPOC</td>
<td>9</td>
<td>47.4</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: Racial and ethnic identities were self-reported. Families had the option to indicate Hispanic or non-Hispanic ethnicity in addition to other race options.

The independent variable of the quasi-experimental, pretest-posttest non-equivalent control group study was the interaction with a near-peer mentor during a STEM club focused on engineering. Only the treatment group, Group A, participated in the near-peer mentoring. Seven eighth-grade volunteers (five girls, two boys, three BIPOC) worked with Group A, the treatment group, as near-peer mentors to guide and encourage the students in the second through fifth grades. While middle school-aged near-peer mentors allowed the STEM club to provide small-group support and leadership, only eighth-grade students who demonstrated aptitude in engineering and strong interpersonal skills were invited to act as near-peer mentors in the study. Despite the varied age differences between the mentees and the near-peer mentors, the largest being between second and eighth grader, the skill levels and status of the near-peer mentors make
the eighth graders appropriate to fulfill the role (Tenenbaum et al., 2014). Near-peer mentors led to a more welcoming environment and provided more frequent individual engagement opportunities for participants (Henderson et al., 2021; Kim & Sinatra, 2018; Lunn et al., 2021). The near-peer mentors were assigned to small groups for the duration of the project, working with the same students every week, building rapport, and providing emotional assistance (National Academies of Science, Engineering, and Medicine, 2019).

The near-peer mentors were well-known in the school and were familiar faces to the younger students. Near-peer mentors received one session of training with the researcher to address the best practices for near-peer mentoring. The topics and discussion prompts were modified from the book *Entering Mentoring: A Seminar to Train a New Generation of Scientists* (Handelsman et al., 2005). The following topics were presented:

- the purpose of the study and the role of the near-peer mentor as a coach to answer questions, encourage persistence, and provide support
- maintaining good relationships with mentees by maintaining enthusiasm, making eye contact, calling them by name, and discussing what they are doing
- asking leading questions and allowing mentees to lead the project listening to the mentee and giving constructive feedback by using and refraining from negative comments
- including the researcher when needed to redirect activities.
- acknowledging mentees at school and ensuring they feel “seen”

Near-peer mentors were closely monitored throughout the STEM Club experience to ensure messages were positive and that mentees were empowered to do their own projects with help; additionally, near-peer mentors guided and dialogued with mentees to elicit ideas from the mentees (Clarke-Midura et al., 2018). Near-peer mentors reflected on experiences after mentees
were dismissed each week to consider the successes and challenges of the STEM Club session, as well as to share best practices with one another (Rockinson-Szapkiw et al., 2020).

Groups A (i.e., treatment group) and B (i.e., comparison group) met for five consecutive weeks for ninety minutes, maximizing the program's impact through repeated engagement (Archer et al., 2021). Group A met on Tuesdays, and Group B (i.e., comparison group) met on Thursdays. During STEM Club, students explored civil engineering by building towers and bridges; these activities allowed students to engage in the engineering design process, as well as to focus on inquiry experiences with problem-based activities to solve real-world problems. Students were also introduced to professional engineers from diverse backgrounds as role models. Role models, especially diverse role models, mitigated stereotypes and contributed to the development of engineering career interest and self-efficacy (Capobianco et al., 2012; Henderson et al., 2021). Parents, guardians, and influential adults were invited to join the meetings in the fourth and fifth weeks to share an engineering showcase celebration.

This research employed a convenience sample accessible to the researcher during the investigation window (Cresswell & Cresswell, 2023). As members of the same school population, all members of the sample population participated in formal STEM classes during the school day. Group C (i.e., control group) received no additional interventions. The students who opted to remain in the control group were not segregated in any way during formal STEM class time, and their survey data was collected identically to the Group A and Group B students.

The dependent and covariate variables of student perceptions of engineering career pathways were measured using the STEM Future-Career Interest Survey (STEM Future-CIS) (Playton et al., 2023) (See Appendix A for STEM Future-CIS questions). The STEM Future-CIS was utilized because it aligns with SCCT and assesses student self-efficacy, outcome
expectation, interest, personal goals, and personal inputs (Kier et al., 2013; Playton et al., 2023). The instrument was also chosen to address the study's constructs and the participants' age level. A pretest and posttest provided the researcher with a means to control existing engineering identity (Cresswell & Cresswell, 2023).

Additionally, an ex-post facto, causal-comparative study was included to examine the possible influence of near-peer mentors on the perception of engineering career pathways of students who identify as girls and BIPOC. Boys and girls and Whites and non-Whites (i.e., BIPOC) populations within the treatment group were compared on their perceptions of engineering career pathways as measured by the STEM Future-Career Interest Survey (STEM Future-CIS) (Playton et al., 2023). The independent variables of gender and BIPOC identity were gathered using the school database of demographic data provided by parents. The dependent variable was the mean survey scores as a measure of engineering career pathway perception.

**Participants**

This study occurred in a suburban parochial school in the second through fifth grades. The small school has fewer than 250 students in preschool through eighth grade. There was a total of 66 students in the sample population, with 36 (54.5%) girls and 30 (45.5%) boys. The school population was predominantly White, with 12% Hispanic or Latinx, 7% Asian, 3% two or more races, and 1% Black or African American students. These percentages were based on enrollment in 2023-2024. Socioeconomically, the families in the school population were middle to high-income earners. Most of the students were Catholic and came from families with an average of three children. Many children attending this school had parents who were college graduates with one or more degrees. The school does not employ selective admission policies as it welcomes students of all academic and social levels, as well as faith backgrounds. Tuition
assistance was and remains available to families with financial needs from the school education foundation. Additionally, several students in the sample population attended the school with the financial assistance of TN Education Savings Account vouchers.

This study included students in the second, third, fourth, and fifth grades. Students participated in engineering education as part of their STEM curriculum. Additionally, the school offered a variety of extracurricular/informal learning opportunities, one being the STEM Club. The parents of the students received an invitation for their children to participate in the STEM Club. When parents and guardians opted into STEM Club, they indicated Tuesday, Thursday, or No Preference for participation. Parents did not know which day of the week featured the near-peer mentoring treatment. The students with no preference for the day of the week were assigned based on the total number of group participants and the variance of grade levels within the group. Although equivalency was impossible, the two groups were similar in size and gender
distribution. In terms of grade level distribution and BIPOC population, the Tuesday group reflected more diversity.

As previously explained, the control group did not attend STEM Club, the comparison group attended STEM Club on Thursdays with no near-peer mentors, and the treatment group attended STEM Club on Tuesdays with near-peer mentors. As this research took place in a suburban parochial school in the midsouth where the researcher has been a school staff member for 17 years and where she is the STEM teacher for the school, working with students in the first through eighth grades, the sample was a convenience sample, and the comparison and treatment groups were volunteers.
Setting

This research took place in a suburban parochial school in the midsouth. STEM classes at the school are across all elementary grades and are bi-monthly special classes focused on building a foundational connection between science, technology, engineering, and mathematics through real-world experiences. The regular STEM classes, which are driven by the Next Generation Science Standards (NGSS), center on the engineering design process and occur in the school’s STEM lab, a dedicated space for STEM and science classes. Student seating is configurable at eight adjustable tables. Additionally, students can access a class set of Chromebooks for computer-aided design (CAD) using Tinkercad and SketchUp software; designs can be printed on two MakerBot 3D printers in the lab. Students also have access to Sphero Bolt robots, BirdBrain Finch 2.0 robots, BirdBrain Hummingbird Bits, littleBits, and Arduino electronics components, in addition to K’Nex, and Lego building materials. The lab is outfitted with Keva planks and a plethora of consumable supplies for engineering design and testing. Measurement tools, Vernier probes, and apps are available to analyze and communicate results.

STEM Club meetings occurred in the same STEM Lab space where students meet for STEM classes. The meetings began at 3:15 p.m. at the end of the school day and lasted until 4:45 p.m. for a ninety-minute engagement period. In each club meeting, participants engaged in inquiry experiences featuring engineering design thinking activities aligned with the Engineering Design Standards outlined in the Next Generation Science Standards (NGSS) (NGSS States, 2013) (See Appendix D for Engineering Design Standards from the NGSS). The engineering design process guided participant activities through the five phases of design thinking: empathize, define, iterate, prototype, and test (Bush et al., 2018). Participants added a
communication phase to the process by sharing their designs and articulating their process through a design showcase for parents and guardians during the fourth and fifth STEM Club sessions. Current events and literature, such as picture books, created the backdrop of real-world needs that engineered solutions could solve. Participants were introduced to diverse role models virtually through video profiles available from the American Society of Civil Engineers, Job Talks, KQED Quest, and Explorist. The video profiles were short, between two and six minutes in length, and profiled female and male engineers of varied ethnicities. The engineer profiles were interspersed with active content to provide an engaging overview of the career. Additionally, several engineers visited in-person during the showcase events. The club also explored civil engineering through tower and bridge design, as outlined in Table 5. The fourth and fifth club meeting times were a celebration showcase with parents in which students shared their portfolios. Attendance during the third week of the STEM Club was impacted by numerous illnesses that also impacted school attendance in general. As a result, a fifth club session was added to the STEM Club to ensure that all participants had ample time to complete and showcase projects. A complete list of curriculum materials is located in Appendix B
<table>
<thead>
<tr>
<th>Meetings</th>
<th>Topic</th>
<th>Activity</th>
<th>Engagement Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>What is an engineer?</td>
<td>Testing shapes for strength and building tall towers</td>
<td>Rosie Revere, Engineer by Andrea Beaty</td>
</tr>
<tr>
<td></td>
<td>What do civil engineers do?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>Engineers build things like bridges and buildings using the Engineering Design Process.</td>
<td>Building bridges to help people or animals move from place to place.</td>
<td>Someone Builds the Dream by Lisa Wheeler</td>
</tr>
<tr>
<td>Week 3</td>
<td>Bridges add value to the community.</td>
<td>Design an original bridge structure to support weight.</td>
<td>Secret Engineer: How Emily Roebling Built the Brooklyn Bridge by Rachel Dougherty</td>
</tr>
<tr>
<td>Week 4</td>
<td>See what we can do!</td>
<td>Complete bridge projects.</td>
<td>Design showcase for special visitors.</td>
</tr>
<tr>
<td>Week 5</td>
<td>See what we can do! Continued</td>
<td>Share bridge projects with parents and community stakeholders.</td>
<td>Special visitors including community engineers.</td>
</tr>
</tbody>
</table>

*Note.* Topics, activities, and engagement resources used in STEM Club were identical for groups A and B. Detailed plans, supply lists, and resources are available in Appendix E.
**Intervention**

The intervention, interaction with near-peer mentors, took place in the context of an informal learning environment, specifically the extracurricular activity of a STEM Club. Near-peer mentors are people who closely resemble their mentees in social, professional, or age levels (Frances et al., 2020). In this study, near-peer mentors were eighth-grade students, a few years older than their mentees, who had experienced similar STEM challenges in the same school with the same teacher as their mentees. The common experience of the near-peer mentors and mentees provided the opportunity to develop a relationship in which younger students were comfortable seeking academic and personal advice and support (Zaniewski & Reinholz, 2016). Near-peer mentors gave participants more personalized, timely feedback (Henderson et al., 2021; Martinez & Whiting, 2021). As the near-peer mentor focused attention on the wishes and priorities of their mentees, the mentees were able to build confidence in their engineering abilities (National Academy of Science, Engineering, and Medicine, 2019). The near-peer mentors provided feedback and encouragement (i.e., social persuasion); they also acted as another pair of hands to manage supplies, to complete fine motor tasks that younger students find difficult, and to model appropriate behavior in group work (i.e., vicarious experience).

Formal STEM classes continued during the same months as the STEM Club. Students in Groups A and B participated in identical formal STEM classes. No differentiation was made between students participating in the study.

**Instrumentation and Data Collection Methods**

The dependent variable (i.e., posttest) and covariate (i.e., pretest) were defined as students’ perceptions about engineering career pathways considered through the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, and personal inputs (Kier et
al., 2013; Playton et al., 2023). The STEM Future-CIS (Playton et al., 2023), an adaptation of the STEM-CIS instrument (Kier et al., 2013), was used to measure the covariate (e.g., pretest) and dependent variable (i.e., posttest) by gathering data on the SCCT variables of self-efficacy, outcome expectation, interest, personal goals, and personal inputs in elementary students (Kier et al., 2013; Playton et al., 2023). These two instruments align with the constructs of SCCT. However, the STEM Future-CIS only includes prompts designed to assess the constructs of self-efficacy, outcome expectation, interest, personal goals, and personal inputs because the developers felt the construct of contextual inputs was not developmentally appropriate for elementary-aged students (Playton et al., 2023).

The pretest and posttest surveys were administered to participants with Qualtrics. To complete the STEM Future-CIS, students responded to a series of prompts, seven of which were part of the engineering subscale. Responses were made on a 5-point Likert-type scale (0 = Never, 1 = Not Really, 2 = Sometimes, 3 = A Lot, 4 = Always). Mean scores on the engineering subscale could range from zero to four, with higher scores indicating more positive perceptions of engineering career pathways.

The STEM Future-CIS included detailed protocols specified by Playton et al. (2023) and was administered using an interactive interface designed by the developers in Qualtrics. During the survey, the researcher and an assistant teacher were present. The survey responses were exported into a spreadsheet and entries were coded for student anonymity with student numbers developed by the researcher. Demographic characteristics such as grade level and gender were coded as well. Only the researcher had access to the raw data and original survey responses to protect participants' identities. Survey data did not impact the scores of the sample population.
Although the STEM Future-CIS instrument was administered in its entirety, specific indicators aligned closely with this investigation of perceptions of engineering career pathways through the lens of SCCT, and as such, the data for the engineering subscale, was extracted for this study. Table 6 outlines the survey questions and how each construct aligned with Research Question 1: To what extent, if any, does suburban parochial students’ participation in a near-peer mentor experience during STEM Club influence second-fifth grade students’ perceptions about their engineering career pathways, defined in the combined constructs of SCCT (self-efficacy, outcome expectation, interest, personal goals, and personal inputs), controlling for the previous engineering career pathway perceptions, as measured by the STEM Future-CIS instrument?
### Table 6

*STEM Future-CIS Survey Engineering Questions Aligned with SCCT Constructs*

<table>
<thead>
<tr>
<th>SCCT Construct</th>
<th>STEM Future-CIS Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>self-efficacy</td>
<td>I do well in work that uses engineering.</td>
</tr>
<tr>
<td></td>
<td>I am able to finish projects that use engineering.</td>
</tr>
<tr>
<td></td>
<td>If I learn engineering, it can help me when I grow up.*</td>
</tr>
<tr>
<td>outcome expectation</td>
<td>If I learn engineering, it can help me when I grow up.*</td>
</tr>
<tr>
<td></td>
<td>My family would like it if I used engineering when I grow up.</td>
</tr>
<tr>
<td>interest</td>
<td>I like doing engineering work.</td>
</tr>
<tr>
<td>personal goals</td>
<td>I will try hard at doing engineering work.</td>
</tr>
<tr>
<td></td>
<td>When I grow up, I could use engineering in my job.</td>
</tr>
<tr>
<td>personal input</td>
<td>If I learn engineering, it can help me when I grow up.*</td>
</tr>
<tr>
<td>contextual support</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Note:* The STEM Future-CIS is validated for second through fourth grades. The developers of the STEM Future-CIS did not address contextual support in the engineering subscale, and literature on the instrument indicated that some questions addressed more than one SCCT construct, as indicated by the asterisk.

The STEM Future-CIS was developed from the STEM-CIS for elementary students. Lexile readability techniques were used to reword questions, and emojis were added to the Likert-type scale to improve the participants’ comprehension of the survey (Playton et al., 2023). The revised instrument was validated by exploratory and confirmatory factor analysis as a whole and as subscales. The subscales were found to have internal consistency with a Cronbach’s alpha of 0.85 on the engineering subscale. Analyses by the developers indicated that the STEM Future-
CIS was a good fit for measuring student perceptions of engineering career pathways (Playton et al., 2023). The engineering interest subscale did not address the contextual support construct because the developers found that second through fourth-grade students had not had enough exposure to engineering as a career to answer questions designed for the construct with fidelity (Playton et al., 2023). Although the instrument has only been validated for second through fourth-grade students, it was also administered to the fifth-grade student participants. Principal components analysis was run to validate the fifth-grade results despite the slight discrepancy between the instrument's target age level and the study participants' age level.

**Data Collection Procedures**

The course materials were gathered and prepared between November 2023 and January 2024. Communication with the STEM Future-CIS developer, Dr. Stephanie Playton, facilitated the use of the instrument, as she provided the STEM Future-CIS as a Qualtrics file. Once the course materials, picture books, and activities were arranged in a weekly progression, Dr. Amanda Rockinson-Szapkiw and Dr. Stephanie Ivey reviewed the entire STEM Club curriculum. Their expert suggestions were implemented in the finalized materials.

While the IRB application was initially submitted on December 28, 2023, it was returned for clarification and additional information and subsequently resubmitted three times in January 2024. The IRB application passed the pre-review process and was submitted for initial approval on January 16, 2024. The board returned the application with contingencies on January 30, 2024, and the study was approved by the board on February 13, 2024.

When school reconvened after the holidays in January 2024, the researcher communicated with the families of the sample population to promote the STEM Club opportunity. Families self-selected to participate and registered via Google Forms. Parental
consent forms and student assent forms were explained and distributed to all families and participants in the sample population. In January, the near-peer mentor volunteers were trained in best practices for facilitating student work.

With the help of the STEM teaching assistant, the researcher conducted pre-intervention surveys of all students in the school population during the week of January 22, 2024, the STEM Club’s first meeting. The pre-intervention surveys were administered using Qualtrics on individual Chromebooks in STEM classes during the regular school day. The survey responses were coded for anonymity with codes created by the researcher. Weekly STEM Club meetings, which ran for five weeks, began on January 23, 2024, and ended on February 22, 2024. The STEM Club engineering showcase with students, near-peer mentors, parents, and community stakeholders occurred in the fourth and fifth weeks of the study. The researcher and the STEM teaching assistant conducted a post intervention survey of all students in the school population in the last week of February. The post intervention surveys were administered using Qualtrics on individual Chromebooks in STEM classes during the regular school day. The data was coded for anonymity, aligned with pre-survey data, and analyzed for incomplete data sets. Data was analyzed at the end of February and results were compiled for distribution. The researcher will host an informational session at the test site to share the investigation results with parents and students in April 2024.

As a faculty member at the test school, the researcher conducted this study with integrity and quality while maintaining the strict guidelines of the IRB committee. The researcher strove to be impartial and prevent harm to the students in the test and control groups. Surveying is typical in the school’s STEM class, as STEM and engineering interests are regularly measured for use in program evaluation and planning. The instrument was administered to all students in
STEM classes during the school day. Parents and participants who did not wish for student data to be included in the analysis for this study had the option not to participate. Only data from students who gave assent and whose parent or guardian gave consent was included in this study. Student survey data has been and will be maintained with anonymity and confidentiality. Finally, the data sample was of a sufficient size that the publication of specific reporting would not breach privacy.

Analysis

To explore the three research questions, one-way analyses of covariance (ANCOVA) was utilized to examine if any statistical difference existed in engineering career pathway perceptions across the three groups, as well as across gender and racial/ethnic groups. Based on the self-selected nature of the participation in this study, as well as the independent variables of gender and race/ethnicity that could not be manipulated, ANCOVA was the best form of analysis to mitigate the selection threat to validity (Gall et al., 2010). The pretest served as the covariate, while the posttest served as the dependent variable of engineering career pathway perceptions. The ANCOVA analysis allowed the researcher to compare the differences in the groups, providing a control that reduced the people factor selection threat to validity (Cresswell & Guetterman, 2019). ANCOVA also enabled the researcher to adjust for the effects of outside variables other than the independent variable that were related to the dependent variable, such as the pretest for all three research questions included in this study (Urdan, 2017).

The three ANCOVA tests used general linear model variate analyses, and the $p$-values were used to determine whether to reject or fail to reject the null hypothesis (Morgan et al., 2013). The $p$-value is a probability score based on calculated value, critical value, and degrees of
freedom. If the $p$-values were .05 or less, the null hypothesis was rejected (Bandolos, 2018; Cronk, 2018; Morgan et al., 2013; Urdan, 2017).

However, prior to conducting the ANCOVA, the researcher conducted internal consistency tests using Cronbach’s alpha to confirm the validity of inclusion of the seven engineering indicators. Additionally, the researcher performed assumption testing on the pre and post engineering means of the STEM Future-CIS administrations. The assumption of normality was evaluated with the Kolmogorov-Smirnov test comparing the distribution of the pre and posttest means. A $p$ value of greater than .05 indicated normal distribution (Morgan et al., 2013). Boxplots were used to inspect data for extreme outliers, any data residing 1.5 box lengths or more from the box (Urdan, 2017). Homogeneity of variance was evaluated with two methods, scatterplots to explore homoscedasticity and with $= Levene’s Test of Equality of Variances (Morgan et al., 2013). Equal variance could be assumed if the significance value was more than .05, while a significance level of less than .05 indicated that equality of variance was not plausible. If the assumption of equality was violated, averaging the variances was not statistically sound and modified statistical procedures were employed (Urdan, 2017).

As ANCOVA is a general linear model, an assumption of linearity was tested before the ANCOVA to determine the relationship between the dependent variable and the covariate. If the scatterplot produced a curvilinear relationship, the use of the covariate would be reconsidered, or the variable would be altered (Bandalos, 2018); however, the scatterplot featured a straight line indicating reasonable linearity (Bandalos, 2018). Finally, the relationship between the dependent variable and covariate was examined with a homogeneity of regression slopes assumption. Graphic (scatterplot) and statistical outcomes demonstrated the consistency of the relationship between groups. The assumption would have been violated if the scatterplot lines for the
dependent variable and covariates differed or if the statistical significance was greater than .05 (Urdan, 2017). Moderate violations were noted if they existed; however, as the sample size was sufficient, the ANCOVA was considered a robust procedure (Bandolos, 2018). All analyses were conducted using the statistical software IBM SPSS version 29. Reliability and assumption tests are outlined in Table 7.

**Table 7**

*Data Analysis Testing and Procedures*

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Test</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal consistency</td>
<td>Cronbach’s alpha</td>
<td>( \alpha \geq 0.5 )</td>
</tr>
<tr>
<td>Normality</td>
<td>Kolmogorov-Smirnov</td>
<td>( p &gt;.05 )</td>
</tr>
<tr>
<td>Extreme outliers</td>
<td>Boxplots</td>
<td>Data within 1.5 box lengths of box</td>
</tr>
<tr>
<td>Homogeneity of variance</td>
<td>Scatterplots of predicted values and standardized residuals</td>
<td>Scatter pattern</td>
</tr>
<tr>
<td>Homoscedasticity</td>
<td>Levene’s Test for Equality of Variance</td>
<td>( p &gt;.05 )</td>
</tr>
<tr>
<td>Linearity</td>
<td>Scatterplots</td>
<td>Linear relationship</td>
</tr>
<tr>
<td>Homogeneity of regressions slopes</td>
<td>Tests of Between-Subject Effects</td>
<td>( p &lt; .05 )</td>
</tr>
</tbody>
</table>
CHAPTER FOUR: RESULTS

As previously mentioned, research interventions designed to expand engineering career pathway perceptions tend to focus on secondary and collegiate students (Playton et al., 2023; Simpson & Bouhafa, 2020) despite the understanding that career interest development begins to form in pre-adolescence and expands in response to internal and external factors (Falco, 2016; Gottfredson, 1981). There is a gap in the literature examining the influence of engineering education interventions focused on students in the elementary grades (Capobianco et al., 2012; Pantoya et al., 2015; Paul et al., 2020). To help close this gap in the literature, this quantitative study, a quasi-experimental, pretest-posttest non-equivalent control group study explored the influence of interaction with a near-peer mentor during a STEM Club on the perceptions about the engineering career pathways of elementary students. The study included students in the second through fifth grades in a small, suburban, parochial school. The following research questions were the focus of this study:

Research Question 1. To what extent, if any, does suburban parochial students’ participation in a near-peer mentor experience during STEM Club influence second-fifth grade students’ perceptions about their engineering career pathways, defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports, controlling for the previous engineering career pathway perceptions with pre-intervention scale surveys, as measured by the STEM Future-CIS instrument?

Research Question 2. While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of girls and boys after engagement with near-peer mentors during STEM Club?
Research Question 3. While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of students who identify as BIPOC and those who identify as white after engagement with near-peer mentors during STEM Club?

**Participant Demographics**

There were 66 students in the second through fifth grades enrolled in the school where this research occurred. The parents of the 66 students were asked to consent to using their child’s data for this study. The parents of 53 students completed the consent agreement. Of these 53 students, 50.9% \((n = 27)\) were girls and 34.0% \((n = 18)\) identified as BIPOC. In addition to parental consent, student assent was obtained for the use of survey data.

Parents of all students received an overview of the study and an invitation to enroll their children in the after-school STEM Club. Parents could choose the day of the week that best worked for the child, yet parents and children were unaware which day corresponded with the treatment or comparison group. Parents day selections resulted in 19 students in the treatment group, Group A, of whom 47.4% \((n = 9)\) were girls and 47.4% \((n = 9)\) identified as BIPOC. The comparison group, Group B, enrolled 15 students, 53.3% \((n = 8)\) of whom were girls and 20.0% \((n = 3)\) who identify as BIPOC. The 19 students of the remaining families comprised the control group, Group C, 52.6% \((n = 10)\) of whom were girls and 31.6% \((n = 6)\) who identify as BIPOC. Tables 8 and 9 illustrate the demographic data of participants.
### Table 8

**Study Group Demographic Table by Grade Level**

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Group A</th>
<th></th>
<th>Group B</th>
<th></th>
<th>Group C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment Group</td>
<td>Comparison Group</td>
<td>Control Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>35.2</td>
<td>15</td>
<td>27.8</td>
<td>19</td>
<td>37.0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>3</td>
<td>23.1</td>
<td>5</td>
<td>38.5</td>
<td>5</td>
<td>38.5</td>
</tr>
<tr>
<td>Grade 3</td>
<td>6</td>
<td>46.2</td>
<td>4</td>
<td>30.8</td>
<td>3</td>
<td>23.1</td>
</tr>
<tr>
<td>Grade 4</td>
<td>4</td>
<td>30.8</td>
<td>5</td>
<td>38.5</td>
<td>4</td>
<td>30.8</td>
</tr>
<tr>
<td>Grade 5</td>
<td>6</td>
<td>42.9</td>
<td>1</td>
<td>7.1</td>
<td>7</td>
<td>50.0</td>
</tr>
</tbody>
</table>

### Table 9

**Study Group Demographic Table by Demographic Group**

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Group A</th>
<th></th>
<th>Group B</th>
<th></th>
<th>Group C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment Group</td>
<td>Comparison Group</td>
<td>Control Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>35.2</td>
<td>15</td>
<td>27.8</td>
<td>19</td>
<td>37.0</td>
</tr>
<tr>
<td>Girls</td>
<td>9</td>
<td>47.4</td>
<td>8</td>
<td>53.3</td>
<td>10</td>
<td>52.6</td>
</tr>
<tr>
<td>BIPOC</td>
<td>9</td>
<td>47.4</td>
<td>3</td>
<td>20.0</td>
<td>6</td>
<td>31.6</td>
</tr>
</tbody>
</table>

*Note:* Racial and ethnic identities were self-reported. Families had the option to indicate Hispanic or non-Hispanic ethnicity in addition to other race options.

### Data Preparation

Data for this study was collected using the STEM Future-CIS (Appendix A), which is a Likert-type scale survey intended to gather data on the SCCT variables of self-efficacy, outcome
expectation, interest, personal goals, and personal inputs in elementary students (Playton et al., 2023). The survey was administered to the study participants twice in its entirety.

The raw data was exported as a Microsoft Excel spreadsheet from Qualtrics and coded with demographic data and anonymous student codes. The survey data from the pretest and the posttest were aligned by participant number. Of the 53 participants, one did not complete a pretest, and one did not complete a posttest, therefore their data was excluded in the analyses. The data was imported from Microsoft Excel into IBM SPSS version 29. The Likert-type question data were identified as scale data, while demographic information was coded as nominal data.

The STEM Future-CIS includes 25 Likert-type questions, four for science, seven for engineering, six for math, and eight for technology. As the data for this research was focused on engineering, only the seven engineering questions were included in the data analysis.

**Reliability Analysis**

The researchers who developed this scale validated the STEM Future-CIS instrument for second through fourth grade (Playton et al., 2023). Reliability analysis procedures were performed on the covariate (pretest) and dependent variable (posttest) data to ensure the reliability of the instrument with the sample population.

Internal consistency was evaluated for the pre and posttest using a Cronbach’s alpha coefficient, and scores indicated a high level of internal consistency for the pretest ($\alpha = 0.797$) and posttest ($\alpha = 0.892$).

**Research Question 1**

The primary purpose of this study was to explore the quasi-experimental question: To what extent, if any, does suburban parochial students’ participation in a near-peer mentor
experience during STEM Club influence second-fifth grade students’ perceptions about their engineering career pathways, defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports, controlling for the previous engineering career pathway perceptions with pre-intervention scale surveys, as measured by the STEM Future-CIS instrument.

**Descriptive Statistics.** The STEM Future-CIS instrument features seven engineering specific Likert-type score questions with answers ranging from a score of one ("Never") to five ("Always"). A higher mean of any indicator indicated increased SCCT construct factors for the group. A higher overall engineering mean indicated increased pathway perceptions. The descriptive statistics of the disaggregated treatment, comparison, and control groups are outlined in Table 10 which includes the mean, standard deviation, adjusted mean score, and standard error mean for each variable.
Table 10

*Engineering Means of the Covariate Pretest, Posttest, and Adjusted Mean*

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Covariate Pretest</th>
<th>Dependent Variable Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ ($SD$)</td>
<td>$M$ ($SD$)</td>
</tr>
<tr>
<td>Treatment Group A</td>
<td>3.90 (0.91)</td>
<td>4.11 (0.91)</td>
</tr>
<tr>
<td>Comparison Group B</td>
<td>3.89 (0.93)</td>
<td>3.66 (0.93)</td>
</tr>
<tr>
<td>Control Group C</td>
<td>3.91 (0.86)</td>
<td>3.79 (0.86)</td>
</tr>
</tbody>
</table>

Table 11 presents the means and standard deviation for indicators and groups on the covariate pretest administration of the STEM Future-CIS.
Table 11

Engineering Indicator Means of the Covariate Pretest

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Group A Treatment Group</th>
<th>Group B Comparison Group</th>
<th>Group C Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>n</td>
</tr>
<tr>
<td>E1 - self-efficacy: I do well in work that uses engineering.</td>
<td>18</td>
<td>3.89</td>
<td>15</td>
</tr>
<tr>
<td>E2 – personal goals: When I grow up, I could use engineering in my job.</td>
<td>18</td>
<td>3.33</td>
<td>15</td>
</tr>
<tr>
<td>E3 – self-efficacy: I am able to finish projects that use engineering.</td>
<td>18</td>
<td>4.11</td>
<td>15</td>
</tr>
<tr>
<td>E4 – personal goals: I will try hard at doing engineering work.</td>
<td>18</td>
<td>4.56</td>
<td>15</td>
</tr>
<tr>
<td>E5 – outcome expectations: If I learn engineering, it can help me when I grow up. *</td>
<td>17</td>
<td>3.88</td>
<td>15</td>
</tr>
<tr>
<td>E8 – outcome expectations: My family would like it if I used engineering when I grow up.</td>
<td>18</td>
<td>3.72</td>
<td>15</td>
</tr>
<tr>
<td>E9 – interest: I like doing engineering work.</td>
<td>17</td>
<td>4.06</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 12 presents the mean and standard deviation data for indicators and groups on the dependent variable posttest administration of the STEM Future-CIS. Indicator E5 codes as outcome expectations and can be considered as an indicator for also self-efficacy and personal input.
Table 12

*Engineering Indicator Means of the Dependent Variable Posttest*

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Group A Treatment Group</th>
<th>Group B Comparison Group</th>
<th>Group C Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>n</td>
</tr>
<tr>
<td>E1 - self-efficacy: I do well in work that uses engineering.</td>
<td>18</td>
<td>4.28</td>
<td>15</td>
</tr>
<tr>
<td>E2 – personal goals: When I grow up, I could use engineering in my job.</td>
<td>18</td>
<td>3.78</td>
<td>15</td>
</tr>
<tr>
<td>E3 – self-efficacy: I am able to finish projects that use engineering.</td>
<td>18</td>
<td>4.22</td>
<td>15</td>
</tr>
<tr>
<td>E4 – personal goals: I will try hard at doing engineering work.</td>
<td>18</td>
<td>4.33</td>
<td>14</td>
</tr>
<tr>
<td>E5 – outcome expectations: If I learn engineering, it can help me when I grow up.*</td>
<td>18</td>
<td>3.78</td>
<td>14</td>
</tr>
<tr>
<td>E8 – outcome expectations: My family would like it if I used engineering when I grow up.</td>
<td>17</td>
<td>3.71</td>
<td>15</td>
</tr>
<tr>
<td>E9 – interest: I like doing engineering work.</td>
<td>17</td>
<td>4.24</td>
<td>15</td>
</tr>
</tbody>
</table>
Note: Indicator E5 codes as outcome expectations and can be considered as an indicator for also self-efficacy and personal input.

**ANCOVA**

An analysis of covariance (ANCOVA) was chosen as the best analysis for research question one. The pretest data, as planned, served as the covariate. The posttest data served as the dependent variable. Independent variable categories include the treatment, comparison, and control groups. Although the independent variable groups were similar in size and gender distribution, the proportions of race and grade level differed across groups; therefore, these factors were added as covariates to the analysis.

**Assumptions.**

Assumption tests were completed prior to conducting the ANCOVA. Kolmogorov-Smirnov tests were used to assess the normality of each grouping variable based on the small sample size of each group (Bandalos, 2018). The significant values ranged from .05 for the treatment group to .20 for the comparison and control groups. The assumption of normality was tenable for all groups as \( p > .05 \) in all cases.

The data sets included no extreme outliers in an exploration of boxplots of grouping variables, as shown in Figure 1. One univariate outlier in the data with values greater than 1.5 box-lengths from the box was found upon inspection of the boxplots. However, no extreme outlier was identified in the data for the dependent variable. Results with and without the outlier included did not differ significantly. Therefore, the outlying case was included in the analysis, given that the data came from a real student.
Additionally, the predicted values and standardized residual values produced by the one-way ANCOVA procedure were inspected for outliers. The largest standardized residual value was 1.75, indicating that the dataset didn’t include any outliers exceeding the maximum of ± 3 standard deviations. A Kolmogorov-Smirnov test of normality for the standardized residuals resulted in values of $p = .09$ for the treatment group, $p = .02$ for the comparison group, and $p = .04$ for the control group. Therefore, the assumption of normality was met for the treatment group, but this assumption was violated for the control and groups. However, the decision was made to continue with the ANCOVA testing based on Warner’s (2013) findings that ANCOVA is robust with minor normality violations.

The homogeneity of variance was evaluated in two ways. The predicted values and standardized residuals were plotted in a scatter pattern to find that the assumption of homoscedasticity was met, as shown in Figure 2. Levene’s Test for Equality of Variance
confirmed that the variances were equal, with a significance value greater than .05 as $p = .053$.

Therefore, the assumption of homogeneity of variances was not violated.

Figure 2

Scatterplot: ANCOVA Predicted Values and Standardized Residual Values

The assumption of linearity was explored by visually examining scatterplots. As shown in Figures 3, 4, and 5, a linear relationship existed between the pretest and posttest for each group.
Figure 3

Scatterplot: Linear Relationship Between Treatment Group A Pretest and Posttest
Figure 4

Scatterplot: Linear Relationship Between Comparison Group B Pretest and Posttest
In a univariate linear model, the Tests of Between-Subjects Effects indicated the assumption of the homogeneity of regression slopes was violated as the interaction term was not statistically significant, $F(1) = 12.98, p < .001$. However, transforming data did not influence results, thus, data was not transformed. Table 13 shows the assumption tests and results.
Table 13

Data Analysis Testing and Results for Research Question #1

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Test</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normality</td>
<td>Kolmogorov-Smirnov tests</td>
<td>Assumption of normality was tenable for all groups as p &gt; .05 in raw data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>However, when standardized residuals were evaluated, the treatment group met the test of normality with p = .09, while the control and comparison groups yielded a p &lt; .05.</td>
</tr>
<tr>
<td>Extreme outliers</td>
<td>Boxplots</td>
<td>One univariate outlier in the data with values greater than 1.5 box lengths of box. However, no extreme outlier was identified in the data for the dependent variable.</td>
</tr>
</tbody>
</table>
Table 13 continued

*Data Analysis Testing and Results for Research Question #1*

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Test</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneity of variance</td>
<td>Scatterplots of predicted values and</td>
<td>Scatter pattern shows random distribution of variables.</td>
</tr>
<tr>
<td>Homoscedasticity</td>
<td>standardized residuals</td>
<td></td>
</tr>
<tr>
<td>Homogeneity of variance</td>
<td>Levene’s Test for Equality of Variance</td>
<td>Homogeneity of variances was met as $p = .053$</td>
</tr>
<tr>
<td>Linearity</td>
<td>Scatterplots</td>
<td>Linear relationship exists between the pre and posttest data for each group.</td>
</tr>
<tr>
<td>Homogeneity of regressions slopes</td>
<td>Tests of Between-Subject Effects</td>
<td>The interaction term was not statistically significant; therefore, the homogeneity of regression slopes was violated with $p &lt; .001$.</td>
</tr>
</tbody>
</table>
groups, $F(2, 49) = 2.15, p = .011$, partial $\eta^2 = .18$. While the effect size, based on Cohen’s (1988) was large, $\eta^2 = .184$, the observed power was .78, which was moderately high.

Pairwise comparison demonstrated that there was a significant difference between the treatment and comparison groups. No other comparisons reached statistical significance ($p = .011$). Inspection of the descriptive statistics indicated that students in the treatment group scored higher on the post STEM Future-CIS than students in the comparison group. Interestingly, the posttest scores of the treatment group increased from the pre to posttests while the comparison group scores decreased.

**Research Question 2**

An ex-post facto, causal-comparative study was included in this study to examine what statistically significant difference, if any, exists between the engineering career perceptions of girls and boys after engagement with near-peer mentors during STEM Club while controlling for the previous engineering career pathway perceptions.

An analysis of covariance (ANCOVA) was chosen as the best means for analyzing the data from the between group design. The pretest data served as the covariate, and the posttest data served as the dependent variable. Independent variable categories included the gender groups of boys and girls. The descriptive statistics of the independent variable groups are outlined in Table 14, including the mean, standard deviation, adjusted mean score, and standard error of each group.
Table 14

Descriptive Statistics for the Girls and Boys in the Treatment Group A (n = 19)

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Covariate Pretest M (SD)</th>
<th>Dependent Variable Posttest M (SD)</th>
<th>M adj (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls (n = 9)</td>
<td>3.89 (0.72)</td>
<td>4.02 (1.20)</td>
<td>4.06 (0.25)</td>
</tr>
<tr>
<td>Boys (n = 10)</td>
<td>3.97 (0.54)</td>
<td>4.19 (0.61)</td>
<td>4.16 (0.23)</td>
</tr>
</tbody>
</table>

Note: Covariates appearing in the model are evaluated at the following values: Covariate = 3.934453781512605.

Assumptions

Assumption tests were completed prior to conducting the ANCOVA. Kolmogorov-Smirnov tests were used to assess the normality of each grouping variable based on the small sample size of each group. The significance value for girls was $p = .04$ and $p = .20$ for boys. Therefore, the assumption of normality was only tenable for the post STEM Future-CIS means of the boys as $p > .05$ greater for boys however, not for the girls ($p < .05$). In light of the small sample size ($n = 18$) with few data points and a slightly nonnormal distribution analysis continued (Bandalos, 2018), a nonparametric test was employed to confirm the findings of the ANCOVA.

The data set showed no extreme outliers in an exploration of boxplots of grouping variables, as shown in Figure 6. Two univariate outliers in the data with values greater than 1.5 box-lengths from the box were found upon inspection of the boxplots. There was, however, no extreme outlier identified in the data for the dependent variable. Results with and without the inclusion of outlier did not differ significantly. Therefore, the cases were incorporated in the analysis given that the data came from a real student.
Additionally, the predicted values and standardized residual values produced by the one-way ANCOVA procedure were inspected for outliers. The largest standardized residual value was 1.81 indicating that the dataset did not include any outliers exceeding the maximum of ± 3 standard deviations. A Kolmogorov-Smirnov test of normality for the standardized residuals resulted in significance values of $p = .20$ for both gender groups, boys and girls. Therefore, the assumption of normality was met for the standardized residual data.

The homogeneity of variance was evaluated in two ways. The predicted values and standardized residuals were plotted in a scatter pattern to find the assumption of homoscedasticity was met as shown in Figure 7. Levene’s Test for Equality of Variance confirmed that the variances were equal with a significance value greater than .05 as $p = .90$. Therefore, the assumption of homogeneity of variances was not violated.
The assumption of linearity was explored by visually examining scatterplots. As shown in Figure 8, a linear relationship existed between the pretest and posttest for each group.
Figure 8

Scatterplot: Linear Relationship Between the Pretest and Posttest of Girls and Boys

In a univariate linear model, the Tests of Between-Subjects Effects indicated the assumption of the homogeneity of regression slopes was not statistically significant, $F(1,16) = 2.502, p = .138$, therefore the assumption of homogeneity of regression slopes was met as $p > .05$.

Analysis Results

After the covariate adjustment for the pretest scores, the ANCOVA results indicated that there was not a statistically significant difference in the post STEM Future-CIS scores between girls and boys participating in the treatment group A, $F(1,16) = 2.50, p = .138$, partial $\eta^2 = .161$. Given the small sample size and assumption violations, a Mann Whitney U, non-parametric analysis was also conducted to verify results. The results of the Mann Whitney U were not significant ($p = .573$). Effect size, based on Cohen (1988) was large $\eta^2 = .161$. The strength of the relationship between the type of group and the STEM Future-CIS was large, accounting for 16.1% of the variance of the dependent variable. The observed power was .31 which was moderate. The results indicate that the treatment was effective for both girls and boys.
Research Question 3

An ex-post facto, causal-comparative study with an ANCOVA was also included in this study to examine what statistically significant difference, if any, existed between the engineering career perceptions of students who identify as BIPOC and those who identify as White after engagement with near-peer mentors during STEM Club while controlling for the previous engineering career pathway perceptions.

An noted, the analysis of covariance (ANCOVA) was chosen as the best analysis for the within group design. The pretest data served as the covariate, and the posttest data served as the dependent variable. Independent variable categories include the racial/ethnic identities of BIPOC and white. The descriptive statistics of the independent variable groups are outlined in Table 15, including the mean, standard deviation, adjusted mean score, and standard error of each group.
Table 15

Descriptive Statistics of Racial/Ethnic Groups in Treatment Group A (n = 19)

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Covariate Pretest M (SD)</th>
<th>Dependent Variable Posttest M (SD)</th>
<th>M adj (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIPOC (n = 9)</td>
<td>3.91 (0.71)</td>
<td>3.98 (1.15)</td>
<td>4.05 (0.25)</td>
</tr>
<tr>
<td>White (n = 10)</td>
<td>3.95 (0.58)</td>
<td>4.22 (0.67)</td>
<td>4.20 (0.23)</td>
</tr>
</tbody>
</table>

Note: Covariates appearing in the model were evaluated at the following values:

Covariate = 3.934453781512605.

Assumptions

Assumption tests were completed prior to conducting the ANCOVA. Kolmogorov-Smirnov tests were used to assess the normality of each grouping variable based on the small sample size of each group. The significant value for students who identify as BIPOC was $p = .02$ and $p = .20$ for students who identify as white. Therefore, the assumption of normality is only tenable for the post STEM Future-CIS means of the students who identify as White as $p > .05$ because for students who identify as BIPOC, $p < .05$.

The data set showed no outliers in an exploration of boxplots of grouping variables, as shown in Figure 9.
Additionally, the predicted values and standardized residual values produced by the one-way ANCOVA procedure were inspected for outliers. The largest standardized residual value was 1.81 indicating that the dataset did not include any outliers exceeding the maximum of ± 3 standard deviations. A Kolmogorov-Smirnov test of normality for the standardized residuals resulted in no significant values. Therefore, the assumption of normality was met for the standardized residual data.

The homogeneity of variance was evaluated in two ways. The predicted values and standardized residuals were plotted in a scatter pattern to find that the assumption of homoscedasticity was met, as shown in Figure 10. Levene’s Test for Equality of Variance confirmed that the variances were equal ($p = .05$) as $p = .94$. Therefore, the assumption of homogeneity of variances was not violated.
Figure 10

*Scatterplot of the ANCOVA Predicted Values and Standardized Residual Values.*

The assumption of linearity was explored by visually examining scatterplots. As shown in Figure 11, a linear relationship existed between the pretest and posttest for each group.
In a univariate linear model, the Tests of Between-Subjects Effects indicated the assumption of the homogeneity of regression slopes was not statistically significant, $F(1,16) = 2.212, p = .161$; therefore the assumption of homogeneity of regression slopes was met as $p > .05$.

**Analysis Results**

After the covariate adjustment for the pretest scores, the ANCOVA results indicated that there was not a statistically significant difference in the post STEM Future-CIS scores between students who identify as BIPOC and students who identify as White participating in the treatment group A, $F(1,16) = 2.21, p = .161$, partial $\eta^2 = .145$. Given the small sample size, a Mann Whitney U, a non-parametric analysis was also conducted to verify results. Results of the Mann Whitney U were not significant ($p = .863$). Examination of the descriptive statistics indicated that students who identify as White in the treatment group A scored higher on the post STEM Future-CIS than students who identify as BIPOC in the same group; however, this
difference was not at a significant level. Effect size, based on Cohen (1988) was large \( \eta^2 = .145 \).
The strength of the relationship between the type of group and the STEM Future-CIS was large, accounting for 16.1% of the variance of the dependent variable. The observed power was .28 which was small.

**Summary**

Three research questions were explored with descriptive statistics and inferential statistics. The ANCOVA test for Research Question 1 revealed a statistically significant difference across groups, with the statistically significant difference being between the treatment group and the comparison group. Further, ANCOVAs revealed no statistically significant differences in the perceptions of engineering career pathways between girls and boys or between BIPOC and White populations in the treatment group.
CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

Expanding engineering career pathways, especially for underrepresented student populations is crucial to innovation and the worldwide economy (Rodriguez et al., 2017; Roman, 2021). As aforementioned, little research has explored the expansion of engineering career pathway perceptions in elementary students, albeit career interest development begins to form in pre-adolescence and expands in response to internal and external factors (Falco, 2016; Gottfredson, 1981). This study sought to explore a gap in the literature examining the influence of engineering education interventions focused on students in the elementary grades (Capobianco et al., 2012; Pantoya et al., 2015; Paul et al., 2020). The primary purpose of this quantitative study, a quasi-experimental, pretest-posttest non-equivalent control group study, was to explore the influence of interaction with a near-peer mentor during a STEM Club on the perceptions about the engineering career pathways of elementary students. The study included students in the second through fifth grades in a small, suburban, parochial school and investigated the following research questions:

Research Question 1: To what extent, if any, does suburban parochial students’ participation in a near-peer mentor experience during STEM Club influence second-fifth grade students’ perceptions about their engineering career pathways, defined in the constructs of SCCT: self-efficacy, outcome expectation, interest, personal goals, personal inputs, and contextual supports, controlling for the previous engineering career pathway perceptions with pre-intervention scale surveys, as measured by the STEM Future-CIS instrument?

The secondary purpose, using a causal comparative approach was to explore two additional research questions:
Research Question 2: While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of girls and boys after engagement with near-peer mentors during STEM Club?

Research Question 3: While controlling for the previous engineering career pathway perceptions, what statistically significant difference, if any, exists between the engineering career perceptions of students who identify as BIPOC and those who identify as white after engagement with near-peer mentors during STEM Club?

**Study Findings**

STEM Future-CIS Survey data collected from 53 students was analyzed to examine the impact of the interaction with near-peer mentors during STEM Club on the mentees’ engineering pathway perceptions. Analysis of Covariance (ANCOVA) testing showed statistically significant differences between the treatment and comparison group in reference to Research Question 1 but no statistically significant difference in the pre-STEM Future-CIS and post STEM Future-CIS results for Research Question 2 or Research Question 3.

**Research Question 1**

The initial ANCOVA testing for this research question showed a statistically significant difference between the independent variable groups. The engineering career pathway perceptions of the treatment groups were statistically different from those of the comparison group, but not of the control group.

Like the Army Educational Outreach Program or the Gains in the Education of Mathematics and Science (GEMS), the statistical data remains encouraging for future studies (Brown et al., 2020). The data from this study indicated that students who received mentorship in the treatment group increased in their engineering career interest. These findings support the
importance of exposing elementary students to various careers options with the scaffolding of mentoring to build self-efficacy (Altoum, 2021; Falco, 2016; Zhao et al., 2023). Interestingly, in the presence of the mentor, participants in the treatment group showed an increase in self-efficacy and interest, while there was little change in personal goals and outcome expectations as evidenced by the STEM Future-CIS indicators from the covariate pretest to the dependent variable posttest. The findings on self-efficacy and interest are similar to the findings on research with middle and high school aged students (Clarke-Midura, 2016; Clarke-Midura et al., 2018; Sun & Clarke-Midura, 2022). The near-peer mentors provided treatment group A participants with a sounding board, advisor, and extra pair of hands. The project completion and design success, although not quantified in the data, differed between the treatment group A and comparison group B. Participants in treatment group A, with the support of near-peer mentors, created bridges and towers with greater stability and design intricacy than the participants in comparison group B.

Research Question 2

Gender differences were the basis of research question two. Treatment group A consisted of 19 students, nine of whom were girls. The group's grade levels (age) were not equally distributed as three students were in 2nd grade, six were in 3rd grade, four were in 4th grade, and six were in 5th grade. Seven near-peer mentors were working with treatment group A, five girls, three of whom identify as BIPOC, and two boys. The ANCOVA tests showed no statistically significant difference between girls' and boys' post STEM Future-CIS perceptions.

Despite the determination that no statistically significant change occurred, the results of the exploration of differences in the impact on girls and boys remain helpful. The statistical mean of the STEM Future-CIS for both girls and boys increased. The girls' scores grew from 3.89
(pretest) to 4.02 (posttest); the mean score for the boys increased from 3.97 (pretest) to 4.10 (posttest). It is important to note that the increase in both the girls’ and the boys’ group was identical (both groups grew .13 points). Thus, although the engineering career pathway perceptions of the girls did not close the gap, they did not fall behind. Furthermore, these results indicate that the treatment was equally successful for girls and boys.

A wealth of research has been devoted to exploring differences in attitudes, self-efficacy, and interests of girls and boys in reference to the broad category of STEM careers. Prior studies have shown that a considerable percentage of girls' career aspirations are a response to both the impacts of nurture and nature (Brown et al., 2016; Unlu & Dokme, 2018; van den Hurk et al., 2019). This present study did not include academic achievement as a variable, so existing skillsets and abilities (both of which can be influenced by nurture and nature) were not considered beyond the students’ self-reporting of abilities in the STEM Future-CIS instrument.

**Research Question 3**

Racial/ethnic identity was the basis of research question three. The ANCOVA testing for this question explored the difference between the engineering career pathway perceptions of students who identify as white and students who identify as BIPOC in treatment group A. Although there were differences in the groups’ mean scores, the ANCOVA showed no statistically significant differences between the two racial groups. However, it is important to note the marked differences in the means of participants who identified as white contrasted with the results of those students who identified as BIPOC. The distribution of the racial/ethnic groups in treatment group A was quite similar, with ten students identifying as white and nine as BIPOC. Of the students identifying as white, five were girls and five were boys. Of the BIPOC-identifying students four were girls and five were boys. The pretest and posttest mean scores
from the STEM Future-CIS were nearly unchanged for the students identifying as BIPOC, while the means of the students identifying as white clearly increased. Furthermore, a comparison of BIPOC girls and BIPOC boys indicated that the difference between the means for the girls was negative, while the difference in the means for the boys was positive.

The findings regarding the difference between BIPOC girls and boys were not consistent with existing research on the influence of near-peer mentors on underrepresented populations (Clarke-Midura et al., 2018). Given that the near-peer mentors who identified as BIPOC were girls while all the boy near-peer mentors were white, prior research would suggest a likely increase in the girls’ posttest engineering career pathways data and a possible decrease among the boys (given the differences in racial identity) (Clarke-Midura et al., 2016). However, this present study found that the means for the girls’ engineering career pathways data decreased. Studies in related literature have indicated that underrepresented populations benefit from near-peer mentors to whom they can relate (Al-thani et al., 2023; Clarke-Midura et al., 2018; Tenenbaum et al., 2014). As such, this study’s inconsistent finding requires reflection concerning ways the present study could have been more carefully structured to better meet the needs of participants who identify as BIPOC girls.

**Limitations**

This study was impacted by two uncontrollable factors: weather and illness. The study was planned for a January 2024 start date. The participants were enrolled, but before the intervention began, the geographic area experienced a snowstorm that canceled school for six days. The STEM Club for treatment group A and comparison group B began the week when students returned to classes. This delayed commencement of the club impacted the timing of the STEM Future-CIS pretest submission. The original expectation was for the survey to occur an
entire week before the intervention began, not just one day. The snow delay also reduced the near-peer mentor training contact hours significantly. Additionally, during the study timeframe, illness dramatically impacted school attendance. According to school attendance records, as many as half of the students in the school missed one or more days of class due to flu, strep, or COVID during the four weeks of the study. These absences influenced STEM Club attendance too; multiple participants missed one STEM Club meeting. To overcome the absences, the study was extended for one week to give the participants more exposure, and the post STEM Future-CIS was administered a week later than initially planned.

Another limitation of this study concerns validity—specifically, regarding the participants. With a small, parochial school sample population \( N = 66 \) with parents' self-selected participation, there was no possibility of randomization so the research findings were limited from the outset (Cresswell & Cresswell, 2023). Although the parents opted to have their child participate and chose the day of the week for participation, the parents did not know whether their child was in the treatment or comparison group at the point of participation. The uneven distribution of participants between the groups was also a concern. Although the three study groups were similar in size and gender distribution, they were not identical. Furthermore, the groups varied widely in both BIPOC population representation and grade level (age) distribution. Thus, the variances in group dynamics posed additional statistical concerns.

Additional population limitations were a lack of socioeconomic diversity, as most families in the school population were comprised of middle to high-income earners and college graduates with one or more degrees. With less than 25% of the school’s population identifying as a minority group, the sample population also lacked ethnic diversity.
Biases

There were several threats to bias in this study. The first threat was the close connection between the researcher and the participants. Due to the environment of the study, blind data gathering was not possible. By administering the STEM Future-CIS instruments to the control and treatment populations, bias was intentionally considered and mitigated (Gall et al., 2010). Additionally, a second person, an assistant teacher, was present when the STEM Future-CIS surveys (Playton et al., 2023) were administered. The teacher assistant was trained in appropriate administration techniques and ways to address students' questions without influencing the study (Gall et al., 2010). The researcher collaborated with the instrument developers, using a premade Qualtrics file supplied by Dr. Playton to ensure the STEM Future-CIS was administered with fidelity (Gall et al., 2010).

Subjectivities

This study was partly driven by stereotypical limitations that the researcher, a female, experienced in her education. No teacher or counselor encouraged her to be anything beyond stereotypical jobs for women: a secretary, a teacher, or a nurse. The researcher considered architecture in high school but was discouraged from pursuing this technical field during the few career counseling encounters she experienced. The only career role models she watched were in the military, and even in that sector, no one talked to the girls about pursuing roles other than that of pilot. In fact, there simply were no engineering or architectural role models present. As such, she wanted to conduct this study to learn more about ways to help other students, girls and boys in the majority and minority populations, identify and understand the extensive engineering opportunities available.
**Future Research**

Although the available research is extensive and growing, several areas of study beg to be explored. For example, results from new studies of students in kindergarten through third grade could provide teachers with vital insights to plan future interventions. Students are the most open to learning at this age and exhibit fewer behaviors tied to societal stereotypes (Steinke et al., 2021). Secondly, utilizing near-peer mentors who are only a few years older than the study participants is a largely untapped avenue of investigation even though the connections made by the near-peer mentors and mentees could dramatically impact engineering interests (Birney & McNamara, 2022; McLean et al., 2020). Finally, although there are several instruments for measuring career interest, most have not been tested with preadolescent groups. As such, future researchers would benefit from having more than one instrument available to evaluate participants of this age level. Pairing existing best practices in constructive experiences and relationships in an informal learning environment with early elementary students and peer mentors could produce positive results in developing engineering career pathways.

**Recommendations**

Although this study did not yield the results that were desired, the overall design of the study was worthwhile. If the study were to be repeated, several actions could be taken to strengthen the validity and possibly improve the outcomes.

The largest area of weakness was the duration of the study. A longer time frame with more interactions between the participants, the near-peer mentors, and the researcher could have greatly strengthened the data. By extending the STEM Club activities for several months, a whole semester, or an entire school year, the interactions between the near-peer mentors and mentees would be significantly reinforced since research has shown that frequent, prolonged
interactions build rapport and self-efficacy (Brown et al., 2020; Sun & Clarke-Midura, 2022). Additionally, a prolonged study would allow for more personal interactions with role models and authentic audiences. Granted, this present study included visitors at one session; however, the participants could have benefited from more frequent and varied exposures to in-person engineers (Kier & Blanchard, 2020; McLean et al., 2020).

The near-peer mentors played an integral role in treatment group A, but the effectiveness of the mentors varied. Several mentors kept their entire focus on the mentees and provided outstanding support during activities, while a couple were distracted and less engaged even though all of the mentors had an incentive to participate. Namely, eighth grade students at the test site are required to earn at least thirty hours of community services hours in a two-year time frame. Thus, the near-peer mentors earned community service hours for participation in the STEM Club. Perhaps, future studies could include a more extensive training of the near-peer mentors; this change could significantly enhance their effectiveness (Pon-Barry et al., 2017).

One final area of improvement would be adding qualitative data collection and analysis to create a mixed methodology investigation. Qualitative data would add deeper insights into the personal experiences of the participants; additionally, a qualitative component to this study could provide an avenue to better understand issues such as the variation in the near-peer mentors’ interaction level.

By all appearances, the STEM Club experiences were positive. The participants were actively engaged, joyful, and proud of their work. The interactions between the participants and the near-peer mentor, as well as the interactions between the participants and the researcher, were encouraging. The parent feedback was overwhelmingly positive, with the researcher being repeatedly told how much the participants loved STEM Club; however, there was no evidence of
this feedback in the strictly quantitative student data collection. Adding another dimension to the study would allow for the story of the STEM Club to be told, as well as measured in a much deeper way (Collins & Onwuegbuzie, 2006; Main et al., 2022; Morelock, 2017)

**Implications**

This study focused on the interaction between adolescents and near-peer mentors, but the study included several other components that also have implications for formal and informal educators. The informal learning environment allowed participants to engage in vicarious experiences in a low-risk environment, which expanded student agency while building skills (Hazari et al., 2022; Martinez & Whiting, 2021). High-engagement hands-on activities were completed through the use of the engineering design process. Additionally, each STEM Club opened with the reading of a children’s literature trade book related to the activity of the day. These books allowed the researcher to introduce role models through stories which featured diverse characters involved in exciting roles. The participants, especially the younger ones, enjoyed the books and took time to look at the pictures during the STEM Club’s free time. These story books offered participants the opportunity to make meaningful connections between the work of engineers and the creative activities completed in STEM Club (International Technology and Engineering Educators Association, 2020). Given the positive influence of the STEM themed literature, one implication of this study encourages educators to consider the use of children’s literature in the STEM classroom as recommended by the Nationals Science Teachers Association and the Children’s Book Council (NSTA, 2024).

**Conclusion**

Despite the challenges of time, weather, and illness coupled with the lack of statistically significant results, this study was a personal success for the participants, families, near-peer
mentors, and the researcher. The relationships and interactions between participants of different age levels in a low-risk, high-engagement environment were beneficial to everyone involved. The implications of the impact of robust hands-on activities, coupled with children’s literature, role models, and authentic audiences will have a lasting legacy with the students in treatment group A and comparison group B. Future research studies focusing on one or more components of this investigation have the potential to find significant results with a larger population over a longer duration.
REFERENCES


Bagenal, F. (2023). Enhancing demographics and career pathways of the space physics workforce in the US. *Frontiers in Astronomy and Space Sciences, 10.*
https://doi.org/10.3389/fspas.2023.1130803


https://doi.org/10.24908/pceea.vi.15839


https://doi.org/10.1109/FIE.2009.5350817.


https://doi.org/10.1002/sce.21670


https://doi.org/10.1037/lat0000202


https://media.defense.gov/2021/Jan/14/2002565311/-1/-1/0/FY20-INDUSTRIAL-CAPABILITIES-REPORT.PDF


https://doi.org/10.29329/ijpe.2020.268.1


https://doi.org/10.1103/PhysRevPhysEducRes.12.020106

https://lib.dr.iastate.edu/etd/17009


https://doi.org/10.1177/20101058211057325


https://ir.library.illinoisstate.edu/jste/vol52/iss1/5


https://doi.org/10.3389/fpsyg.2020.02204


Helmenstine, A.M. (2019, November 24). *Top reasons to study engineering*. ThoughtCo

https://www.thoughtco.com/why-study-engineering-604017


https://doi.org/10.1080/00940771.2022.2163218


https://doi.org/10.1016/j.linged.2017.05.003

https://doi.org/10.1007/s10763-019-10042-z

https://doi.org/10.1007/s11165-013-9389-3


https://doi.org/10.3390/educsci12010048


https://doi.org/10.1080/19404476.2023.2195794


https://doi.org/10.1080/03043797.2017.1287664

https://digitalcommons.odu.edu/cgi/viewcontent.cgi?article=1141&context=stemps_fac_pubs


https://doi.org/10.17226/12187

https://doi.org/10.17226/25284

https://doi.org/10.17226/25568


National Science and Technology Council, Interagency Working Group on Inclusion in STEM, Federal Coordination in STEM Education Subcommittee, Committee on STEM Education. (2021, September). *Best practices for diversity and inclusion in STEM education and research: A guide by and for federal agencies*. https://doi.org/10.17226/12187


https://www.nsta.org/best-stem-books-k-12


https://www.nspe.org/resources/licensure/why-pes-matter


Pon-Barry, H., Packard, B.W., & St. John, A. (2017). Expanding capacity and promoting inclusion in introductory computer science: a focus on near-peer mentor preparation and


https://www.researchgate.net/publication/289830420_Causal-comparative_research_designs

https://doi.org/10.20982/tqmp.19.1.p025

https://doi.org/10.1007/s41979-020-00034-y


https://www.britannica.com/technology/engineering

Society for Women Engineers. (2023). *Job outlook for engineers*. SWE.org
https://swe.org/research/2023/job-outlook/


https://epublications.marquette.edu/gjcp/vol1/iss2/14


https://www.timeshighereducation.com/student/subjects/what-can-you-do-general-engineering-degree


https://doi.org/10.1007/s11422-005-9009-2

unexpected benefits for mentors from traditionally underrepresented backgrounds.

*Perspectives on Undergraduate Research and Mentoring*: PURM, 4(1),

http://digitalcommons.nl.edu/ie/vol8/iss2/5

https://api.semanticscholar.org/CorpusID:151140471

https://www.teachengineering.org/

https://doi.org/10.1007/s11165-018-9729-4


122

https://doi.org/10.1080/09500693.2018.1540897


https://www.proquest.com/openview/a83a5a992763ccefadda510438f009d3/1.pdf?pq-origsite=gscholar&cbl=34845


adolescent girls within the context of informal science learning. *Journal of Youth Adolescence.* https://doi.org/10.1007/s10964-023-01868-6
APPENDIX A

Items on the STEM Future Career Identity Survey (STEM Future-CIS)

Directions: Students will complete the STEM Future-CIS online or Chromebooks.

Each question is a Likert scale with the Emojis for the following choices:
Never means, it does not happen.
Not Really means, it happens but not very much.
Sometimes, it happens about half of the time.
A Lot means, it happens most of the time.
Always means, it happens all of the time.

Science
1. I am able to do my science work.
2. I wonder about jobs that use science.
3. I want to talk to people who have jobs in science.
4. I will work hard in science class.

Engineering
1. I do well in work that uses engineering.
2. When I grow up, I could use engineering in my job.
3. I am able to finish projects that use engineering.
4. I will try hard at doing engineering work.
5. If I learn engineering, it can help me when I grow up.
6. My family would like it if I used engineering when I grow up.
7. I like doing engineering work.

Mathematics
1. I am able to do my math work.
2. I wonder about jobs that use math.
3. I want to talk to people who have jobs in math.
4. I am able to get good grades in math.
5. When I grow up, I could use math in my job.
6. I will work hard in math class.

Technology
1. I am good at using technology.
2. When I grow up, I could use technology in my job.
3. I like using technology.
4. I am able to learn new technology.
5. I could learn new technology that can help me with school.
6. I like jobs that use technology.
7. My family would like it if I used technology when I grow up.
8. If I learn technology, it could help me when I grow up.

# APPENDIX B

Curriculum Resources Used in STEM Club

<table>
<thead>
<tr>
<th>Club meeting</th>
<th>Activity</th>
<th>Engagement Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td>Testing shapes for strength and building tall towers.</td>
<td><strong>STEM Club 1 Slides</strong></td>
</tr>
<tr>
<td>January 23, 2024</td>
<td>What is an engineer? What do Civil Engineers do?</td>
<td><strong>Rosie Revere, Engineer</strong> by Andrea Beaty</td>
</tr>
<tr>
<td>January 25, 2024</td>
<td><strong>Teach Engineering Straw Tower Activity</strong></td>
<td><strong>Video: What Do Civil Engineers Do?</strong></td>
</tr>
</tbody>
</table>

1. Club participants will eat snacks and gather in groups.
2. Welcome by Mrs. Mangin
3. Read aloud by Mrs. Mangin (VE)
4. Hands-on activity: Using straws, try to make a tower that can support an index card.
   Can it support a ping-pong ball? (PA) (PS)
   *plastic bendy straws*
   *masking tape*
   *index cards*
   *assorted toys and balls to place on top*
   *Can you create a tower with straws and tape?*
   *Experiment with different shapes like squares, circles, and triangles.  
   *Think about the towers you saw in the slide show. What shape do you think is the strongest? Which shape will allow your tower to stand tallest?*
5. Watch the video about Civil Engineering (VE) (SP)
6. Hands-on activity: Using paper and tape, try to make the tallest tower you can that will support a tennis ball.
   Can it support a book? (PA) (PS)
   *construction paper*
   *news print*
   *cardstock*
   *index cards*
   *printer paper*
   *masking tape*
   *tennis balls*
   *books to place on top*
   *Your task is to create the tallest tower that can support a tennis ball. We will measure from the table to the bottom of the ball.*
What shapes should you use? Take a moment to talk to your partners and make a sketch of the tower. How will you make the tower components? Will you fold or roll the paper?

7. Discussion: Who can tell me about civil engineers? What did you learn about tower construction? If you were going to do this again, what materials would you like to have? (SP) (PS)

8. Dismiss

<table>
<thead>
<tr>
<th>Week 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January 30, 2024</td>
<td>Building bridges to help people or animals move from place to place.</td>
</tr>
<tr>
<td>February 1, 2024</td>
<td>STEM Club 2 Slides</td>
</tr>
<tr>
<td>Engineers build things like bridges and buildings using the Engineering Design Process</td>
<td>Someone Builds the Dream by Lisa Wheeler</td>
</tr>
<tr>
<td></td>
<td>Teach Engineering Activity Operation Build a Bridge*</td>
</tr>
<tr>
<td></td>
<td>Video: Job Talks – Civil Engineer</td>
</tr>
<tr>
<td></td>
<td>Visit from Germantown Public Works Employee</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Club participants will eat snacks and gather in groups.</td>
<td></td>
</tr>
<tr>
<td>2. Welcome by Mrs. Mangin</td>
<td></td>
</tr>
<tr>
<td>3. Read aloud by Mrs. Mangin (VE)</td>
<td></td>
</tr>
<tr>
<td>4. Hands-on activity: Create penny bridges. How do you span the distances? What if we add popsicle sticks? (PA) (PS)</td>
<td></td>
</tr>
<tr>
<td>*pennies</td>
<td></td>
</tr>
<tr>
<td>*popsicle sticks</td>
<td></td>
</tr>
<tr>
<td>Can you create an arch bridge or a beam bridge with penny supports? Can you span the supports with pennies? Can you span the supports with popsicle bridges?</td>
<td></td>
</tr>
<tr>
<td>How many pennies can you use in a bridge before it falls?</td>
<td></td>
</tr>
<tr>
<td>5. Watch the video about Civil Engineering (VE) (SP)</td>
<td></td>
</tr>
<tr>
<td>6. Hands-on activity: Using popsicle sticks and tape, create a truss bridge for animal toys to cross the river on the map (a challenge course will be placed on the floor in the room. The landforms on either side of the river will be elevated on boxes). (PA) (PS)</td>
<td></td>
</tr>
<tr>
<td>*popsicle sticks</td>
<td></td>
</tr>
<tr>
<td>*masking tape</td>
<td></td>
</tr>
<tr>
<td>*map challenge course</td>
<td></td>
</tr>
<tr>
<td>*assorted animal toys</td>
<td></td>
</tr>
</tbody>
</table>
Your task is to create a truss bridge that you can place over the river on the map to help the animals move from one side to the other safely. Make sure your bridge is placed carefully on the landforms then place animals on the bridge and start moving them across. How many animals can your bridge support? Can you bridge work in a different location along the river bank?

7. Public works employee visitor will talk about the bridges in our city and how they are maintained. (VE) (SP) (PS)

8. Discussion: What did you learn about Germantown bridges and the Public Works department? What did you learn about building bridges? If you were going to do this again, what materials would you like to have? (SP) (PS)

9. Dismiss

<table>
<thead>
<tr>
<th>Week 3</th>
<th>Design an original bridge structure to support weight.</th>
<th>STEM Club 3 Slides</th>
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<tbody>
<tr>
<td></td>
<td>Rosie Riveters</td>
<td>Secret Engineer: How Emily Roebling Built the Brooklyn Bridge by Rachel Dougherty</td>
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<td></td>
<td>Suspension Bridge lesson developed during a Teach Engineering workshop</td>
<td>Video: Career Spotlight – Civil Engineer</td>
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<td></td>
<td>Bridges add value to the community.</td>
<td>Visit from a Civil Engineer</td>
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</tbody>
</table>

1. Club participants will eat snacks and gather in groups.
2. Welcome by Mrs. Mangin
3. Watch the video about Civil Engineering (VE) (SP)
4. Read aloud by Mrs. Mangin (VE)
5. Engineering Design Challenge: Create a (suspension) bridge for the toys. Students will have part of next week’s club to continue this creation (PA) (PS)
   ***students will be encouraged to try to create a suspension bridge but they will be allowed to make any type of bridge
   *paper towel tubes
   *straws
   *popsicle sticks
   *string
   *yarn
   *note cards
   *wood splints
*cardboard  
*metal washers for weight  
*assorted tapes

**Procedures**

A. Create 2 towers to support your bridge (straws, popsicle sticks, paper towel tubes, etc). The towers should be self-supporting if possible or taped to the desktop. The towers need to have a shelf/ledge to support the roadway.

B. Choose a roadway material and create a long piece for the span of the roadway.

C. Choose your suspension cable and suspender material.

D. Use tape as your end anchors for the cables.

E. Attach the suspenders with knots and loops.

F. Can you get the roadway suspended and supported?

G. Can you put any weight (washers) on the roadway without collapsing the bridge?

6. Photograph and document bridges

7. Discussion: What challenges did you face in this activity? What is the purpose of the towers on a suspension bridge? If you were going to do this again, what materials would you like to have? (SP) (PS)

8. Dismiss

---

**Week 4**  
**February 13, 2024**  
**February 15, 2024**

Complete and bridge projects with parents and community stakeholders.  
See what we can do!  
[STEM Club 4 Slides](#)  
Parents and special visitors will visit the club after 4 pm.

1. Club participants will eat snacks and gather in groups.
2. Welcome by Mrs. Mangin
3. Watch the video about Civil Engineering (VE) (SP)
4. Continue the Engineering Design Challenge that began last week. (PA) (PS)
5. Interact with visitors, sharing designs. (PA)(PS) (SP)
6. Dismiss

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**Week 5**  
**February 20, 2024**  
**February 22, 2024**

Create structures of your choice and share bridge projects with parents and community stakeholders.  
[STEM Club 5 Slides](#)  
Andrew Learns about Engineers: Career Book for Kids by Tiffany Obeng
Free design and see what we can do!

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<tbody>
<tr>
<td>1.</td>
<td>Club participants will eat snacks and gather in groups.</td>
</tr>
<tr>
<td>2.</td>
<td>Welcome by Mrs. Mangin</td>
</tr>
<tr>
<td>3.</td>
<td>Read aloud by Mrs. Mangin (VE)</td>
</tr>
<tr>
<td>4.</td>
<td>Hands-on activity: Use Keva planks to create a small city (PA) (PS)</td>
</tr>
<tr>
<td>5.</td>
<td>Interact with visitors, sharing designs. (PA)(PS) (SP)</td>
</tr>
<tr>
<td>6.</td>
<td>Dismiss</td>
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</table>

Lessons are coded for sources of self-efficacy: performance accomplishments (PA), vicarious experiences (VE), social persuasions (SP), and physiological states (PS)

*Teach Engineering lessons are modified to meet the needs of STEM Club. The sources are listed as inspiration for club meetings. The activities for the STEM Club may employ different materials and simplified instructions.

APPENDIX C

Design Thinking Framework

APPENDIX D

Next Generations Science Standards for Engineering Design (NGSS, 2013)

K-2. Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education.

Science and Engineering Practices

Asking Questions and Defining Problems

- Ask questions based on observations to find more information about the natural or designed world. (K-2-ETS1-1)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-2)

Developing and Using Models

- Model in K-2 builds on prior experiences and processes to include using and developing models (i.e., diagrams, drawings, physical replica, schematic, or storyboard) that represent concrete events or design solutions.
- Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)

Analyzing and Interpreting Data

- Analyze data in K-2 builds on prior experiences and progressions to collecting, recording, and sharing observations.
- Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)

Disciplinary Core Ideas

ETS1.A: Defining and Defining Engineering Problems
- A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)
- Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-3)
- Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-4)

ETS1.B: Developing Possible Solutions
- Designers can be inspired through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solution to other people. (K-2-ETS1-2)

ETS1.C: Optimizing the Design Solution
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)

Crosscutting Concepts

Structure and Function
- The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

The section entitled “Disciplinary Core Ideas” is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reported with permission from the National Academy of Sciences.
3-5 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specific criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 3-5 builds on grade-k-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on grade-k-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

Disciplinary Core Ideas

ETS1A: Defining and Defining Engineering Problems

Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success (3-5-ETS1-1).

ETS1B: Developing Possible Solutions

Research on a problem should be carried out before beginning to design a solution. Testing a solution involves experimentation and trialing how well it performs under a range of likely conditions (3-5-ETS1-2).

ETS1C: Optimizing the Design Solution

Optimizing the design solution is an important part of the design process, and shared ideas can lead to improved designs (3-5-ETS1-3).

3-5.Electrical, Computer, and General Information Technology

APPENDIX E

Internal Review Board Approval

Institutional Review Board
Division of Research and Innovation
Office of Research Compliance
University of Memphis
215 Admin Bldg
Memphis, TN 38152-3370

February 13, 2024

PI Name: Didda Mongin
Co-Investigators:
Advisor and/or Co-PI: Amanda Rockinson
Submission Type: Initial
Title: Developing Engineering Career Pathway Perceptions in Elementary Students with Near-Peer Mentors in an Informal Learning Environment
IRB ID: PRO-FY2023-152

Expeditied Approval; February 13, 2024

The University of Memphis Institutional Review Board, FWA00006015, has reviewed your submission in accordance with all applicable statutes and regulations as well as ethical principles.

Approval of this project is given with the following obligations:

1. When the project is finished a completion submission is required
2. Any changes to the approved protocol requires board approval prior to implementation
3. When necessary submit an Incident/Adverse events for board review
4. Human subjects training is required every 2 years and to be kept current at cffprogram.org.

If applicable, please upload a copy of the IRB Approval Letter to your Cayuse Proposal record.

For additional questions or concerns please contact us at irb@memphis.edu or 901.673.2705

Thank you,
James P. Whelan, Ph.D.
Institutional Review Board Chair
The University of Memphis