“UNCOVER[ING] THE PRECIOUS POTENTIAL IN EVERY CHILD”: THE EFFECTS OF A STEM PRE-COLLEGE PROGRAM ON FORMER PARTICIPANTS’ ACADEMIC AND CAREER TRAJECTORIES

BY

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DISSERTATION

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ABSTRACT

Little is known about how former participants of STEM pre-college programs make sense of their program experiences. These pre-collegiate experiences influence former participants' academic, career, and life trajectories even if participants did not continue on STEM-related studies or careers. We investigated the experiences of former participants of STEM pre-college programs to understand the long-term effects of these programs using a qualitative research design, interpretative phenomenological analysis (IPA), and phenomenological variant of ecological systems theoretical approach (PVEST). Single-person, semi-structured interviews with former participants of STEM pre-college programs provided insight and perspectives about their experiences. Former participants expressed that their STEM pre-college program provided them the space to overcome self-limitations, be seen, value community, and exposure to STEM resources as foundational to their STEM academic and life outcomes. When designing and implementing STEM pre-college programs tailored to engaging racially underrepresented K-12 students, these findings provide STEM PCP stakeholders a novel approach to uncover information on programming effects long-term.

"Black Orions"

I thought about you.
Your divine intervention.
You see, you thought of me before I had a single moment of life on this earth
And I just wanted to tell you that I am gonna be all right.
Breathe.

Caught in the fields of cotton.
You longed for some resemblance of home and closure to this hell.
Dreams became true when you closed your eyes
And thought of how I was one of the fruits of your labor.
Breathe.

You heard about how the North Star guided others through the darkness, and you trusted no one or nothing but your God.
They would provide you the salvation as you waited for their return.
Hearing you smile in their heaven from seeing what he has made.
Breathe.

Divine intervention was not rapid.
You labored. You labored. You labored.
You wondered how anyone could you be so similar to something so evil.
Patience be to those who value it.
Breathe.

Beyond sky blue,
You died having lived a painful life.
It's amazing to me how beauty crept into your psyche,
And you held strongly to your convictions because they were the only thing that was real.
Breathe.

I thought about you today.
Your divine interventions.
You see, you thought of me before I had a single moment of life on this earth.
And I just wanted to tell you that,
You can breathe knowing that we are gonna be alright.

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LIST OF ABBREVIATIONS

KAB	Knowledge, attitudes, and behaviors
PCP	Pre-college program
PVEST	Phenomenological variant ecological systems theory
STEM	Science, technology, engineering and mathematics
U.S.	United States of America
URSs	Historically underrepresented students in STEM

DEFINITIONS AND OPERATIONALIZATIONS

Science, technology, engineering, and mathematics (STEM)

The National Science Foundation (NSF; 2014) defines science, technology, engineering, and mathematics (STEM) as containing occupations in biological, agricultural, life, computer, health, physical (e.g., chemistry, physics, astronomy, and earth/ocean/atmospheric sciences), social sciences (e.g., economics, psychology, sociology) as well as mathematics and statistics, engineering, and teachers of math and science fields in postsecondary and pre-college settings. Like the NSF, the American College Test (ACT; 2018) considers medical and health fields as a part of STEM. I borrow from both ACT and NSF definitions of STEM in this work. Along with these definitions, I define STEM as the broad field of occupations where individuals utilize and/or engage with disciplinary knowledge and practices from science and engineering fields. In this work, this word is operationalized in the context of STEM PCPs (defined later). Ultimately, STEM is used to describe people's specific actions in their educational journey in persisting toward a STEM major and/or career (Winkleby et al., 2009).

Historically underrepresented students in STEM (URSs)

This group consists of underrepresented students (e.g., Black, Latino, American Indians or Alaska Natives, first-generation, women, and low-income persons) in STEM fields in the United States (U.S.; Eagan et al., 2013; National Academies of Sciences, Engineering, and Medicine, 2016). The term, URS, is outdated within academic literature describing underrepresentation in STEM fields. However, I refer to URSs throughout my work since this specific demographic set is well documented in the STEM research literature (Institute of Medicine, 2010). I am aware of emerging groups as underrepresented, including ability, age, sexual immigration-generational, and religious backgrounds (A. M. Ortiz & Waterman, 2016; Wang, 2020); however, I will not include these emerging underrepresented groups in this work.

Persistence and retention

Postsecondary persistence is students' ongoing enrollment in postsecondary education, while retention, instead, describes ongoing enrollment in their first postsecondary institution (Mayhew et al., 2016).

Educational and occupational inequality and STEM inequality

Educational and occupational inequality is when members of a group have unequal access to social, economic, and cultural assets (i.e., educational and occupational opportunities), that affects other groups' fair and equal access to the same resources (Grusky & Manwai C. Ku, 2008; Lewis-McCoy, 2014). In this work, STEM inequality is when members of a group have unequal access to STEM-specific opportunities, majors, careers, fields, and paths that affects other groups' fair and equal access to the same opportunities.

Pre-college program (PCP)

PCP represents an education intervention for K-12 students before postsecondary attendance. Many studies have interchangeably referred to PCPs with other names including but not limited to college-outreach (e.g., Denner et al., 2005), college bridge (e.g., Strayhorn, 2011), college-preparation (e.g., Aidman & Malerba, 2017), college-access (e.g., Epps et al., 2016), and pre-college (e.g., Epps et al., 2016) though some (e.g., bridge) can differ in its design and implementation.

STEM PCP

STEM PCP describes a PCP with a STEM-focused mission of addressing URSs' enrollment and retention difficulties in STEM majors and careers (Kitchen et al., 2018).

CHAPTER 1: INTRODUCTION

Introduction

The United States (U.S.) has had a long-term interest in increasing and diversifying the STEM pipeline since the 1960s (DeJarnette, 2018; Hagedorn & Purnamasari, 2012; National Center for Science and Engineering Statistics, 2019; Winkleby et al., 2009), yet despite this persistent endeavor, the U.S. has an alarming issue in adequately supporting first-generation, low-income, Black, Latino, Native American, women, and other historically underrepresented students toward degree completion in STEM fields (Eagan et al., 2013; Hagedorn & Purnamasari, 2012; Institute of Medicine, 2007, 2010). These students typically enroll in remedial coursework, have lower educational success (i.e., GPA) compared to peers with college-educated parents, and have lower baccalaureate participation and attainment rates than non-minority, higher-income, non-first-generation college students (Le et al., 2016). STEM graduation rates in 2016 show women earning bachelor's, master's, and doctorate degrees at 50, 44, and 41 percent, respectively, while Black, Latino, and Native American people earned bachelor's, master's, and doctorate degrees at 22, 13, and nine percent respectively (National Center for Science and Engineering Statistics, 2019). These statistics differ grossly when intersecting multiple social identities; thus, posing a great need to address the various academic and structural inequalities within the STEM fields that limit URSs' success. As the U.S. job market continues to evolve, postsecondary educators need to effectively respond to issues of underrepresentation in postsecondary institutions and STEM pathways (Institute of Medicine, 2010).

Literature review

Historical underrepresentation in STEM

Though stagnant funding in the early 1950s led to the creation of the NSF, the U.S. increased its federal dollars substantially in response to the Soviet Union's Sputnik satellite launch in 1957. Thus, this Cold War event put "unprecedented new resources into advanced research" for 4-year postsecondary institutions (Thelin, 2011, p. 280) and created "greater interest in community college vocational programs (Brint & Karabel, 1989, p. 83) via the Vocational Act of 1973 and Higher Education Act of 1965. As a result, 2-year and 4-year postsecondary institutions benefited greatly from these renewed federal policies (Brint & Karabel, 1989) and this competitive STEM spirit persisted for decades. In the 2000s, the Institute of Medicine (2007, 2010) published *Rising above the gathering storm, revisited: Rapidly approaching category 5* and *Rising above the gathering storm revisited: Rapidly approaching category 5* calling for a concerted national effort to meet the future demands of the U.S. job market in STEM fields. Though these works do not acknowledge the explicit function and role of racism and capitalism driving unequal access to STEM careers and fields, many scholars cite these works as instrumental pieces that further galvanized STEM funding and ongoing STEM initiatives, interventions and endeavors for broadening participation in STEM throughout the 2010s (Ashley et al., 2017; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2016, 2019; National Research Council, 2012; National Science Board, 2014).

Many of these events coincide with the establishment of STEM infrastructure and the blooming of grander ideas related to transforming the U.S. postsecondary system to become universal, accessible, and capable of removing the educational inequalities of the U.S. (Zook, 1947). In considering these historical events, I argue that many of the interventions toward impacting the learning outcomes of students in STEM prior to 1965 include postsecondary institution-building as well as changes to institutional mission, curriculum, classroom, and research efforts to address STEM needs of the U.S. Alongside the aforementioned existing theoretical and conceptual models related to URSs' retention, various approaches were instituted by postsecondary institutions after 1965 to address specific issues of URSs' retention.

Intervention programs

Several strategies have been implemented by P-20 stakeholders to address issues of racial underrepresentation in STEM fields, including articulation agreements, academic and curricular supports, curricular revisions, professional development, peer support interventions, mentorship programs, undergraduate research experiences, STEM-comprehensive programs (e.g., Meyerhoff Scholarship program, etc.) and STEM pre-college programs (PCPs) (Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2016, 2018, 2019; National Research Council, 2012; Wang, 2020). Altogether, these promising STEM-specific approaches provide impactful means for supporting URSs through their postsecondary STEM journeys. Considering these STEM-specific approaches, I will examine an emerging approach that I believe effectively addresses the STEM inequalities of URSs.

STEM pre-college programs for underrepresented students

PCPs represent one example of these postsecondary interventions. STEM PCPs, and PCPs, in general, have delivered supplemental curriculum, skills, and resources for URSs to successfully navigate STEM majors and careers (Ashley et al., 2017; Douglas & Attewell, 2014). Many studies have focused on researching STEM PCPs to improve the program's quality and effectiveness (Ashley et al., 2017; Swail & Perna, 2002). However, in the discussion of STEM

PCPs' value and contribution to the lives of underrepresented students, few studies have investigated the long-term effects of these programs. Subsequently, STEM PCP stakeholders have little understanding of the factors that lead former participants to persist on to STEM-related majors and careers. Investigating the long-term impact of STEM PCPs is an essential piece of evidence for STEM PCPs' effectiveness to financial stakeholders and broader societal interests (Tierney, 2002).

With former participants of STEM PCPs having amazing insight into how to develop personally and professionally, this topic is essential because policymakers and postsecondary administrators need to prepare current URS constituents to manage college demands. In my work, I am interested in addressing the following question: how do historically underrepresented students in STEM who participate in a STEM pre-college program situate these experiences in their personal and professional development?

Overall, studies on STEM PCPs outline positive outcomes for STEM PCP participants. Ashley and colleagues (2017), though, note that these studies rarely reveal shortcomings and limits of STEM PCPs, which disserves many of the existing and novel STEM PCPs by neglecting to share common practices to avoid when establishing a new or revamping an old STEM PCP. Therefore, Ashley and colleagues suggest that future research share detailed guidance for STEM PCPs to aid in the continuous improvement and delivery of STEM content. Taken together, existing research designs fail to center the perspectives and experiences of participants in these STEM PCPs as well as fail to provide detailed, robust descriptions of STEM inequality phenomena. Fortunately, qualitative research designs can aid in this effort; therefore, I will draw from Spencer et al.'s (1997) phenomenological variant of ecological systems theory

(PVEST). Drawing from Bronfenbrenner's ecological model (1979, 1993), Spencer and colleagues (1997) posit in their PVEST that students' development of self hinges on:

- their environments providing iterative messaging and feedback on who and what they will be,
- their experience of meaning-making, and
- their "self" and identity in light of their microsystems and macrosystems.

Taken together, students' view of themselves evolve as a function of "experiences and feedback" influencing "self-perceptions" and "self-organization" of external and internal information about self, where they are capable of seeing themselves separate from others' expectations and negative, harmful assumptions and ideologies (Ozaki et al., 2020, p. 258).

While there are many researchers who have recently contributed to STEM retention literature using PVEST (Collins, 2018; Corneille et al., 2020; House, 2022; Maurya, 2022; McGee, 2013; McGee, 2009; McGee & Bentley, 2017; McGee & Spencer, 2015; Morton, 2017; Morton & Parsons, 2018), Morton remains as one of few authors who consistently publishes on PVEST, while investigating the STEM identity and retention of undergraduate Black students (Corwin et al., 2020; Morton, 2017, 2020; Morton & Parsons, 2018; Ortiz et al., 2019). Morton has found that during their undergraduate research experiences, Black female students were empowered by their gender and racial identities, utilized many tools to address arising challenges, and experienced "identity-based challenges." Based on Morton's work, PVEST may help to articulate the various social and structural factors that influence former participants' academic, career, and life trajectories during and after their STEM PCP experience, and this current study expands upon the previous usage of PVEST by exploring early-STEM exposure influence on STEM identity and retention of URSs.

While we know a fair deal about STEM PCPs' impacts on URSs' short and intermediate personal and professional goals, we know comparatively little about STEM PCPs' impact on URSs' long-term goals. Specifically, the factors that influence former participants of these programs to continue on to STEM majors and careers years later on in life. Centering former participants' reflections and experiences about their STEM PCP experiences can provide insight into the design and interventions that do work in promoting URSs throughout the STEM pipeline. This gap in the existing literature is what the present study aims to fill.

Methods

This study draws from a previous study that I performed using a basic qualitative design. The past study investigated the long-term effects of a STEM PCP on its former participants from participants' points of view and perspectives. Using thematic analysis, I learned how favorably three participants (*n* = 3) viewed their STEM PCP experience, early-STEM exposure, and STEM- interest and career messaging from various adults within their lives. One of the participants shared that the program "uncover[ed] the precious potential in every child." Having piloted this study, many of its methodological components inform this study's design. Existing literature does not center on former participants' reflections and experiences about their STEM PCP. This study aims to fill the gap by centering participants' experiences to provide insight into the design and interventions that do work in promoting USRs throughout the STEM pipeline. I used a revised semi-structured interview protocol (see Appendix A; Glesne, 2016; Weiss, 1995). Additionally, I offered a demographic, open-ended survey to former STEM PCP participants and I employed an interpretative phenomenological analysis. I added the demographic survey to clarify information collected during the interview process, and I added this specific methodological technique because it aids in understanding and uncovering how an experience impacts internal mechanisms of individuals (Mayoh & Onwuegbuzie, 2015).

Rationale for qualitative research design

Current research studies fail to understand STEM persistence and retention through the lens of former STEM PCP participants' experiences, who have matured and matriculated into the workforce, and this critical perspective can inform future iterations of STEM interventions. Using interpretative phenomenological analysis, my study explores how former participants conceptualize, internalize, and make meaning from their STEM PCP experiences. Since a qualitative methodological design may deliver grounded and solid findings, I selected qualitative methods to uncover nuances and details that may be more challenging to ascertain using quantitative methodological techniques alone (Glesne, 2016).

Sample and setting

For this study, I interviewed four former participants (n=4) of a STEM PCP called the Beginning Early Program (BEP) at Upper Midwest University. The program, program sites, and all participants were assigned pseudonyms. BEP has delivered over 40 years of access to year-round academic enrichment coursework at its university setting to K-12 URSs in an urban Midwestern city. With the goal of increasing students' confidence, study skills, and habits useful for successful matriculation into postsecondary institutions and healthcare professions, BEP students receive coursework on reading, science, and mathematics subjects throughout the academic school year and summer. Through established programming and connections, BEP allows students to gain STEM mentoring, collegiate lab experiences, and health-career workshops and conferences led by health professionals.

The number of participants used for my study considered the suggested homogenous sample size of between four and 12 for doctoral interpretative phenomenological analysis (IPA) studies (Smith, 2009). Former participants of the BEP who graduated from the program between 2011 and 2013 were selected and interviewed for my sample. I selected participants from this narrowed program completion timeframe because participants are more likely to have similar programmatic and cultural influences compared to individuals before 2011 and after 2013. Additionally, this timeframe depicts a period of at least nine years of post-program experience (e.g., undergraduate and postgraduate training, employment, income, lived experience, etc.) for the participants.

Sampling procedures

Due to safety protocols to curb the spread of COVID-19, I started my study in January 2022 using Zoom, an online video conferencing tool, and University of Illinois Qualtrics survey platforms to perform all activities for this study (*Qualtrics*, 2020). I obtained participants for my study through purposive, convenience sampling (Creswell & Creswell, 2018; Smith et al., 2009). To do this, I connected with former participants through emails and social media. Current BEP leaders shared information about my study through their email listserv, and I posted my study on social media, and both of these practices were approved by an ethics review board. If former participants were interested in the study after encountering information about the study from BEP leaders or social media posts, the individual contacted me by email requesting for more information about the study and I then provided an informed consent form and coordinated a time to perform a semi-structured interview (see Appendix B).

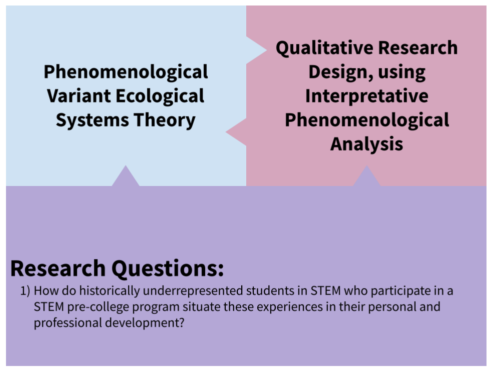
Participants were reminded throughout the study (i.e., written information in the consent letter, before the interview, after the interview, and before the survey) that participation is voluntary, and they can choose to leave the study whenever they see fit without penalty. In addition to the semi-structured interview, participants completed a 10-minute demographic, open-ended survey on their educational background and STEM-messaging from their STEM PCP experience using a unique participant ID shared with them after their interview. The study's activities, including the maximum assumed time for the survey and minimum interview time, ranged from 63 to 68 minutes. At the conclusion of each interview, I completed reflexive activities to support clear takeaways and improve my interviewing quality across interview sessions. These activities included speaking with my colleagues about summaries from each interview, reviewing and noting significant points in my interview notes, and writing several short reflections about the qualitative data and procedures (Delamont, 2016; Glesne, 2016; Smith et al., 2009). I also bracketed my initial reactions of this STEM PCP and others (Smith et al., 2009).

Data analysis plan

I analyzed my qualitative data sources using interpretative phenomenological analysis (Smith et al., 2009). Using Smith's IPA six-step process for analyzing qualitative data, I managed each qualitative data source, performed cross-case analysis, and identified emergent, divergent, and convergent themes. To do this, I used online artificial intelligence software (*Otter.ai*) to complete transcription of audio recordings (Otter, 2019), which I reviewed for accuracy and clarity. Next, I used *ATLAS.ti* software to analyze interviews and open-ended survey items (*ATLAS.ti*, Version 22.0.1 for Mac). Using this software, I organized connections between (divergence among) qualitative data cases into clusters. Lastly, I assigned each cluster a descriptive label in order to apply the theoretical frameworks informing this study (see Figure 1.1).

Figure 1.1

Interconnection between selected theoretical framework, research question, and research design



The interviews addressed my research question interests primarily because they provided context for how former participants experienced and understand their STEM PCP (see Appendix A). I designed my research protocol to effectively answer how their STEM PCP operates in their personal and professional development, and I used participants' responses to inform the findings of my study. To complement this work, I analyzed the collected survey data using an interpretative phenomenological analysis and I used this data, along with my interview and reflexive notes, to provide additional descriptive information and findings.

Trustworthiness

I implemented several strategies to increase the trustworthiness of my qualitative data collection and analysis processes, including reflexive writing, member checks, thick descriptions, and independent audit (Anfara et al., 2002; Creswell & Miller, 2000; Smith et al., 2009; Tracey, 2010). During the data collection portion of my study, I performed Maxwell's (203) reflexive writing techniques through multiple memos to improve and move my research study forward. I also consulted with colleagues before and after some interviews to deepen my conceptual understanding and theoretical framing of this study (see Creswell & Miller, 2000). During the data analysis portion of my study, I maintained an organized system for my notes, interview scheduling, data files, tables, and writing drafts to produce a "credible" trail of my analyses (Smith et al., 2009; Yin, 1989). Lastly, in my final write-up, I provided a thick description of the data wherever possible by providing extensive examples from qualitative data sources to corroborate my conclusions (Tracy, 2010).

Pilot study results

I was fortunate to collect the pilot results of this study during the fall 2019 semester. The pilot study results showed participants' discussions of three main themes that consistently appeared in the discussion. These elements were critical factors in developing the academic trajectory and STEM career trajectories for former STEM pre-college participants. Participants identified that their STEM pre-college provided them a *headstart* with college preparation services that made them unique from their peers. Participants also discussed how early STEM exposure gave them the chance to *live multiple lives* by providing them knowledge and access to STEM careers and opportunities. Finally, participants identified the effect of their STEM pre-college program on their *legacy* through mentorship and supporting others.

Summary

Based on a pilot study, this current study explores the effects of a STEM PCP on the academic and career trajectories of URSs. This research project is unique because it aligns with existing literature by exploring the impact of STEM interventions on URSs. However, this study's methodological and theoretical frameworks attempt to uncover the particular internal and external mechanisms that former participants attribute to their STEM intervention, a STEM PCP, to understand how participants understand their education and life trajectories as a function (or not) of their STEM PCP. Using PVEST as a theoretical lens, the level of introspection and insight from former participants in this study can only arise after individuals who have undergone their postsecondary or graduate experiences after their STEM PCP. It is crucial to perform this study, now more than ever, to capture the growing numbers of former participants of these programs and understand more about the factors that contribute to URSs' persistence on to STEM majors and careers to better the STEM outcomes of URSs for generations to come.

CHAPTER 2: LITERATURE REVIEW

Racial underrepresentation in higher education

In the United States (U.S.), first-generation and low-income persons constitute historically underrepresented groups who enroll in postsecondary institutions at lower rates compared to their actual population as college-aged students (Swail & Perna, 2002a). Studies support that underrepresented students are less likely to be college-ready and have lower bachelor-degree completion rates than peers (Le et al., 2016). The sociohistorical legacies of racism and capitalism mainly explain today's educational attainment (Massey, 2007). However, underrepresented students' personalities, abilities, and motivations also explain their postsecondary degree attainment (Aljohani, 2016), which is ever-present in STEM and postsecondary education literature.

Since the 1950s, postsecondary funding and enrollment surges across many racial groups have occurred due to significant social and political strife. Since White settlers first encountered Native Americans, settlers have orchestrated the removal of Native Americans from their land, mass genocide of Native American people, and the stripping of the economic opportunity afforded to present-day Native Americans (Alexander, 2010). Since the arrival on ships in North America in 1619, African Americans have navigated psychological and physical distress inflicted by the White, heteropatriarchal, capitalist society of the U.S., where Blacks were forced into slavery for more than 200 years, subjugated to segregation and low-paying jobs during Jim Crow for more than 80 years, and today, face continued oppression and anti-blackness (Alexander, 2010; Hill Collins, 2014; Massey, 2007). Following the Treaty of Guadalupe Hidalgo, many Latinos (in this case, used to describe White and Black Hispanics or any person with origin from any Latin and South American country) faced disenfranchisement and subjugation to lower-paying jobs during the early-20th century to vilification and defamation in the late-20th century (Massey, 2007). The U.S. banned people of Asian descent from immigrating in the 1920s; however, until this changed, specific Asian groups were prohibited from owning property, prohibited from becoming citizens, and subjugated to internment camps in the mid-20th century (Yosso, 2005).

Today, it is essential to note that some Asian groups' postsecondary success is related to their subgroup identification (Hartlep et al., 2013), and just as other racial and ethnic differences described above, there are varying degrees of postsecondary success that subgroups experience within racial and ethnic differences. For example, within the U.S. population, Vietnamese, Filipino, Hmong, Cambodian, Bhutanese, and Burmese people experience lower levels of postsecondary success than Chinese, Korean, Indian, and Japanese (Shivaram, 2021). Additionally, in the context of STEM, Asian women experience the duality of overrepresentation due to their race, yet underrepresentation due to their gender (Castro & Collins, 2021). Although this work does not cover the historical experiences of underrepresented groups in detail, it is crucial to capture the unique and harmful conditions of the racialized and gendered U.S. The point of this section is not to trivialize or reduce the unique experiences of underrepresented groups into a single paragraph; instead, this section is meant to note the nuanced experiences of racial URSs living in the U.S. and how this affected their postsecondary education pursuit and degree attainment before the 1960s.

The sociohistorical context of the U.S. significantly influenced the admissions and treatment of underrepresented students at postsecondary education institutions. Postsecondary institutions since the late-18th century were chartered to assimilate and Christianize Native Americans, and this grossly affected the postsecondary enrollment and success of Native

Americans to this day (O’Brien & Zudak, 1998; Thelin, 2011). African Americans were prohibited from attending public postsecondary institutions until the late-19th century; instead of admitting students, states established “separate but equal facilities,” leading to the creation of Historically Black Colleges and Universities (HBCUs; O’Brien & Zudak, 1998; Thelin, 2011). However, these institutions were underfunded and purposely made inferior (subjugated to career and technical education) by policymakers (O’Brien & Zudak, 1998; Thelin, 2011). The rise of Spanish-speaking Latino populations gave rise to the need to create and enroll people into English as Second Language courses to aid in language acquisition and proficiency; however, the federal government underfunded these ESL programs, making it difficult for Latinos to obtain these services, and subsequently, difficult for Latinos to reach their educational goals (O’Brien & Zudak, 1998). Finally, although Asian Americans are considered overrepresented in postsecondary education and stereotyped as a "model minority" today, Asian subgroups vary in their educational attainment; however, there is little research on Asian Americans in postsecondary education historically, especially Asian subgroups like Southeast Asians and Pacific Islanders (Hartlep et al., 2013).

Altogether, underrepresented groups’ lived experiences in the U.S. and within postsecondary institutions until the 1960s consisted of overt marginalization, hostility, and constrained opportunities (Anderson, 2002), and profound changes in inclusion and education and workplace opportunities significantly affected the U.S. beyond the 1960s. It is essential to identify important social and historical events that influence, to some extent, prevailing theoretical and conceptual models in postsecondary STEM pathways. These sociohistorical and political contexts directly (and indirectly) influence the existing and emerging theoretical and conceptual models related to addressing inequalities along STEM pathways for URSs. Therefore, it is important to acknowledge these historic trends before examining how theoretical and conceptual models perpetuate (or not) patterns of inequality in postsecondary STEM pathways.

Racial underrepresentation in STEM fields

Within the U.S., issues of STEM participation across racially underrepresented students persist (Eagan et al., 2013; Hagedorn & Purnamasari, 2012; Institute of Medicine, 2007, 2010). Reports show that these students are more likely to enroll in remedial collegiate courses, have lower academic collegiate success, and lower collegiate degree completion and attainment than non-minoritized counterparts (Le et al., 2016). In 2016, Black, Latino, and Native Americans combined earned STEM bachelor, master, and doctorate degrees at 22, 13, and 9 percent, respectively, despite representing 28 percent of the population (National Center for Science and Engineering Statistics, 2019). Despite this, there are great disparities across STEM fields (e.g., physical sciences v. life sciences) and when intersecting multiple social identities for some. At the intersection of choice and access, there is a great need to understand the internal and external complexities driving "who will do science," as Pearson and Fletcher (1994) deduced in their book, *Who Will Do Science? Educating the Next Generation.* As the U.S. job market evolves in favor of a highly-skilled STEM workforce, it will become increasingly important for researchers to effectively respond to issues of underrepresentation in STEM fields and explore meaningful options for improving STEM outcomes for URSs (Institute of Medicine, 2010).

Although many URSs struggle in their postsecondary STEM education journey, postsecondary educators have utilized various theoretical and conceptual frameworks to change these gross socioeconomic, gender, and racial differences in postsecondary STEM pathways. This work will review and critique the major theoretical and conceptual models guiding the persistence and retention of URSs in postsecondary STEM education spanning over 70 years.

Before examining each model's benefits and limits related to improving postsecondary STEM pathways, I will briefly review historical and social factors influencing these various theoretical and conceptual models. Then, I will move from individual-based to system-based theoretical and conceptual models. Lastly, I will conclude with the overall value of these models in light of improving postsecondary STEM pathways.

Historical STEM intervention efforts

The U.S. federal government embedded interests in STEM fields in the mission, curriculum, and classrooms of 4-year postsecondary institutions throughout the mid-1800s to 1900s (Thelin, 2011). Postsecondary institutions before the mid-1800s were majorly established for the elite and prioritized religious and liberal arts training (Geiger, 2016; Thelin, 2011). However, the first Morrill Land Grant Acts of 1862 and 1890 established postsecondary institutions that were "utilitarian" in nature and where these institutions taught agricultural, mechanical, and other practical arts (Geiger, 2016, p. 16). Through legislative action, the Morrill land grants offered affordable and accessible postsecondary education that by institutional design and mission focus "[did not] exclude other scientific and classical studies" ("The Morrill Act, 1862", 1961 as cited in Geiger, 2016, p. 17). For example, many 4-year land grant postsecondary institutions today include in their institutional name "A&M" to reflect their institutional mission of offering agricultural and mechanical training to postsecondary-attending students (e.g., Alabama, Texas, and Louisiana A&M Universities; Thelin, 2011, p. 76). The enduring legacy of these land grants also set a precedent for the establishing HBCUs and their initial subverted educational beginnings, where they "were neglected with respect to facilities, salaries, and staffing" (Thelin, 2011, p. 136). The enduring legacy of these land grants also caused rippling effects for postsecondary education entirely. Before these land grants, postsecondary institutions "develiver[ed] kinds of practical instruction and services" that were favored by many forms of U.S. government (Thelin, 2011, p. 136). Fernandez and colleagues (2021) argue that profound access to STEM PhDs was made possible through "mass undergraduate education [push], decentralized funding of universities, and flexible mission charters for Ph.D. training" (p. 79). Indeed, this work pushes the significant role of higher education, and the U.S. government instituted profound changes that led to the current system and structure as we understand it today.

Approaches to addressing underrepresented persistence and retention in STEM majors and careers

Although many URSs struggle in their postsecondary STEM education journey, postsecondary educators have utilized several approaches to address these racial differences within the STEM pipeline, including, but not limited to, improved articulation agreements, STEM academic and curricular supports, supportive and inclusive STEM curriculum revisions, professional development on STEM equity and inclusion topics for STEM postsecondary educators, peer supports (e.g., STEM living-learning communities, STEM study groups, social integration activities, etc.), mentorship, undergraduate research experiences, STEM collegiate comprehensive programs (e.g., Meyerhoff Scholarship program, Vanderbilt University School of Medicine African American and Disadvantaged Student Pipeline Program, etc.), and STEM PCPs (Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2016, 2018b, 2019; National Research Council, 2012; Wang, 2020). This work will explore these current and emerging efforts to address STEM access and success issues, specifically outlining the factors contributing to our current understanding of persistence and completion to better understand young people's learning experiences.

Individual-based factors impacting STEM inequality

Individual-based factors place the problem or issue of STEM inequalities onto individuals. These include, but are not limited to, psychological attributes and characteristics (i.e., STEM interest, self-efficacy, sense of belonging, and STEM-identity), gender and race stereotype threat, capital and capital deficiency, social cognitive career theory, and aspirational momentum (Alemdar et al., 2018; Bering et al., 2008; Bourdieu, 2002; Coleman, 1988; Deil-Amen & Turley, 2007; Institute of Medicine, 2007; Lareau, 2003; Lewis-McCoy, 2014; Massey et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2016; Renn & Reason, 2013; Wang, 2020).

Psychological attributes and success characteristics. STEM interest, self-efficacy, sense of belonging, and STEM-identity are all psychological attributes described as relevant and necessary for individuals interested in STEM majors and careers to succeed (Ashley et al., 2017; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2018b; National Academy of Engineering, 2018). Culminating studies point to the importance of these well-defined concepts to URSs pursuing STEM careers, and I will briefly explain each construct. Any single (or combination of) STEM learning opportunities can contribute to URSs' STEM interests in pursuing and continuing along the STEM pathway (Dou et al., 2019; Murray et al., 2016). More STEM opportunities can further URSs' self-efficacy, which is the confident belief in their ability to successfully do specific tasks (Bandura, 1997; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2019). Through continued exposure and engagement in these STEM learning opportunities and URSs' postsecondary education, they develop a sense of belonging (Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2016; National Academy of Engineering, 2018;

Strayhorn, 2016). Lastly, STEM-identity describes the interactive, complicated internal mechanisms one forms from interfacing with STEM learning opportunities that motivate continued "behavior[s]," "choices," and affinity toward the STEM discipline and community (Dou et al., 2019, p. 45). Taken altogether, these constructs shape how researchers understand URSs persistence in postsecondary STEM pathways. By outlining and attending to the internal mechanisms that influence STEM career interests, researchers can work toward investigating how particular interventions may affect these particular constructs within URSs. Thus, this process has given further credence to these constructs (Ashley et al., 2017).

Gender and race stereotype threat. Gender and race stereotype threats are described as being harmful to URSs persistence along postsecondary STEM pathways. As a concept, Steele & Aronson (1995) were the first to define stereotype threat as the effect of existing negative stereotypes on a person's performance on a given task. Steele and Aronson documented that people of a stigmatized group experience stereotype threat when negative stereotypes are made salient. The risk of affirming these negative stereotypes drives them to perform worse in evaluative situations confirming the stereotype. Under repeated stereotype threat conditions, URSs may disconnect from their STEM disciplinary interests, cope by developing and engaging in other areas of interests, and internalize microaggressions that afflict their self-concept and STEM self-efficacy (National Academies of Sciences, Engineering, and Medicine, 2016). Despite awareness of stereotype threat across postsecondary settings, URSs still report pre-college and postsecondary challenges navigating microaggressions and biases from past teachers, postsecondary educators, postsecondary administrators, and peers (Wang, 2020).

Capital and social networks. URSs underperformance in STEM, and academics in general, derive from notions that URSs are capital deficient compared to non-URS peers

(Massey, 2007). As an emerging theoretical perspective with the four types of capital: human, social, cultural, and economic capital, I will briefly describe each. Human capital is the “knowledge, skills, abilities" from training and education, while social and cultural capital constitutes the benefits only accessible to members due to their enactment of “norms, values, and behaviors” as a function of their membership in a specific social network (Bourdieu, 2002; Strayhorn, 2016). Economic capital is the direct access to “money. . . [or] property rights” (Bourdieu, 2002, p. 16). In the context of postsecondary STEM pathways, acknowledgment of and contributions to URSs’ capital can further their participation along postsecondary STEM pathways (Massey et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2019). Research on capital has led to a greater understanding of individuals' knowledge of and interface within their respective environments. Research on capital helps contribute to our collective sense of how people engage with and navigate their environments.

Social cognitive career theory. Another prominent individual-based factor explaining STEM inequalities is social cognitive career theory (SCCT), which examines the internal and external mechanisms that drive individuals’ career behaviors and choices (Morton, 2017; National Academy of Engineering, 2018). SCCT subsumes several individual factors mentioned above. To this date, SCCT describes targeted career knowledge, self-efficacy, and other barriers that can influence URSs’ trajectories long-term (Carpi et al., 2017; National Academy of Engineering, 2018). This theoretical model accounts for individual (i.e., race, gender, health, personality traits) and background (i.e., home and school environment and family income) contexts as influential on STEM learning opportunities and experiences and outcome expectations (e.g., personal evaluation, feedback, or internal effects). This theoretical model helps frame the comprehensive and complicated internal and external mechanisms when young people pursue postsecondary STEM pathways. SCCT may explain what may assist URSs in their postsecondary STEM pathway, and altogether, SCCT may help existing postsecondary educators design and implement support for URSs.

Aspirational momentum. Lastly, Wang considers STEM pathways from the perspective of 2-year postsecondary institutions. Wang's (2015, 2016, 2020) central argument over the past several years on STEM transfer work revolves around developing students' aspirational momentum, where students "build and extend transfer [their] capital" (Wang et al., 2017, p. 314). These developmental efforts include appropriate and adequate social and academic support, interactions, advising, and knowledge useful for transferring. Wang has explored the application of momentum in reviewing the STEM coursework quality points that 2-year postsecondary students obtain early on in their studies (2015) and in documenting students' experience in STEM transfer as either continued (described as "linear upward"), detoured, deterred, or brok[en] away from STEM coursework, interests, and pursuits (Wang, 2020, p. 24). Though this work narrowly applies to 2-year postsecondary students, this conceptual model is beneficial to the retention efforts of URSs because it aids 2-year postsecondary educators in identifying the choices and behaviors that may help or limit URSs success along their postsecondary STEM journey.

In summary, many individual-based factors suffer from narrowed focus and little critique of institutional/systemic role and responsibility to meaningfully benefit URSs pursuing postsecondary STEM paths. The proceeding section considers institutional/systemic factors contributing to STEM inequality in postsecondary settings, including those that partially address these limits.

Institution/Systemic-based factors impacting STEM inequality

Institution/Systemic-based factors place the problem or issue of STEM inequalities onto P-16 institutions and the various social systems organizing these P-16 institutions. These include, but are not limited to, adequate STEM preparation, admissions and affordability, icy postsecondary climates, STEM validation, STEM course sequencing, academic, curricular, and social supports, and transfer agreements (Aljohani, 2016; Bowen et al., 2006; Clark, 1960; Fike & Fike, 2008; Institute of Medicine, 2011; Jorstad et al., 2017; Mayhew et al., 2016; Metz, 2004; National Academies of Sciences, Engineering, and Medicine, 2016; Rendon, 1994; Thelin, 2011; Wang, 2020).

Adequate STEM preparation. Inadequate academic preparation for STEM majors and careers at the K-12 level is well documented within academic literature (Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2019; National Academy of Engineering, 2018). Conley (2008) posits that college readiness has sufficient preparation to enroll and succeed in postsecondary institutions without developmental or remedial coursework. Conley also shares that college readiness includes students' ability to readily access content knowledge and use appropriate academic behaviors. In particular, STEM preparation may look like URSs having adequate learning opportunities in math and science coursework to succeed in a postsecondary STEM pathway. To explain these differences among URSs, researchers point to poor K-12 teacher preparation (Institute of Medicine, 2007), low availability in rigorous science and math courses during middle and high school (ACT, 2018; Institute of Medicine, 2007; National Academy of Engineering, 2018), and educational and learning opportunity resource gaps between low- and high-SES, K-12 schools (National Academy of Engineering, 2018).

Admissions and affordability. URSs have been reluctantly considered for admission and enrollment by postsecondary institutions since the dawn of their creation (Crow & Dabars, 2020; Thelin, 2011). Rather than reckoning difficult and necessary ways to better support and address equity and inequality issues that URSs experience along their postsecondary STEM journeys, Crow and Dabars (2020) argue that modern-day postsecondary institutions define excellence through selectivity, and admissions to our most selective universities correlate strongly with privilege and affluence. Therefore, considering those who enroll in STEM fields offers postsecondary educators opportunities to review their existing admission practices and policies to be more equitable and accessible to URSs and their educational contexts.

Postsecondary affordability and financing also pose challenges to URSs degree completion in STEM majors. Uneven distribution of state financial resources to postsecondary institution types led to 4-year postsecondary institutions obtaining more funds despite having fewer students than 2-year postsecondary institutions (Wang, 2020). Chase and colleagues (2014), Dowd (2012), and Wang (2020) note that 2-year postsecondary students struggle with frequent financial burdens of housing, food, transportation, childcare, and other taken-for-granted everyday benefits that different socioeconomic classes have access. Though federal aid and Pell grants have minimally increased for low-income postsecondary students, since its inception, the pace of loan availability has risen even faster (Institute of Medicine, 2011). Additionally, postsecondary financial aid shifted from need-based to merit-based aid, potentially favoring affluent families while discouraging low-income students altogether due to the high debt potential of postsecondary education (Institute of Medicine, 2011; Johnstone, 2016; McGuinness Jr., 2016). Lastly, with many 4-year postsecondary institutions moving toward high-tuition/high-aid financial model due to decreases in state appropriations, rising tuition cost also has left an increasing burden on URSs and their families to manage the cost of postsecondary education as mentioned earlier (Institute of Medicine, 2011; Johnstone, 2016; McGuinness Jr., 2016).

Navigating icy postsecondary environments. Studies have noted chilly climate effects such as loneliness, micro/ macro-aggression, and other negative messaging or interaction from peers and educators either furthered or harmed students' transfer interest and progress. Other instances of icy postsecondary environments include the lack of cultural identity and feelings of belonging for some historically underrepresented groups in STEM (Jackson, 2013; Jorstad et al., 2017; National Academies of Sciences, Engineering, and Medicine, 2018b; Reyes, 2011; Wang, 2020). Similar to the concept of chilly climate, cooling-out may deter URSs from completing their postsecondary STEM journey. In Clark's (1960) cooling-out article, Clark argues that 2-year postsecondary advising and academic policies thwart students' ability to continue their education journey. These efforts can drive students to stop/drop out of school and pursue interests and goals contrary to their initial intent. These students do not continue to more advanced study (e.g., more advanced STEM coursework or transfer onward to 4-year postsecondary institutions). It is important to note that historically Black Colleges and Universities (HBCUs) and programs like the Meyerhoff Scholars Program at the University of Maryland, Baltimore County have dramatically increased the participation and success of African Americans with STEM degree credentialing (National Academies of Sciences, Engineering, and Medicine, 2016, 2018b). These are environments integratively combat factors driving STEM inequality in postsecondary settings.

STEM validation theory. Developed by Rendon (1994), STEM validation considers internal and external processes that encourage STEM persistence of underrepresented students by validating agents within students' lives (i.e., mentors, educators, and peers). Altogether, these validating agents trigger academic and interpersonal validation of students, which in turn affects their STEM self-efficacy, engagement, and understanding. This theory focuses on how institutions can utilize their person-power and programming resources to promote underrepresented students' navigation of "'traditional' cultural norms of science" (Burt et al., 2020, p. 20). Recent research supports STEM validation theory can provide a window into STEM identity development and demonstrate the elements within students' environments that aid in their persistence and success.

STEM gatekeeper courses and sequencing. STEM gatekeeper courses and sequencing are conceptually pertinent items to give attention to at the institution level. Depending on the postsecondary institution in question, STEM remedial coursework may (or may not) count toward URSs' STEM degree completion, which may extend URSs graduation time and cost (National Academies of Sciences, Engineering, and Medicine, 2016). STEM gatekeeper courses can cause URSs to continue or not along a postsecondary STEM pathway (National Research Council, 2012). Researchers have found that few URSs persist into more advanced STEM coursework when URSs enroll in remedial classes (Cohen & Kelly, 2019, 2020). How students manage and perform in these courses can determine how they decide to engage with their postsecondary STEM journey further. STEM course sequencing can also introduce and maintain STEM course gatekeeping (Chawla, 2020; Wang, 2020). The sequencing, rigidness, and inflexibility of the STEM curriculum can be a challenge for URSs to execute during their postsecondary STEM journey (National Research Council, 2012; Wang, 2020).

Academic, curricular, and social supports. Intentional opportunities designed for URSs can promote URSs' academic and social integration (Institute of Medicine, 2011). Wang

(2020) discusses various strategies to improve STEM student momentum, from redesigning advising practices to better meet varying and individual demands of students to embracing ongoing proactive advising practices and improving how advisors work with postsecondary faculty. Redesigned advising across postsecondary institutions to be more flexible in advising delivery can better support students with varying work schedules and role demands and create additional social and structural networks to show that postsecondary educators care about how students progress with coursework and personal goals.

Beyond academic support, postsecondary educators can also design undergraduate experiences that ensure URSs obtain the necessary skills and experiences to thrive in STEM experiences. Today's undergraduate students have many different opportunities to engage in research during their postsecondary experiences, either as course-based undergraduate research, independent study (e.g., Gilmore et al., 2015), summer research internship, or a living-learning community providing a research-based experience (Laursen et al., 2010). STEM living-learning communities, study groups, or other social integration activities provide URSs an outlet to share with one another the unique set of problems they face when their identities intersect and coping strategies, opportunities, and resources(Wang, 2020). Rather than managing through their STEM journeys alone, URSs can thrive from the collective knowledge and awareness of navigating STEM pipelines at their respective schools, and these peer-to-mentor and peer-to-peer experiences can be embedded in a number of STEM learning opportunities (e.g., postsecondary institution, STEM PCP, STEM comprehensive program, research experience, etc.; Institute of Medicine, 2011). The absence of these integrated activities can further hinder URSs' STEM identities and limit real-world experiences that enhance URS knowledge and interests in STEM fields.

Articulation agreements state- and nation-wide. The literature on STEM transfer at 2-year postsecondary institutions documents several issues that negatively affect students' persistence in STEM (Chase et al., 2014; Dowd, 2012; National Academies of Sciences, Engineering, and Medicine, 2016; National Research Council, 2012; Packard & Jeffers, 2013; Wang, 2020). Packard & Jeffers (2013) and Wang (2020) note the alarming quality of advising at 2-year postsecondary students. Students have obtained inaccurate information, leading to prolonged and expensive delays in their STEM degree program. Additionally, Dowd (2012) discusses the importance of clear articulation agreements and curriculum alignment between 2-year and 4-year postsecondary institutions. Wang (2020) goes further by sharing how 2-year postsecondary students in STEM have forsaken or delayed their STEM-degree pursuits due to insufficient transfer-policy transparency, expensive transfer partnerships, poor initial advising on STEM transfer coursework, and inadequate institutional supports for diverse student learners (Dowd, 2012; Hagedorn & Purnamasari, 2012; Packard & Jeffers, 2013, 2013; Wang, 2020). In turn, transferring studies from 2-year postsecondary institutions into 4-year institutions poses significant financial security concerns and risks to students' ability to complete their education in a timely manner.

In summary, institution/system-based factors struggle to acknowledge and support the unique background characteristics of URSs pursuing postsecondary STEM paths and isolate viable practices that recruit and sustain URSs enrollment in STEM fields. The proceeding section posits a less considered factor, ecological in nature, that contributes to STEM inequality in postsecondary settings.

Benefits and limits to institution/system-based factors. These institution/system-based factors have aided in our understanding of improving the learning experiences for URSs;

however, there are some limits to the utilization of these factors alone. Similar to individual-based factors, these factors enter responsibility of STEM inequality on the institutional agents' actions and choices, and the success of relationships between institutional agents across institutional entities. Additionally, these factors ignore the role of race and culture in affecting the lives and relationships between and among individuals within institutions and social systems (Morton, 2017).

Ecological factors Impacting STEM Inequality

Ecological factors place the problem or issue of STEM inequalities on the internal conditions of and interactions between individuals and institutions/systems. STEM collegiate comprehensive programs and STEM PCPs are examples of ecological-based programming.

STEM collegiate comprehensive programs. Programs like the Myerhoff program have dramatically increased the participation and success of African Americans with STEM degree credentialing (National Academies of Sciences, Engineering, and Medicine, 2016, 2018b). Through a summer bridge program combined with undergraduate peer support, financial support, mentoring, and research experiences, Myerhoff offers a highly structured program that indoctrinates scholars into the legacy and mission of the Myerhoff program. The Myerhoff program exemplifies a single postsecondary institution's commitment to an intentional and meaningful experience that trains and develops URSs. It sets up URSs for long-term success in the STEM journey, and there are similar programs to the Myerhoff program at institutions like Vanderbilt University, Ohio State University, and others.

STEM collegiate comprehensive programs encapsulate many of the concerns shared within the other STEM approaches. Due to the intricate nature of STEM inequalities for URSs, STEM comprehensive programs, like the other STEM-specific approaches, are introduced very late into URSs' academic journeys. STEM collegiate comprehensive programs target a specific subset of URSs who have successfully (or adequately) navigated their K-12 schooling experiences and are made aware of STEM collegiate comprehensive program offerings. This concern may be alleviated if postsecondary institutions choose to use tools at their disposal. Altogether, these promising STEM approaches provide great ways for supporting URSs through their postsecondary STEM journeys.

STEM PCPs. Of the emerging approaches reviewed, I believe the merits of STEM PCPs, specifically those that impact URS before postsecondary enrollment. I will provide some empirical evidence to further support this claim before concluding on the necessity of STEM PCPs to improve STEM outcomes URSs.

Though much of this work has pointed to the role and impact of postsecondary institutions on URSs during college, I argue that the current state of URSs condition requires looking into meaningfully impacting and improving their pre-college educational conditions. Swail and Perna (2002) note the vital need for PCPs given the current inequalities embedded in the U.S. education system:

> If society could regenerate the school system, early intervention and pre-college outreach programs would not be needed. But the reality is that schools are failing and children are falling through the cracks without being noticed. (p. 32)

In other words, there is a clear precedent for the role PCPs play in addressing educational inequalities. As stated earlier, policymakers and postsecondary educators have implemented several education initiatives to diversify the STEM pipeline. PCPs represent one example of these interventions; the Upward Bound program is an example of a PCP. Established in 1965, Upward Bound is the oldest federally-funded PCP that specifically targets disadvantaged, teenaged students who satisfy one or both of the following characteristics: low-income (student's family income is within 150 percent above of the poverty line), or first-generation (student is first college attendee in the family; Epps et al., 2016). Since 1965, the U.S. federal government has played a crucial role in establishing a PCP infrastructure (Swail & Perna, 2002b). In a national survey of these programs conducted in 1999, Swail and Perna reported over 1,100 programs. Though this number does not include bridge programs, many postsecondary institutions have bridge programs and/or federal programs like Upward Bound or GEAR UP. Despite these programs being for URSs, these programs systemically lack consistency in structure, curricular program offerings, and indefinite endowment (Ashley et al., 2017). Regardless, given the grave concerns of our K-12 education infrastructure, reviewing the benefits of PCPs, specifically STEM PCPs, is essential.

STEM PCPs, and PCPs, in general, have delivered supplemental curriculum, skills, and resources for URSs to successfully navigate the STEM pipeline (Ashley et al., 2017; Douglas & Attewell, 2014). Ashley and colleagues (2017) and Decker and McGill (2019) offer systematic reviews that explore other's research on STEM PCPs. STEM PCPs may have enormous benefits for racial URSs attending postsecondary institutions (e.g., Ashley et al., 2017). In particular, these STEM PCPs have improved students' retention and graduation rate as well as students' remediation, academic content knowledge, GPA, participation in research, increased interest in STEM, sense of belonging, sense of preparedness, networking with other students and faculty, and interests towards a specific STEM major. Many studies have researched STEM PCPs for bettering its program's quality and effectiveness using a quantitative approach, with two using national longitudinal datasets (e.g., Burack et al., 2019; Findley-Van Nostrand & Pollenz, 2017) and others exploring the impact of a STEM PCP on students' short-term (STEM academic achievement, interests, plans, majors) and intermediate goals (STEM retention, undergraduate psychosocial goals, and undergraduate internships and engagement; Burack et al., 2019; Crutchfield et al., 2011; Findley-Van Nostrand & Pollenz, 2017; Kitchen et al., 2018; Winkleby et al., 2009; Yelamarthi & Mawasha, 2008; Zhe et al., 2010). Overall, these studies share mostly positive views of STEM PCPs. However, as Ashley and colleagues (2017) pointed out, studies within their systematic review do not show instances where STEM PCPs were unsuccessful. Knowing this, the researchers pushed for research to discuss revised “iterations” of STEM pre-college programming to help this area avoid certain practices and move meaningfully forward in designing and implementing early-STEM experiences for students.

Targeting URSs at young ages (middle school or earlier) with STEM opportunities can result in adequate preparation, interest, and continuation along STEM pathways, which STEM PCPs can do (DeJarnette, 2018). STEM PCPs have the most capacity to address many of the STEM-specific approaches (e.g., offer STEM academic and curricular supports, provide space for supportive and inclusive STEM curriculum revisions, deliver professional development on STEM equity and inclusion topics for all STEM educators, provide peer supports (e.g., STEM study groups, social integration activities), provide mentorship, offer pre-college research experiences, etc.) while incorporating the guiding aforementioned conceptual and theoretical models (i.e., improve psychological attributes and characteristics, STEM interest, self-efficacy, sense of belonging, and STEM identity) toward, address gender and race stereotype threat, recognize and build capital and capital deficiency, further academic preparation, minimize and mitigate chilly climate and cooling out effect, offer STEM credit, develop affordable and financially-found STEM pathways, mitigate enrollment and privilege, encourage P-20 collaboration efforts, and build capacity for utilizing social cognitive career, input-environment-outcome, student involvement, and other retention theories).

Having acknowledged the empirical evidence that STEM PCPs support remediation, academic content knowledge, GPA, participation in research, increased interest in STEM, sense of belonging, sense of preparedness, networking with other students and faculty, and interests in a specific STEM major, I contend that STEM PCPs remain as an effective strategy to address issues of racial and low-income underrepresentation in STEM fields (Ashley et al., 2017). Although I grant that STEM PCPs bode many of the concerns pointed out by the other STEM-specific approaches to STEM inequalities (e.g., costly, difficult to sustain, etc.), I still maintain that STEM PCPs constitute the best way to improve STEM inequalities for URSs. Though Mayhew and colleagues (2016) have mixed reporting on bridge programs in general, I believe that the particular benefits of PCPs on URSs subsume the promise of several of the STEM-specific approaches reviewed. If allowed to have the financial resources and the intentional design of STEM collegiate comprehensive programs by postsecondary institutions, like the Myerhoff program, then STEM PCPs could best support the retention and education outcomes of URSs.

In summary, ecological-based factors are an emerging and novel approach for understanding the learning experiences of the URSs navigating the STEM pipeline. Yet, it serves as a solid foundation for expanding our current understanding of STEM inequalities by considering internal and external mechanisms that encourage URSs along STEM paths.

Benefits and limits to ecological-based factors

Although ecological-based factors aid in our understanding of improving the learning experiences for URSs, there is more work required in this area. Just as the previous studies have done, Vulperhorst and colleagues (2018) note:

> In order to understand how interests develop and how interests are pursued in educational [programs], research has to become more and more holistic in design. Not only should researchers study how multiple interests are pursued, researchers should also examine across which contexts interests are pursued. (p. 843)

Vulperhorst and colleagues explore STEM persistence in international contexts. Though Vulperhorst and colleagues do not explicitly mention the importance of an ecological approach within their study design, their implications point to the growing need for researchers to design studies that explore a more composite view of STEM persistence and retention in curbing STEM inequalities of today. An ecological-based view aids in this endeavor by centering its work on the lived experiences of Black and other diverse populations and embedding critical views of human development to understand how individuals make decisions and choices in their environment (Spencer et al., 1997; Spencer, 2007). Using an ecological-based view to understand issues of STEM persistence can aid in clarifying the complicated, dynamic internal and external mechanisms that drive URSs to choose STEM pathways in ways that existing literature has not done thus far. Doing so advances the current progression of STEM inequality research by subsuming our understanding of individual- and institution/system-based factors into a complicated, dynamic, and composite view for improving the learning experiences of URSs. Using an ecological-based approach (and its factors) on STEM inequality research is a novel and ongoing endeavor that has yet to be critiqued by the literature, and I foresee this as an excellent means of improving the learning experiences of URSs.

Research on underrepresented students in STEM PCPs

Within this work, I examine the quality of extant research evidence for addressing current challenges related to STEM inequality. I focus exclusively on STEM education and in particular, the quality of research evidence regarding STEM PCPs because

- these programs typically serve to promote the high-demand, skilled workforce of STEM fields,
- these programs typically focus on improving the learning outcomes and retention of one or more URS groupings, and
- this body of work serves as my primary research interest (Ashley et al., 2017; Douglas & Attewell, 2014; Swail & Perna, 2002a).

Ashley and colleagues (2017) provide a comprehensive literature review of 46 peer-reviewed and non-peer-reviewed studies on STEM bridge programs. Ashley and colleagues' work acknowledges that STEM bridge programs generally met their goals in improving students' retention and graduation rate as well as students' remediation, academic content knowledge, GPA, participation in research, increased interest in STEM, sense of belonging, sense of preparedness, networking with other students and faculty, and interests towards a specific STEM major. Ashley and colleagues remind us that there is much to be done on this topic (i.e., recording funding sources, reporting program costs, describing students' recruitment, curriculum design and development, program follow-up procedures, and production of higher quality research).

Ashley and colleagues' work demonstrates STEM bridge programs provide a content-specific perspective on the college-bridge program effects. Yet, many findings align with the studies mentioned above on this topic. Like Ashley and colleagues, literature reviews simplify the nuances of various research designs. This work illuminates the importance of considering the overall research output of topics like STEM PCPs. Meta-analysis research designs are similar to literature reviews. They review recent research designs in one space. However, there typically is a quantitative piece to meta-analyses; these studies show the effect size or impact of their phenomena. Although this study contains meta-analysis, meta-analysis can demonstrate causal evidence that justifies a treatment or intervention when done well. An omnibus meta-analysis study on STEM PCPs may help clarify which STEM PCP interventions work and describe the extent to which STEM PCPs are most effective.

Using a mixed-methods design, Martinez and colleagues (2018) also researched the STEM PCP effects of a week-long NASA summer on 65 Latinx 6-8 graders' STEM perceptions. Students received interviews and pre-post testing on engineering self-efficacy, engineering career knowledge, and engineering career interests. Researchers, unfortunately, found no quantitative evidence for significant changes in engineering motivation and self-efficacy, which the researchers explain may have been due to students having high self-efficacy going into the summer camp. Using qualitative data, Martinez and colleagues demonstrated how excited young people were to engage with their STEM PCP offerings that led them to imagine and explore ways to obtain an engineering career beyond the summer camp time. Even though researchers did not use explicit mixed-methods terminology to discuss their study, it is clear that the quantitative and qualitative methods aided in converging and triangulating this study's results.

Like Martinez and colleagues' (2018) study, mixed-method studies may address the combined limitations of other research designs mentioned earlier; however, mixed-method research requires acknowledging the emerging, ongoing philosophical and conceptual underpinnings of mixed-method study designs. Some studies, like the Martinez and colleagues' study, employ mixed-method research design without these considerations, and with the significant learning curve of mixed-methods required (Creswell & Plano Clark, 2018; Greene, 2007), these inconsistencies, along with the profound time that mixed-method studies need, both impact the quality and frequency of mixed-method studies.

Using a qualitative design, Hargrave (2015) interviewed Black postsecondary students to understand their PCP setting in the Midwest that fueled them to complete STEM degrees. Hargrave uncovered a wave of information on the PCP agents (i.e., postsecondary staff, PCP teachers, STEM professors), interactions (i.e., between PCP teachers and postsecondary staff), and location (i.e., non-school based program site) that influence students to perceive this particular STEM PCP as a counter space promoting their STEM pipeline retention. Using critical race analysis, researchers provide readers with incredible insight into how this STEM PCP affects its students. In another study, Tan and Barton (2020) investigated how pre-college minority students in STEM formed connections between STEM-related worlds and subsequent STEM engagement. Using a conceptual framework called "pathhacking," where youth create their STEM paths due to initial uncertainty (p. 12). Their longitudinal ethnography of 48 youth demonstrated that:

1. youth sought after STEM spaces in their environment to expand their STEM practices and experiences;

2. access to “pathhacking” led to further behaviors that expanded STEM interests and possibilities;
3. youth used tools and people to further their STEM exploration and experiences within their social context.

Tan and Barton argue that social and structural factors shape how young people understand and seek STEM opportunities, and there are many points where youth both access and resist oppressive features in STEM paths. Taken altogether, qualitative research designs provide a window into greater depth and insight regarding issues related to STEM inequalities. By centering research designs around the perspectives and experiences of individuals involved in STEM PCPs, we gain knowledge that expands our understanding of addressing STEM inequalities throughout the U.S. Lastly, Rahm and Moore (2016) use a longitudinal case study design to explore participants’ journey along their STEM paths using an identity-in-practice lens. Using this framework, the researchers illuminate the institutional places that contributed (and did not contribute) to students’ STEM persistence while acknowledging the rich experiences and reflections of former participants using qualitative design.

Quality of research evidence regarding underrepresented students in STEM PCPs. As mentioned above, these studies show how STEM PCPs have improved students’ STEM pipeline success and students’ STEM academic preparedness, academic success, research exposure, interest, sense of belonging, social support including other students and faculty, and career aspirations. However, these studies have some severe conceptual and methodological flaws. First, studies using this research design rely on the self-reported measures of students ranging from 12 to 24 years old. Research on young people limits researchers’ causal claims if there is little to no evidence on how these young people fare years after the programmatic intervention of STEM PCPs, and these results are context-specific. Learning is an intricate and interactive relationship between students' internal and external environments (National Academies of Sciences, Engineering, and Medicine, 2018a). I think advancing casual work about STEM PCPs' effects on young people beckons a research method design and tool that can ascertain complex and intricate results. Indeed, quantitative research designs can and are complicated; however, existing research tools meant to extrapolate how people *understand* their experiences limit studies using quantitative research design. These validity concerns impact quantitative study designs and other research designs mentioned later; however, it is important to note because these may affect how readers and scholars understand and engage in this work. Additionally, using positivist/post-positivist paradigms, these research designs attempt causality and objectivity. Failing to critique the positionality or interpretations of the researcher ignores the context surrounding the research and affects the kinds of research unfolding on this topic (Creswell & Creswell, 2018; Stage & Wells, 2014). Lastly, some quantitative studies fail to center STEM PCP participants' experiences of these STEM PCPs. Understandably, this can be hard due to how quantitative designs utilize research tools (i.e., experimentation, surveys, etc.) to do this work. This concern also afflicts qualitative and other research designs.

There are some concerns with existing qualitative research designs. Despite using anecdotal evidence, some generalizability and sample population concerns noted earlier where focused on young people who may not demonstrate the efficacy of STEM PCPs and student outcomes (i.e., completing a STEM degree, pursuing a STEM career, etc.). Additionally, these studies can take longer to produce and disseminate due to their methodological demands (Creswell & Creswell, 2018), yet these types of research studies typically attempt to acknowledge and mitigate researcher bias.

In my work, I am interested in uncovering the experiences of former participants of a STEM PCP. Within my research design, like Hargrave (2015), I interview and design survey questions to ascertain the aspects of their personal and professional development beyond their STEM experience that influenced and hindered their ability to continue along their STEM pathway. In turn, I hope to share with other STEM PCP stakeholders the features and characteristics of a learning environment that promotes URSs' participation in STEM fields. I also hope to demonstrate to other scholars the value and importance of documenting the experiences of former participants of these programs.

Theoretical framework

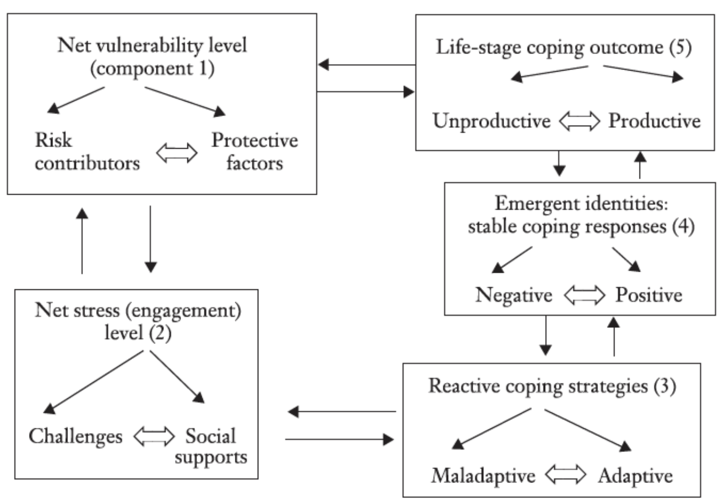
I will draw from Spencer and colleagues' (1997) phenomenological variant of ecological systems theory (PVEST) to do this work effectively. Spencer (1997, 2007) advances this work by incorporating phenomenology and critical analysis of the human development field into her PVEST theoretical framework. PVEST explores individuals' internal and environmental mechanisms that drive coping behaviors in vulnerable situations (Spencer et al., 1997; Spencer, 2007). Spencer (1997, 2007) coined the framework in the human development field to make sense of the diverse life outcomes that unfold. In the early-1990s, Spencer studied strength and resilience in the development of African American youth.

Spencer rooted PVEST in phenomenology, ecology, and criticality. The field of phenomenology emphasizes individuals and their understandings of their lived experiences of phenomena. Phenomenology incorporates self, context, and context-specific behaviors based on encountering challenges within one's environment. Secondly, Bronfenbrenner's (1979) ecological systems theory introduced the foundation for discussing how individuals' development and behaviors are impacted by a network of complex relationships at multiple levels (e.g., chrono-, macro-, exo-, meso-, and micro-). This ecological approach investigates how and in what ways social, cultural, political, and historical forces influence an individual's context. Lastly, with initial-PVEST studies rooted in studying Black youth's resilience and development, it became important to incorporate criticality. Criticality acknowledges the prolific and ongoing function of racism and oppression embedded in human environments and how these influence identity and engagement.

PVEST incorporates perception and self-appraisal considering social, cultural, and historical influences. PVEST also allows for dynamic self-appraisal and meaning-making processes. There are five recursive, bidirectional components to PVEST: net vulnerability, net stress, reactive coping processes, emergent identities, and stage-specific coping outcomes (see Figure 2.1).

Figure 2.1

Spencer's phenomenological variant ecological systems theory



Note. Spencer, M. B. (1995) Old issues and new theorizing about African American youth: A phenomenological variant of ecological systems theory. In R. L. Taylor (Eds.), *Black youth: Perspectives on their status in the United States.* Prager.

Social and biological identities an individual maintains throughout their lifespan influence their context-based experiences. These identities influence an individual's perceptions of context-based experiences, which may be perceived as a risk or protective factor (net vulnerability). These context-based experiences of incidents and event instances are stress engagements that an individual experiences. As an individual manages stress engagements, they may perceive the presence or absence of support structures (net stress) and enact adaptive (or maladaptive) coping processes (reactive coping processes). An emergent identity arises from the collection of individual responses and perception of the self by self and others due to consistent, similar responses to stress. Emergent identities contribute to life-stage outcomes, which shape and inform one's perception, experience, and response to self. Over time, there are perceived differences in the value of these engagements, which one encounters during development. Lastly, through these responses, individuals must reconcile their experiences through continued, internally-driven inquiry and decision-making processes (life-stage coping outcome). The other components of PVEST shape life-stage outcomes, and in turn, these outcomes can impact an individual's net vulnerability. In this study, retention in STEM (or not) via an individual's selection of a STEM postsecondary major, graduate degree, or career as a life-stage outcome is the focus of this study.

Since addressing the current state of STEM educational inequality requires a complex, integrated approach, PVEST delivers by studying the outcomes and decision-making of diverse individuals, like URSs, navigating vulnerable situations like the STEM pipeline (Spencer, 2007; Velez & Spencer, 2018). Understanding STEM inequalities of URSs across P-16 education through this lens remains limited. Scholars have introduced this framework to understand postsecondary retention (Ozaki et al., 2020). Other scholars have explored the effect of PVEST on K-12 Black students in STEM majors and careers in general (Collins, 2018; McGee, 2013), on Black undergraduate students in STEM majors and careers in general (House, 2022; Maurya, 2022), with several focusing on Black women in STEM majors and careers specifically (McGee, 2009; E. O. McGee & Bentley, 2017; McGee & Spencer, 2015), and "advanc[ing] STEM education equity" (Corneille et al., 2020, p. 48).

Specifically, by using PVEST to uncover the internal and environmental mechanisms that influence the persistence of 2-year postsecondary students, Ozaki and colleagues (2020) discovered a more pronounced relationship with participants' environments than previously noted in the retention literature. In several studies, Morton (2017, 2020) reveals, using PVEST, how the oppressive experiences of Black women navigating STEM environments (e.g., STEM culture and programming) impact their STEM identities and participation. Thus, there is great room for continuing STEM inequality research by considering ecological-based factors influencing (or diminishing) STEM inequality. Therefore, research supports that PVEST is a compelling theoretical tool for understanding people from multiple racial and ethnic backgrounds and pursuing STEM fields across P-16 education experiences.

Spencer's PVEST is committed to various affirming and disaffirming experiences that lead to (or not) STEM employment; this model remains relevant for articulating a more in-depth, nuanced view of factors impacting URSs STEM paths. In my work, I am interested in uncovering the experiences of former-STEM-PCP participants. Within my research design, I plan to introduce interview and survey questions that allow participants to discuss personal and professional development areas that both influenced and hindered their ability to continue along their STEM pathway.

Unlike existing prevailing theoretical frameworks exploring STEM inequality, including social and cultural capital, SCCT, STEM validation, and others, scholars use PVEST as a solid, well-rounded framework for understanding the persistence of underrepresented groups in STEM. This theoretical model is a valuable, practical contribution compared to existing models on this topic because it:

- considers what complicated internal and external aspects of individuals' development drive retention along their STEM pathway as a life-stage outcome,
- focuses on the durability and impact of STEM pre-college programming on URS' STEM identity and career choice, and
- clarifies what matters when URSs select STEM majors and careers.

This approach can discern what factors contribute to learners' success while accounting for "students' voices to inform educational practices, policies, and future research focused on broadening participation in STEM careers" (Burt et al., 2020, pg. 2).

Since STEM PCPs serve as a vital way to equip students with the knowledge, attitudes, and behaviors for successful navigation of postsecondary education and continuing on to STEM majors and careers, this work will use PVEST to provide STEM-equity insight into what supports K-12 schools need to produce students capable of attending institutions at higher rates than what we observe today. More than ever, this vital information is essential as our nation increases STEM participation via various diversity and equity initiatives. Additionally, this work will allow postsecondary educators to identify and implement more effective programming for URSs in their schools. If K-12 school districts and postsecondary institutions, via STEM PCPS, had greater coordination around supporting students, this could lead to higher educational and

STEM-degree attainment rates for URSs. Investment in this academic scholarship is important now more than ever in a diverse world that struggles with systemic inequality and inequity.

Summary

Dissecting the factors contributing to URSs' struggle along their postsecondary STEM educational journey is no small goal. Moving from individual-based to ecological-based factors revealed the range of promises and challenges from relying on one set of factors versus another. Though this work is not exhaustive, it promotes an ecological-based approach to addressing STEM inequalities to better the learning experiences of URSs. Non-ecological-based factors lack essential elements of race and culture that are important to account for when considering URSs. These factors also fail to consider the relationships and interactions between individuals and their environments. HBCUs, the Meyerhoff Scholars Program, and other similar programs speak to these points. Moving toward an ecological approach to understanding STEM inequalities of URSs further focuses on individual experiences and isolates what contributes to STEM persistence and academic success. This approach is crucial for advancing our understanding of effective means for improving learning conditions for current and future students in the STEM pipeline.

In reviewing research on STEM PCPs, many studies evaluate the function and impact of their STEM PCP on students and student short and intermediate outcomes (i.e., STEM academic achievement, interests, career plans, majors, STEM retention, undergraduate psychosocial goals, and undergraduate internships and engagement). In contrast, some studies investigate the long-term effects of STEM PCPs on students through literature reviews on STEM PCPs. Overall, these studies share majorly positive views of STEM PCPs. Altogether, existing research designs on STEM PCPs do not provide detailed, robust descriptions of STEM inequality phenomena through the lens of matured former participants' experiences of these STEM PCPs. Looking ahead, using high-quality research designs including PVEST as a theoretical framework, I believe that a qualitative research design will aid in advancing our understanding of STEM paths and inequalities. Using qualitative methods, this level of introspection and insight from participants and researchers can increase the growing body of literature on these programs and aid in understanding more about the aspects that improve success in STEM fields to better student outcomes for generations to come.

CHAPTER 3: RESEARCH METHODS

Introduction

In this study, I examined the reflections and experiences of former participants of STEM pre-college programs to develop insights on how former participants understand the effects of the STEM pre-college programs on their personal and professional trajectories. This chapter describes the research design for the study. The following sections will discuss the research approach within a pragmatic-constructivist paradigm, justifying the methodological decisions implemented. Afterward, I outline the procedures and informed consent process and discuss researcher bias, reliability of data analysis, and ethics.

Phenomena and research question

Based on this study's literature review, I explored how former participants view and understand the impact of their STEM PCP experience on their academic (described as the academic and psychosocial goals of former participants) and professional (described as the career goals of former participants) trajectories (i.e., STEM interests, attitudes, belonging/identity, preparedness, self-efficacy, relationships with family, peers, and educators, networking, content knowledge, GPA, research participation, retention, graduation rate, etc.).

Therefore, I treated these phenomena as similar yet different because the two unpack key contributions to STEM persistence and meaning-making processes of STEM PCPs on participants' life trajectories. To examine these phenomena, I am interested in addressing the following question:

1. How do historically underrepresented students in STEM who participate in a STEM pre-college program situate these experiences in their personal and professional development?

Philosophical assumptions

I draw my research from sociology and psychology disciplines and approach my research using pragmatic and constructivist approaches. As a researcher, I value paradigms that utilize relevant, appropriate methods (pragmatic paradigm) to offer multiple realities and perspectives (constructivist paradigm) to capture our world's complexity and support and provide resources for those most marginalized in our society. Using these perspectives, I see research as an opportunity to capture our world's complexity and move the needle towards providing the support and resources for those most marginalized in our society. I understand that researchers have the unique duty to capture their participants' experiences within the research process. Yet, I also value purposeful, quality work necessary for my research design and endeavor. Through my work and future work with other researchers, I look forward to reshaping the study and field of postsecondary education to reflect better the world we live in today.

Role of the researcher

As a product of several PCPs and STEM PCPs, these programs were foundational to development as well as how I pursued my own academic and career trajectory. Through these programs, I have gained access to STEM professionals, spaces, internships, and conditions that fueled and furthered my academic and career journey, and I attribute much of my success to the individual and combined impact of these programs from 12 years old until today. Due to these programs, I remain in touch with many of my PCP, STEM PCP, elementary, secondary, postsecondary, and graduate educators. These programs have significantly shaped my understanding of self and self-worth in ways that I may not have gathered if I attend my K-12 schooling alone.

I acknowledge the immense value and potential of STEM collegiate comprehensive programs, and I think that there is invaluable information on how STEM PCPs affect participants' long-term knowledge, attitudes, and behaviors (KABs) and their academic and career trajectories. After my STEM PCP experiences many years ago, my STEM PCPs have stuck with me and compelled me to investigate their long-term effects on other former participants. My previous research and STEM PCP experience inform the research questions and design outlined below.

Research design

The design of this current study is informed by a pilot study using a qualitative study design. The pilot study explored the experiences of former participants' personal and career trajectories using semi-structured interviews. Then, I discussed the perceptions of their STEM PCP experience, early-STEM exposure, and schooling and family STEM messaging. Many elements of this previous study design roll over into this current study's design, including the semi-structured interview protocol (Glesne, 2016; Weiss, 1995). Beyond the pilot study's design, I collected open-ended survey responses from former participants on the KABs, considering an interpretative phenomenology approach.

To understand former participants' experiences beyond their STEM PCP experience, I applied the interpretative phenomenological approach, specifically Smith's interpretative phenomenological analysis (IPA; Smith et al., 2009). IPA centers on phenomenology, hermeneutics, and idiography as theoretical underpinnings.

Interpretative phenomenology

Phenomenology as a philosophy and research seeks to understand how individuals conceptualize their experiences of a phenomenon (Creswell, 2013). There are two types of phenomenology, descriptive and interpretative (or hermeneutics). Phenomenology's philosophical origins lie upon Edmund Husserl in the late-19th century, yet beyond phenomenology's origins, Martin Heidegger, a student of Husserl, developed a different phenomenology. Whereas descriptive phenomenology focuses on collecting participants' descriptions of their experiences, hermeneutics emphasizes the meanings beyond the descriptive elements of core concepts (Mayoh & Onwuegbuzie, 2015). Rather than an overemphasis on the participants' descriptions alone, hermeneutics situates the researcher's interpretation as a crucial aspect when researching and interpreting participants' thoughts and reflections about their lived experiences (Gill, 2014; Smith et al., 2009). Lastly, idiography focuses on the "particular," where researchers focus on an individual participant's experience to describe and detail an understanding of the phenomena of interest. Taken altogether, IPA serves in making sense of the behaviors, actions, and choices of former participants beyond their STEM PCP participation (Mayoh & Onwuegbuzie, 2015).

Rationale for qualitative research design

As an exploratory study using interpretative phenomenological analysis, I employed qualitative methods to explore how former participants situate their STEM PCP experiences. A qualitative method can deliver sound and robust results that may be difficult to discern from quantitative reporting (Glesne, 2016). Considering the research needs of the presented phenomena, I chose a qualitative research design featuring interviews of people who self-identify as former participants of a STEM PCP through purposive and convenience sampling (Glesne, 2016), and I asked questions that extracted how former participants presently make sense of their STEM PCP experiences and subsequently, how their STEM PCP experience influenced their academic and professional decision-making.

Using interpretative phenomenological analysis, where I conducted this study using demographic survey items and semi-structured interviews with former participants. Open survey methods were distributed after the semi-structured interviews. Primarily, I expected the survey to correct any miscommunications and misinterpretations. Secondly, I hoped that the survey would provide additional qualitative insights into former participants' framing of KABs and other factors that contributed to their long-term STEM interests. The research design was approved by an ethics review board (IRB; see Appendix C).

Sample and setting

Setting. The Beginning Early Program (BEP) at Upper Midwest University was selected for this study. As a STEM PCP, BEP has provided K-12 URSs in an urban city in the Midwest area access to academic enrichment coursework over the summer and school year in a university setting. Since 1981, BEP's goal has been for all students to gain confidence, study skills, and habits useful for successful matriculation into postsecondary institutions and healthcare professions (Beginning Early Program, n.d.). Students received content coursework in reading, science, and mathematics depending on when participants attended (e.g., during the summer or over the school year). The BEP also allowed students to receive STEM mentoring, conduct lab experiments, learn about collegiate gateway courses, and attend workshops led by health professionals; some of these features are common aspects of other STEM PCPs. Currently, the program consists of over 90% of students from racial URS backgrounds with 58% of students identifying as female. To enroll in the program there are no minimum grade or test scores requirements.

The BEP study site is unique because:

1) majority of program leaders identify as women from Black and Latinx racial backgrounds;

2) it is embedded within the programmatic structure of the college, whose mission is to increase URSs in health sciences and professions;
3) it integrates curricular programming with other STEM schools and administrative units;
4) lastly, it is located in an urban setting with K-12 public, charter, and private students from across its region (Beginning Early Program, n.d.).

Sample. Through purposive, convenience, and snowball sampling, I reached out to BEP's former participants interested in participating in this study via social media posts and emails through the STEM PCP's email listserv spearheaded by the STEM PCP administrators. If they expressed interest in participating, I provided an opportunity for them to submit their interests and consent via email. Participants were reminded throughout the study's activities (interview and survey) that they could choose to leave the study whenever they saw fit and leave without penalty. Using their emails, I coordinated a time to perform a semi-structured interview.

Participants were former participants of the BEP program. In total, six people reached out to me with interest in the study; however, four former participants (n=4) of the BEP were successfully recruited, which aligns with the suggested homogenous sample size of four to 10 participants for IPA doctoral studies (see Table 3.1; Smith et al., 2009). I note "doctoral studies" because Smith and colleagues distinguish between master and doctoral research sample sizes based on their United Kingdom higher education system.

Former participants of the BEP were BEP completers who graduated high school between 2011 and 2013. These participants were selected because they aligned with my pilot sample population's intent of having participants with at least five years of post-program experience (e.g., employment, income, schooling experience, etc.). These study participants were more likely to have similar cultural and programmatic experiences than participants who attended the program before 2011 and after 2013.

This research study was conducted in the Spring of 2022. This study's participant sample completed interviews (*n*=4) and surveys (*n*=4). Given one participant did not complete the survey, I included them in the study's results because their interview provided comparable information and data compared to the other participants. Participants discussed their perceptions of enrolling in BEP experience, early exposure to STEM resources, and understanding of community.

Table 3.1

Description of participants

Name	Interview date	ID	Year of high school graduation	Race	Gender	Current career choice	Undergraduate school type(s)	Highest degree obtained
Myra	1/2022	101	2011-2013	Asian	Female	Medical student	Private, 4-year institution	Bachelor of Science
Jamila	1/2022	102	2011-2013	American Indian and Alaska Native, Black or African American, White (self-identified as Latina)	Female	Lead software developer	Public, 4-year institution; Public, 2-year institution; Public, 4-year institution	Masters in Health Information Science
Nora	2/2022	103	2011-2013	Black	Female	Public health specialist	Public, 4-year institution; Public, 2-year institution; Public, 4-year institution	Dual Masters in Health and Social Services
Kyra	3/2022	104	2011-2013	Hispanic/ Latina	Female	Mechanical engineer	Private, 4-year institution	Bachelor of Science

Sampling procedures

Consent procedures. Each participant was provided an informed consent form when they expressed interest in the study and asked to provide their consent to participate in this study before confirming their interview time and date. All study activities were completed during a meeting between the participant and researcher, using Zoom's online conference platform. Before the interviews began, I offered a brief description of the study, reminded the participant of their rights, asked if they had any questions, and asked for verbal consent to further participate in the study. Afterward, I notified the participant that I planned to audio record and store the interview data in a private, secure location, and the interview proceeded. At the end of the interview, I debriefed the participants about where to find additional information about the study and thanked them for their participation.

After the interview. Participants were provided a link to an online survey, and they were asked to complete the survey using a participant ID supplied by me. This ID linked the survey responses to the semi-structured interview. This short demographic and early-STEM exposure survey was estimated to take approximately 10 to 15 minutes available through the *Qualtrics* survey platform (*Qualtrics*, 2020). Using the assumed highest amount of time possible for the survey, participants took between 63 to 68 minutes to complete all of this study's activities.

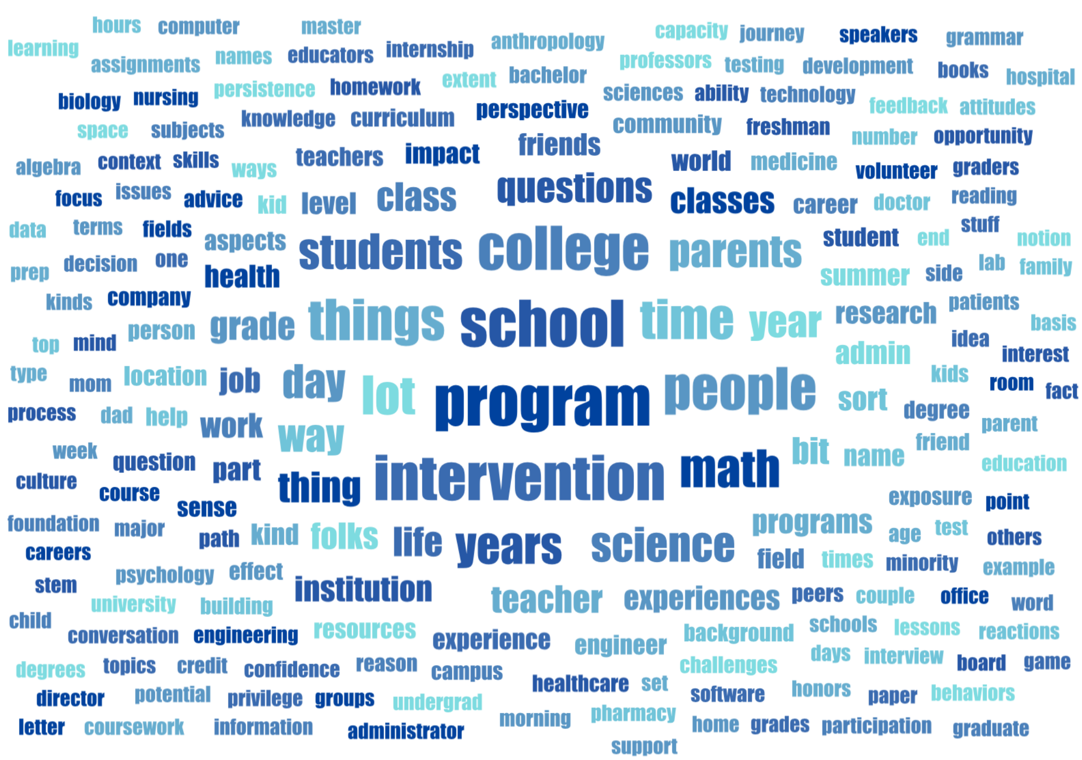
Reflexive writing practices. After each interview, I performed various reflexive activities: chatting with colleagues about interview takeaways, highlighting essential features from my interview notes, and writing several reflexive notes to myself (Delamont, 2016; Glesne, 2016; Smith et al., 2009). During reflexive note-taking, I captured my raw surprises and potential suggestions and changes to the interview protocol (i.e., either created questions for the standalone interview or general interview guide). These processes helped develop clear takeaways from each interview and consider how participants' responses related to (and differed from) one another. These reflexive notes (combined with my semi-structured interview protocol) also allowed me to adjust subsequent interview questions to collect more accurate, straightforward responses from my participants. Ultimately, I expected my interview questions for my current study's participants to address my primary research question.

Data analysis plan

I used Smith's IPA six-step process for my data analysis plan for analyzing qualitative data (Smith et al., 2009). This allowed me to manage each qualitative data source, perform cross-case analysis, and identify emergent, divergent, and convergent themes. Interviews were analyzed using *ATLAS.ti* to facilitate IPA techniques and create convergent and divergent themes across the data sources of participants (*ATLAS.ti*, Version 22.0.1 for Mac). All analyses described were performed considering the theoretical frameworks informing this study. Using *ATLAS.ti,* I also performed a word analysis of nouns across all of the interview transcripts (see Figure 3.1).

Figure 3.1

Word analysis of nouns in interview transcripts (n=4)



For my research question, I expected the semi-structured interviews to address this research interest primarily, and to most effectively reap information from my data, I planned to employ an IPA. Because this analysis describes the lived experiences of a phenomenon and explores the "what" and "how" of individuals, I find this analysis most applicable for understanding how former participants experienced their STEM PCP experience (Creswell, 2013, p. 79). I bracketed my initial reactions from this STEM PCP and others, and I reviewed the transcribed interview materials, moving from significant statements to meaning units and detailed descriptions on the "what" and "how" individuals experience their STEM PCP and early-STEM exposure (Creswell, 2013, p. 79; Smith et al., 2009). By doing this, I effectively answered how their STEM PCP operates in their personal and professional development. Returning to my theoretical framework, I followed the PVEST, as stated earlier, and my analysis promoted an understanding of how BEP, as a STEM PCP and its programmatic activities and exposures, offered multiple contributions in URSs' STEM persistence.

I reviewed this in light of an IPA mentioned earlier in my findings using the other data sources (e.g., interview notes). As for my qualitative results, I shared quotes and my interpretations of said quotes to highlight notable findings from my qualitative sources (see Chapter four; Creswell & Creswell, 2018). Thus, I concluded with broader implications of using IPA and PVEST as a theoretical framework for analyzing STEM PCP experiences (see Chapter five). Though this qualitative inquiry is unique to this specific STEM PCP setting, this qualitative inquiry is nonetheless essential and relevant to understand the effects of these STEM interventions on individuals navigating the U.S. P-20 education system.

Qualitative data analysis. I analyzed the interview transcripts and open-ended survey items. I transcribed my data using an online artificial intelligence software (*Otter.ai*) that performs transcription on audio recordings (*Otter* Team, 2022). Because this is an artificial intelligence software, there were some inaccuracies in my transcriptions, which I manually reviewed each transcript output and revised for any errors. I also assigned pseudonyms to the data, and I modified or redacted any identifiable information of the participants (such as name, identifiable school information, and other identifiable information). The interview data was then uploaded to *ATLAS.ti.* I extracted and consolidated responses to a text document for open-ended surveys before uploading to *ATLAS.ti*. I then followed the IPA analysis steps outlined by Smith and colleagues (see Table 3.2; 2009).

Table 3.2

How will I code the data?

Data source(s)	First step	Second step	Third step	Fourth step	M
Primary sources: Interview transcript Secondary sources: Survey items & reflective memos	• Read • Re-read • Initial coding	• Re-read • Inductive, open, and in vivo coding using *Atlas.ti* • Code for descriptive, linguistic, & conceptual elements	• Reduction of data • Merge codes • Build themes ○ Definition ○ Identify sub-themes	• Search for connections across emergent themes	MOVE TO NEXT CASE
LOOK AT PATTERNS ACROSS CASES					
FINDINGS					

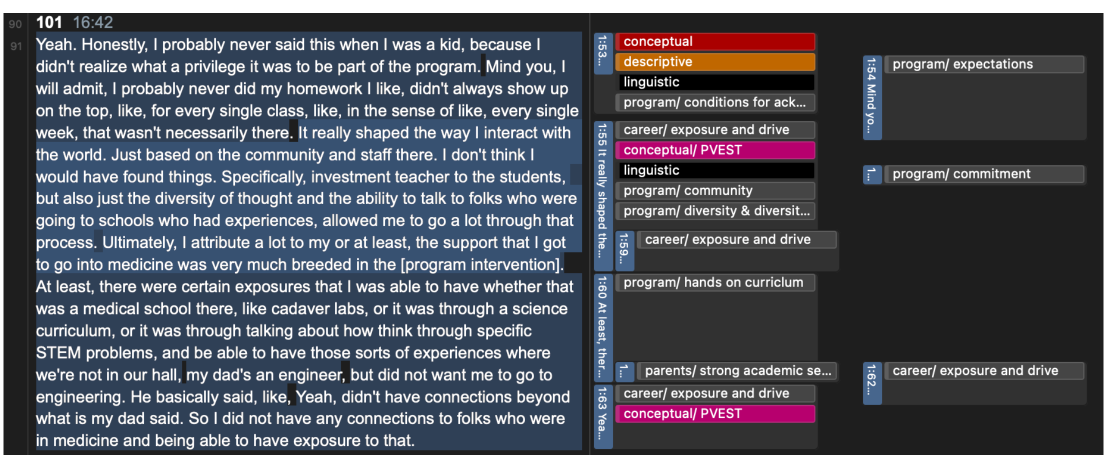
Step 1. Reading and re-reading. IPA requires the researcher's complete immersion into each participants' data (Smith et al., 2009). I read and re-read (including listening to the audio recording when possible) each qualitative data element for my qualitative data. After reading and rereading each qualitative element, I performed reflective writing, making sure to note my "initial" and "striking observations" about the qualitative element so that this is bracketed from

the remainder of the analysis process (Smith et al., 2009, p. 83). This process also allowed me to slow down and center on my theoretical framework and participants, rather than performing a "'quick and dirty reduction and synopsis'" of the qualitative data (Smith et al., 2009, p. 83). Afterward, I repeated the reading and rereading steps to better notice details and better see the lens of each participant. Throughout the remainder of the steps, I continued to perform reflective writing to document my thoughts at each process step.

Step 2. Initial noting. After analyzing each qualitative piece alone, I employed an inductive and open coding approach using *ATLAS.ti* software (see Figure 3.2). Smith and colleagues (2009) offered three specific ways of noting that I employed, including *descriptive*, commenting on the significant or meaningful thoughts of the participant, *linguistic*, commenting on the frequent and patterned language use of participants, and *conceptual*, commenting on the conceptual aspects of the interview using an interrogative- and exploratory- mindset, considering theoretical frameworks and research inquiry. Using these various note-taking lenses, I engaged with and reflected on the participants' accounts for patterns of convergence and divergence.

Figure 3.2

Levels of coding with Myra



Step 3. Developing emergent themes. I familiarized myself with each of the

comments/notes mentioned. I re-read each comment and "reduced the volume of detail while maintaining complexity, mapping the interrelationships, connections, and patterns between exploratory notes" (Smith et al., p. 91). This led me to develop emergent themes in real-time using chunks of the available qualitative elements. In IPA, themes constitute the "original words and thoughts" and "interpretations" of the "analyst" that "reflect the synergistic process of description and interpretation" and "[capture] and reflect an understanding" of the data through a PVEST lens (Smith et al., p. 91).

Step 4. Searching for connections across emergent themes. Using my developed themes, I ordered them by how they appeared in the qualitative data, and I mapped their relationships using the *ATLAS.ti* software (see Table 3.3). This visual guide aided and provided me with a creative structure of the emergent themes. Doing this also allowed me to establish superordinate themes that capture the essence of the participant's account, and I did steps one through four for each available qualitative data element.

Table 3.3

Example of coded data & some emergent theme examples: Nora.

Linguistic/ Frequently used words	Descriptive/ Keywords or phrases	Conceptual comments	Emergent themes	Super-ordinate theme
Intimidated	1:15 ¶ 37 And even joining [program intervention] back in the day was just science and math always kind of intimidated me.	Math and science classes intimida-ting	Help in overcoming shyness + math growth	Self-limitations
	1:24 ¶ 43 Oh my goodness, I first. So I was in fourth grade when I first started any program. And I was I was a little intimidated.	Program initially over-whelming		

Table 3.3 (cont.)

Linguistic/ Frequently used words	Descriptive/ Keywords or phrases	Conceptual comments	Emergent themes	Super-ordinate theme
Shy	1:33 ¶ 43 I can, you know, be not shy. I was a very shy kid, but I still ended up being shy. 1:69 ¶ 157 I don't know why I just go back to confidence as someone who was shy, or someone who, you know, was was not the brightest either. It just gave me so much confidence and ability to see myself on a higher level than what I might have imagined myself, I was just so myopic in my thinking about myself and who I could be.	Self-aware of shyness at an early age Shyness related to or connected with self-confidence and ability	Help in overcoming shyness + math growth	Self-limitations
Help	1:100 ¶ 49 But [program intervention] was the main, like, academic program that was designed in my family's mind to just help me out in terms of getting more science help, more math help, more reading help, things like that. 1:104 ¶ 103 Just the overall nature of the academic portion of the program helps me personally, as I said, I was not surprised. But I just wanted to, I just wanted more [extra] help [with] the subjects I was not strong in. And there are those teachers that I named, or the staff that I've named, they really helped me to feel more confident in that way. 1:113 ¶ 109 For him to break something down for me once that I felt one by one. Even if I had to ask him again. He made me feel like I could do that. And it wasn't a problem. Until I understood it.	Family goal of helping math, reading, and other areas Additional support from teachers to feel confident Teacher willing to break down subject matter for Nora individ-ually	Help in overcoming shyness + math growth	Being seen
Community	1:121 ¶ 115 So like through other like pipeline programs similar to that I was able to do out some post [program intervention], which allowed me to connect with other minority students who were interested in similar psychology or public health-related interests. It allowed me to connect more with those students and see where, how I could see myself in the mix as well.	Connected pipeline program and STEM program inter-vention; connect with similar participants	Pipeline programs	Importance of community
	1:67 ¶ 97 – 98 …There were, man, so many people that were just great, even the parents, I remember, one of our classmates [classmate 1], her grandfather used to be a parent or a parent volunteer, and he was always so	Effect of many people on encourage-ment	People support	

Table 3.3 (cont.)

Linguistic/ Frequently used words	Descriptive/ Keywords or phrases	Conceptual comments	Emergent themes	Super-ordinate theme
	encouraging to us as well. [classmate 2's mom], [classmate's] mom was always a very encouraging parent as well. So there's just so many people that were just, I just wanted to see us succeed as students. And our and their families as well, you know, I felt like it was a mini family, in a way, especially we were there for nine-10 years			
Seeing self	1:40 ¶ 55 I was like, wow, I could see myself doing this. And it was great, because they, specifically the staff specifically brought individuals to that look at where, you know, minorities, so they looked like us. And we were able to kind of I, myself, was able to be like, Oh, I can see myself maybe I consider a pharmacy at one time. And I remember seeing us being introduced to a pharmacist there. And I'm like, oh, man, I could I can, I can see you for the black female pharmacist. And I was like, oh, yeah, I can potentially see myself doing that. And it didn't seem as scary after that. Being was seeing it in real life, what they do after school, so after going through their schooling, so yeah, just awe, and just intelligent.	Able to conceive ability to do STEM work	Seeing myself in future	Early exposure to STEM resources as foundational to STEM interests
	1:68 ¶ 97 She to this day, has been such an encouraging person. She saw my ability before I could even see them	Others see ability and validate it		
	1:144 ¶ 133 After the program, I was encouraged even more, so even. You know, in fourth grade, he was even there now, just like, you know, I think I want to go to college, but [program intervention] allowed me to actually see it, I can see myself on a college campus, like [program intervention site], and I think that that was one of their main internships to to get students to actually see themselves on the college campus.	See self attending college by attending college campus regularly		
	1:182 ¶ 157 Sometimes, when you're not able to see, if you're not able to see yourself in that higher level of education or higher level of profession, it can be hard to really see it, it can be hard to know that you even have the potential to see that.	Difficult seeing representation of self in an experience can make it challenging		

Table 3.3 (cont.)

Linguistic/ Frequently used words	Descriptive/ Keywords or phrases	Conceptual comments	Emergent themes	Super-ordinate theme
	…			
Accelerated	1:86 ¶ 43 And just, you know, I was just, I didn't know what to expect, I knew that we were going to be taking classes, kind of at a more accelerated rate, I started accelerated, accelerated rate them as compared to what our grade levels currently were. 1:102 ¶ 67 With the help of [program intervention] and the science and accelerated science math classes. They helped me as well. So yes, I think it was just I took a few AP classes as well, honors and AP classes [throughout] high school. A long time.	Advanced work compared to school STEM specific advanced work in school	Head start	Early exposure to STEM resources as foundational to STEM interests

Note. Adapted from Lannan (2015).

Step 5 & 6. Moving to the next case and looking for patterns across cases. Because it is important to treat each qualitative element (e.g., interviews and open-ended survey items) as its case capable of being presented as its own, it is important to continue Steps 1 to 4, considering my theoretical lens before proceeding to another case. Thus, I used each case to generate a master table of themes to find connections, determine how a theme from one case clarifies or supports another theme, and reconfigure and re-label themes (see Table 3.4). After doing this, I also provided open space for open-ended qualitative survey elements to be embedded into this whenever possible. These created a structure for discussing my findings and relaying information back to my theoretical framework.

Table 3.4

Cross-case analysis.

Interview questions	Myra	Jamila	Nora	Kyra
Program's meaning to you	Shaped the way interact with the world Relationship and community Diversity of experience and thought STEM exposure to cadaver labs and STEM problems	Need more minorities in STEM One of us will become something Brought hope STEM exposure to cadavers and tours to physical places and events Never diverted from healthcare	Willing to show appreciation of program through volunteering STEM exposure at a hospital setting Realize interests in working with patients and research Sparked STEM interests Performed advanced learning at school due to program curricular exposure	Retrospective thinking - Punishment Best things for self STEM resource access Knowledge of other professions than a standard doctor, lawyer, and teacher Transcend stereotypes of what you will become Admiration Changed trajectory of academic excellence Extra help
Program administrator and teacher impact	*Teacher* Constructive Feedback Assist with disorganized writing Encouragement and trust *Administrator* Recommended for another program Thought was a good fit Saw certain potential	*Teacher* Encouragement in math class Confidence to go to the board and felt like a badass for math problems Considered math major *Administrator* Spiritual support during menthol struggles Personal Growth	*Teacher* Felt comfortable and liked math Made math fun and enjoyable *Administrator* Encouragement Saw ability and potential before self-realized or actualized	*Teacher* Humbling - Nobody likes a smartass Importance of fine-tuning skills Provided School Homework Help Comfort to ask for help *Administrator* College applying resources and constant monitoring Provided additional perspectives - gap year

Table 3.4 (cont.)

Interview questions	Myra	Jamila	Nora	Kyra
		Understand have a seat at the table and have a voice	Encourage to apply for a graduate program Pushed for graduate program completion Motivational Tough love	
Persistence in STEM long-term	Full capacity to do this Reminder that people can do STEM & thrive Exposure to STEM interests Consider medicine as an option	Tested out of math in high school Good foundation in biology Continued STEM in college Fill graduate degree in STEM gaps as a Latina	See self on a college campus after regular campus attendance STEM exposure over the summer triggered the importance of summer internships Valued academic and professional development Early-STEM exposure led to health science interests Access to researchers and speakers laid the foundation for graduate study interests	Placed in STEM tracks in the program Solidified STEM interests
KABs gained from program participation	Impact world view Talk to students with different backgrounds Reminder that people have different lives Provide empathy and grace to others Step back and try to do best	Resilience You get back up when you fall Life happens and you still have expectations	Confidence Importance of seeing others who look like self Expanded horizons Set the bar for future accomplishments	Professionalism Encountered many adults outside of school and family Move beyond the stereotype they have about you Academic excellency

Table 3.4 (cont.)

Interview questions	Myra	Jamila	Nora	Kyra
				Lifelong friendships and community Respect one another

Note. Adapted from Lannan (2015).

Trustworthiness

I took several measures to ensure trustworthiness throughout the data collection and analysis process, including reflexive notes, member checks, thick descriptions, and independent audit using the work of Anfara and colleagues (2002), Creswell and Miller (2000), Smith and colleagues (2009), and Tracy (2010).

Trustworthiness of qualitative analysis

After each interview, I created reflexive writing notes, as described by Delamont (2016) and Glesne (2016). I also developed and wrote multiple analytic memos throughout this project to clarify and move my research design forward as Maxwell (2013) described. Additionally, I collaborated, consulted, and performed peer debriefing with several individuals (e.g., my doctoral committee for this study, doctoral advisor, and doctoral colleagues) about my research study to improve my conceptual thinking and theoretical framework (see Creswell & Miller, 2000). In this work, I also provided a thick description of the data, sharing “concrete detail, explication of tacit knowledge, and showing rather than telling” from my data within my results section (Tracy, 2010, p. 840). Lastly, with regards to my ordering IPA process, I performed an independent audit, where I retained an organized structure of initial notes, interview schedules, audio files, annotated transcripts, theme tables, writing drafts, and final writing reports. I otherwise will erase the audio files, interview transcripts, and annotated transcripts following the study's completion. Doing this, allowed me to assure others that I produce a "credible" report trail of my work, per IRB protocols and procedures (see Table 3.5; Smith et al., 2009; Yin, 1989).

Table 3.5

Data audit

Audit type	Data
File storage	Interview and transcripts (*n*=4) ● Researcher's computer (101-104) ● Researcher's recording Device (101-104) ● Researcher's phone (101-104) ● Researcher's *Otter.ai* account (101-104) Survey ● Qualtrics (*n*=4; 101-104) ● Researcher's computer (101-104) Writing drafts ● Researcher's computer (101-104) ● Researcher's *Google drive* account (101-104)
Memo storage	● Researcher's notebook ○ Notes from interview ■ 101 (1/2022) ■ 102 (1/20222) ■ 103 (2/2022) ■ 104 (3/2022) ○ Memos from interview ○ 101 (1/2022) ○ 102 (1/20222) ○ 103 (2/2022) ○ 104 (3/2022) ● Researcher's computer ○ Additional notes ■ 101 (2/2022) ■ 102 (2/20222) ■ 103 (2/2022) ○ Bracketing (2/2022) ○ Discussion with advisor (2/2022) ○ Memo's on *Atlas.ti* ■ 101 (3/2022) ■ 102 (3/2022) ■ 103 (3/2022) ■ 104 (3/2022)

Summary

As explored earlier, many STEM interventions and initiatives historically focused on influencing students within existing schooling structures, specifically in postsecondary institutions and their classrooms and research endeavors. Though STEM intervention research has moved towards understanding the impacts of informal STEM interventions on URSs (e.g., mentoring, undergraduate research experiences, bridge programs, internships, student supports, out-of-classroom efforts, etc.; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2016, 2018a, 2018b, 2019; National Research Council, 2012), there is still much work to be performed in this area. This research project is unique because it falls in line with existing literature by exploring former participants' experience in an informal STEM intervention, such as a STEM PCP, to understand how URSs understand their education and life trajectories as a function (or not) of their STEM PCP, using PVEST as a theoretical lens. This level of introspection and insight from former participants can only arise after individuals who have undergone their postsecondary or graduate experiences beyond their STEM PCP. Thus, it is important to perform this study, now more than ever, to capture the growing body of former participants of these programs and understand more about the factors that contribute to URSs' persistence into STEM majors and careers to better the STEM outcomes of URSs for generations to come.

Chapter one included discussions of the problem, purpose, and significance of the proposed study. Chapter two reviewed previous literature related to STEM PCPs, retention and persistence, and other relevant theoretical frameworks. Chapter three included a detailed discussion of the rationale used to determine the appropriateness of the qualitative study design as the optimum design choice for the study. The discussion consisted of research method, design appropriateness, sample, informed consent, sampling framework, confidentiality, and instrumentation. In the next chapter, I discuss my findings and conclude with a summary of data collection, analysis, and issues of trustworthiness.

CHAPTER 4: FINDINGS

In this chapter, I present the findings for the research questions regarding how historically underrepresented students in STEM who participate in a STEM PCP situate these experiences in their personal and professional development. My research question and the literature review informed the design, alignment, and execution of the semi-structured interview protocol (see Appendix A; Table 3.1) used to interview former participants of the BEP. I employed a qualitative research design involving IPA to investigate how URSs, who are former participants of STEM PCPs understand their STEM PCP on their academic and career trajectories, using PVEST as a theoretical lens. As an analysis, IPA led to discovering emergent themes within and across this study's cases (Smith et al., 2009). This analysis also allowed me to make an explicit effort to identify convergence and divergence across the cases.

I organized this chapter by presenting the common themes discovered in the data by outlining the themes uncovered within and across cases. The superordinate themes were *overcoming self-limitations and being seen*, e*arly exposure to STEM resources as foundational to STEM interests* (i.e., experiences, professionals, building access, etc.), and the *importance of community*. Each of these themes includes multiple sub-themes that provide a richer and nuanced understanding of each of the superordinate themes (see Table 4.1). The below sections detail the specific experiences that former participants shared and highlight the various forms of marginalization, racism, sexism, and sense of community and shared experiences that each participant faced along their academic and career trajectories. Divergent themes applied to two or three participants, but these did not apply to the entire sample. These included *program timing as dreadful* and *creating a legacy for others*. The final sections of the chapter answer the research questions considering the identified emergent and divergent themes.

Table 4.1

Superordinate and sub-themes

Superordinate themes	Sub-themes
Overcoming self-limitations and being seen	• Reading and writing help • Shy and not the brightest • Navigating mental health • Facing stereotypes

Early exposure to STEM resources as foundational to STEM interests	• Early-on, hands-on STEM curriculum
	• Early exposure to STEM professionals and spaces
	  ○ Early exposure to health sciences
	  ○ Access to internships, field trips, and research
	• Something bigger

Importance of community	• BEP as a community of learners
	• Understanding professionalism
	• Community beyond BEP
	  ○ Support system
	  ○ Community through pipeline programs
	  ○ Making seats at the table

Overcoming self-limitations & being seen (as net vulnerability, net stress engagement, and reactive coping mechanisms)

In an unprompted manner, each participant discussed their experiences as learners independent of the BEP. Each participant shared information about how they viewed themselves as well as how others viewed them. This range of responses varied depending on participants' race and gender as well as socioeconomic, first-generation, and mental health statuses. Ultimately, responses centered around highlighting or noting their self-limitations (i.e., reading and writing help, shy and not the brightest, navigating mental health and facing stereotypes). These identities influenced their perceptions and experiences within and outside the context of their STEM PCP. Ultimately, BEP staff and programming served as protective and social support factors by facilitating the "help," "support," "encouragement," and "motivation" for participants to continue academically and in STEM coursework from elementary school and beyond. These unprompted self-limitations provided a window into each participant's academic journey before enrolling into the STEM PCP, in addition to highlighting the continued challenges that lie ahead for each participant.

Reading and writing help

Myra had regularly been involved in gifted school programs before and during her attendance at the BEP. As an Asian American child of immigrants, Myra's "mom and […] dad [who] knew about it [the program]," which her dad was "happy . . . for that to be happening." Myra's parents entrusted Myra with her education. They were "hands-off" in terms of allowing Myra to "[choose] classes and [make] sure [her] homework was done."

Despite Myra being on top of her academics, Myra described her time during the BEP as an opportunity to "get more attention, especially when it came to reading and writing," which were definitely her "weakest subjects." Throughout Myra's life, she received feedback that she wasn't a "clear writer," she was "disorganized," and her writing "didn't . . . chalk up to the level of education" Myra received thus far. Myra dismissed these forms of feedback because they weren't "constructive." In her "15 to 20 students max" at her BEP English class, Myra was assigned readings on "*Beloved*" and "*To kill a mockingbird."* In these BEP classes, Myra was able to get a more personalized education and get exposure to content that "was eye-opening about . . . history," and the "reality is there's a lot of subjectivity included in the text [in] history books." Through this "different [educational] experience," she thinks she wouldn't have otherwise encountered in her school or "been recommended [in her] high school curriculum."

Today, Myra still acknowledges her weakness and describes herself as "not on top of [her] writing skills." Yet during her time in the BEP program, she was able to spend the necessary time with her teacher to receive the "constructive feedback" that helped her "grow [and] reach [her] full architecture." Although reading and writing help afflicts Myra to this day, it is unclear what Myra would become if she had not connected with her BEP teacher to assist her in her "weakest subjects." The reading and writing helped Myra further, rather than complicate, her along her academic journey.

Shy and not the brightest

Unlike Myra, Nora prescribed more self-limitations to herself. As a young Black woman, BEP filled Nora with feelings of "intimida[tion]." Self-describing as "shy" and "not the brightest," Nora was among many "super-smart peers [across] different grade levels." Adding to her "intimidation feelings," it was her first day on a college campus "as huge as [BEP's college campus]." Despite this intimidation and understanding that classes would go at an "accelerated" rate, Nora hoped she "could handle it."

Nora's shyness was partially fueled by her "struggle [with] math and science in [elementary] school" and being "told by a teacher that [she] wouldn't even make it to college" because of her school test scores and grades. Like her feelings toward BEP, Nora experienced early feelings of "intimidat[ion]" because Nora "felt uncomfortable in asking questions and getting help with [math and science]." Nora's dad found out about BEP through a family friend's child in the program, and Nora speculates that her dad thought it would be a way to "feel more comfortable with math and science, and hopefully be able to improve with those subjects." Through her BEP experiences and math coursework, Nora acknowledges how BEP "gave . . . so much confidence and ability to see [herself] on a higher level than what [she] imagined [for her]self." "[Nora's] horizons expanded" because of her BEP math teacher, who went the extra mile. Her BEP math teacher would "provide extra help," stay "before class or . . . after class . . .

to break down particular math concepts," and allowed her to ask "questions" without feeling like she was a "burden" to him.

Without BEP, Nora may have been deterred from a STEM future altogether. By taking advantage of and working closely with BEP staff, Nora was able to "come out of [her] shell a little bit more]" and clarify ways of "how [other BEP teachers] could help as well." Nora's story (and others) points to Bandura (1997), the Institute of Medicine (2011), and the National Academies of Sciences, Engineering, and Medicine (2019) in that BEP provides STEM opportunities that build self-efficacy and confidence in doing specific tasks. Both Myra and Nora share the burden of recognizing their limitations. While expanded reading opportunities and "constructive" writing feedback furthered Myra's academic success, Nora's innate shyness coupled with her low math and science skills necessitated additional time and support. Through BEP program attendance, Nora overcame pessimistic assumptions from her school about her academic trajectory and who she would later become.

Two sides of a similar coin: Navigating mental health and stereotypes

Jamila and Kyra have related but different self-limitations imposed on them. As Latinas in STEM today, both have navigated stereotypes and struggled to stand out among peers. This section explores how Jamila and Kyra positively discussed BEP impacted their self-limitations.

Navigating mental health. Like Nora, Jamila's first day of BEP was filled with intimidation. From "the kids" to the teachers, Jamila knew that BEP was "going to be a whole new challenge of seeing . . . where it could take [her] education." "Because of [her] own insecurities], [Jamila] didn't feel so smart. [Jamila] didn't feel like [she] could do science. [Jamila felt] like [she] couldn't do math." Jamila's mom and dad enrolled her into the BEP program through the semblance of "miracles" happening at BEP from family friends, and Jamila experienced her version of a miracle.

Jamila was the product of her local school system. She was exposed to "dual language" education throughout elementary and middle schools, where "80% of the curriculum was in Spanish from pre-K to fifth grade [and] in middle school from six[th] to eight[h] [it] was 50/50." Her parents growing up "were always support[ive]." They "pushed [Jamila and her sister]" "to [know] that the little paper matters, that the *papelito*, the diploma, certification . . . matters." As a "middle child," though, Jamila felt relegated to "middle child syndrome." There were many days that Jamila "didn't believe in [her]self" despite having "external factors of people" who did. In talking about how the program affected Jamila beyond the classroom, Jamila candidly shared that she was undergoing a mental health diagnosis during high school, and BEP administrators "prayed over [her]." It was a "very spiritual . . . meeting" that she attributes her growth as a young person to that meeting and her BEP math teacher's support.

Jamila's mental health challenges at a formative point in her life may have significantly affected her along her academic journey as a dual language student. In her high school classes, she "didn't know what the teachers were saying . . . in [her] math class or science [one]." This happened because she knew science and math "terminologies" in Spanish, and it was "a little bit of a struggle to" "know . . . in English and Spanish." BEP math teachers gave her the "confidence to go to the board" even when she didn't know what to do or how to "simplify an [math] equation." Knowing that she was "correct" and getting a "silver medal for math for [her] grade level" showed her that she "could really do math" and she wasn't "that dumb." Like Spencer and colleagues' (2003) work, Jamila determined her language and mental health challenges as a part of her net vulnerability did not define her. By being seen by her BEP administrators and teachers and their use of spirituality when Jamila face stress engagements, these social supports helped Jamila to deeply internalize the importance of "we [as URSs] need to fill in these spaces [and] have a seat at [the] table, and her "voice" matters. Altogether, these adaptive coping strategies support "the role of outside recognition" described by Rodriguez and colleagues (2017), and these further fueled Jamila along her academic and career trajectory.

Facing stereotypes. At the age of 12 in grade school, Kyra was told that "you're a Latino stereotype [and] you'll be pregnant by the time [you'll be] 16." Hearing this, Kyra was "incredibly discourag[ed]." How could any girl hear harmful stereotypes at a young, impressionable age and recover?

Before this impasse, Kyra was transferred from her neighborhood school to a gifted program in the fourth grade, and Kyra "was definitely 100% struggling." Unlike the parents of Nora, Myra, and Jamila, who intentionally transferred their daughters for the promise of something better, Kyra's parents do not recall how they were introduced to BEP. Kyra "remembers going through the interview process [and getting] ask[ed] . . . questions" as an 8-year-old, but Kyra attributes that her parents enrolled her because "it made sense" to join. At the time, Kyra remembers this as a "punish[ing]" experience since "maybe [she] did bad[ly] in school," and perhaps another day of school would "help." In addition to attending the BEP program, Krya attended four other STEM PCPs growing up. However, when Kyra faced the stereotype mentioned above, she was only enrolled at BEP.

BEP staff alternatively had positive messaging regularly on who Kyra would have become. Kyra recalls being told by a BEP administrator, "you're going to be a doctor one day, you're gonna be a scientist, [and] you're gonna do all of these things." At age 9, Kyra asked how they could do these things when they didn't know her, to which the administrator replied" I don't have to know you [. . . to know] that you will accomplish this." For Kyra, this was "so validating to know that people believed in [her], even when [she] [her]self never believed . . . any of this was possible." Kyra's validation point supports STEM Validation Theory because Kyra shows how BEP as a college program supports her, as a URSs, pursuing STEM (Burt et al., 2020).

When Kyra had considered admission for one of the four other STEM PCPs, which BEP connected her to, she had "no idea how to [prep] for an interview of [that] capacity." Having gone to one of the BEP administrators for help, Kyra "walked into the office [for her interview] with red hair." The administrators of the other STEM PCP recognized that Kyra "[stood] out just by [her hair]," and Kyra remembered with glee that she spoke about other ways she stood out with "[her grades] and stand[ing] up for things."

Admission to this STEM PCP and three others later, Kyra held steadfastly as "first-generation" and "one of five girls" pursuing engineering in her college's 200-person major. Kyra's resolute nature aligns with aspects of Dou (2019) in that STEM learning opportunities, like BEP, can motivate "affinity" toward STEM. Fortunately, Kyra's academic trajectory differed from how I started her story, and from the National Academies of Sciences, Engineering, and Medicine (2016) research that shows repeated conditions of facing stereotypes can lead URSs to disconnect from STEM interests. For some, their stories may begin and end with messaging from school teachers about who students would become. For Kyra, early positive messaging encouraged, "validat[ed]," and cushioned her when she came across stereotypes of Latinas and women in STEM.

Net vulnerability, net stress engagement, and reactive coping mechanisms connection

Though Nora, Myra, Jamila, and Kyra differ in their racial, ethnic, socioeconomic, and other salient identities (net vulnerability), BEP provided ripe conditions for acknowledging and overcoming self-limitations as diverse young people (net stress engagements; Spencer, 2007).

Though there are more stress engagements to discuss, it is important to note that each participant demonstrates a reactive coping mechanism. Through “confidence,” “resilience,” the use of “communicat[ion],” and persistence, each participant connects their growth and development to the BEP staff in seeing their potential and providing them the critical help for improving on their academic trajectory. These also connect to Corneille and colleagues (2020) in that BEP aligned with offering content that impacted “STEM identity” and “resilience” through its programming as “psychosocial impacts” on participants’ lives (p. 49). The next section follows the heart of BEP of providing early-STEM resources as a foundation to STEM interests.

Early exposure to STEM resources as a foundation to STEM interests (as net stress engagement)

When describing BEP experiences, each participant discussed the effects of BEP’s early STEM resource exposure as foundational to their STEM interests. The early-on, hands-on STEM curriculum and early exposure to STEM professionals and spaces through BEP programming created deep craters of STEM interests for each participant. BEP impacted how Myra, Kyra, Nora, and Jamila continued on to STEM beyond BEP. In the literature, these BEP’s resources are typically forms of capital that BEP imparts to students (Bourdieu, 2002; Strayhorn, 2016). Fortunately, how Myra, Kyra, Nora, and Jamila handled BEP’s access to resource, furthered their participation along STEM pathways (Massey et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2019).

Early-on, hands-on STEM curriculum

Each participant cites BEP’s STEM curriculum in some manner, and in particular, each participant references to either or both the cadaver and dissection labs available through BEP. When prompted to describe the BEP program, Myra shared:

> *I don't know if it was connected to [BEP], actually retrospect. But there [were] these like cadaver lab days . . . medicine days. And that for me was pretty pivotal and at least considering medicine [and] me in the future.*

Despite Myra's uncertainty about if cadaver labs were affiliated with the BEP program, Jamila corroborates this, having gone to "medical lab" and seeing "cadavers." Thus, during Myra's impressionable years at BEP, Myra formed an awareness and passion for medicine. Myra continued to share:

> *And so I'm talking, I remember there was like a science curriculum where we've dissected I think [a] frog or something of that sort, and that was really really cool. Something I never, I actually still through high school and until . . . college never actually did, which I attribute a lot of my fascination.*

Myra's additional thoughts point to BEP exposing her to STEM content that she otherwise did not have exposure to during high school and until college. This exposure to dissection labs, which Kyra acknowledged remembering dissections as well, created conditions for her interests and "fascination" to remain a STEM major, and ultimately pursue medical school.

Today, as a fourth-year medical student, Myra is in the process of considering her residency. When asked what impact did the program have on Myra becoming a doctor, Myra shared, "Early exposure to . . . a scalpel, and . . . our very tiny structures. And to learn more about it in [the] body. [I] subconsciously, saw the loop played [its] impacts, [and] I'm actually applying to surgery." Myra connects real-time that early exposure with "a scalpel" and knowledge of "tiny structures" led to her particular interests in pursuing surgery for her residency. Though she is not sure of her admission or next steps yet, Myra could deduce that her journey was influenced by BEP's early-on, hands-on STEM curriculum.

Early exposure to STEM professionals and spaces

All participants acknowledged BEP's access to meet and encounter STEM professionals. In particular, Jamilla and Nora are mentioned in this section because both pursued STEM majors, which they did not complete long-term. Ultimately, both cite BEP as influential and instrumental to their STEM interests.

Early exposure to health sciences. Though Jamila was not exposed to the "tech side of healthcare," she learned about "clinical professions like the pharmacy, nursing, [and medicine]" and met health science professionals at BEP. Jamila shared:

> *I think that's why I never diverted from healthcare . . . because . . . when we went to [the] medical lab, and we saw cadavers. Because when we went to the pharmacy school, . . . we were touring these areas. You didn't see people like us in those areas. I didn't see it. . . . That's what the program actually is. . . . I clearly could say that it brought hope.*

As mentioned earlier, Jamila's experiences with the "cadavers" and "touring" the "pharmacy school," these experiences altogether brought her hope. Despite not having evidence of people like Jamila in those spaces, from her point of view, Jamila was committed to pursuing healthcare. It brought Jamila "hope" that she could be the one for others in these fields, and when Jamila later attended and dropped out from her first undergraduate institution studying in nursing, "[her] focus [would] always [be] in healthcare and medicine," and she "credit[s] that to the [BEP] program." Today, Jamila serves as a lead software developer at a health-technology company.

Access to internships, field trips, and research. When asked how the BEP program affected Nora beyond academics, Nora mentioned:

> *But if it weren't for [BEP program college site] or [BEP] though, in the summers, I participated in their summer internship program. My first job was at [BEP program*

college site] hospital. I forget how old I was. But that was the first time I was ever in the hospital setting. And from then on, I'm like [I can] do this. I like being in these clinical settings. I like being around patients. And then, from then I went on to be interested in research. So yes, it was through [BEP] that I gave that interest. . . . I would not have known about that unless it was for that program. So we had a tremendous impact. . . . [I] credit everything.

Through BEP (or BEP's program college site], Nora was provided an "internship" opportunity, where she worked at the "hospital" for the "first time," and learned that she could "do this." Through continued engagement with STEM learning opportunities, Nora's sense of belonging formed, which supports the works of the Institute of Medicine, (2011), National Academies of Sciences, Engineering, and Medicine (2016), and National Academy of Engineering (2018). BEP program experience connected her to internship opportunities that allowed her to see that she enjoyed "patients," "clinical setting," and later "research." This internship experience also taught her an invaluable lesson. When asked what aspects of the program were beneficial, Nora considered:

I think in high school years, we were able to participate in . . . a [summer] internship program, which allowed us to really kind of see [and] visualize ourselves [in] like a clinical capacity or research capacity at those ages. And that was extremely beneficial for me. . . . From then, I only sought out internships every summer. Like in undergrad every summer, I sought out a summer internship program . . . because of [BEP] got me in the mindset of doing that. And so every summer, in undergrad I did . . . a summer internship program that was geared towards my interest in research. And so yeah, . . . definitely those were extremely beneficial aspects.

Nora moves one step further to state how early “internship” experiences set a precedent for her pursuit of “internships throughout undergrad. BEP exposed Nora to experiences that allowed her (and other students) to “see” themselves in a “clinical” or “research” capacity in the future. Nora pursued internships that furthered her “interests in research.” She attributes her initial STEM interests to BEP.

Nora expanded on earlier comments shared by Jamila. Nora shared:

> *[BEP] opened my eyes to research in public health in general, really. So I kind of I give all kudos to them for being my foundation there. . . . Even psychology, I remember when we took a tour of the . . . social work department one time . . . and that kind of got in my mind that at young age, like maybe I can consider this as a profession. So yeah, I kind of continued in that path, years after.*

Nora points to BEP as creating a “foundation” for interest in health and social services. At an early age, BEP exposed Nora to the college department of social work. This early exposure for Nora planted seeds for her to “consider” as a career and profession, which Simpson and Magee (*unpublished manuscript*) also contends in addition to the works of the Institute of Medicine (2011), National Academies of Sciences, Engineering, and Medicine (2016), and National Academy of Engineering (2018). Nora continued:

> *When I was going . . . after undergrad and thinking about what I want to pursue next, I remembered that . . . those [experiences in] BEP. I'm like, oh, yeah, I remember that. I think that's something [I want to] look into. And lo and behold, [BEP administrator] actually encouraged me to apply for the [health and social services] program and actually do a dual degree program.*

Nora pursued graduate degree work and profession in health and social services because of the seeds planted by BEP, and today, Nora serves as a public health specialist, providing public health, education, and social support for callers. Beyond BEP, BEP administrators encouraged her to pursue her graduate studies. Ultimately, Nora's current academic and career trajectory are explicitly tied to the influence of the BEP program, on-campus partnerships, and staff, who continue to remain in touch years after Nora's graduation.

Altogether, BEP ties Jamila and Nora's academic and career experiences to the program offerings during BEP. The profound ways BEP exposed young people to health sciences through learning experiences, professionals, and physical building access had long-term effects on participants, and Jamila and Nora's experiences speak to that.

Something bigger

Kyra mentioned BEP's impact several times as "something bigger." Kyra shared an early memory when she was on campus:

> *I remember they had all of these banners of like, . . . Class of 2003. This is the banner from the class of 2005. And I just remember, . . . looking up there and being like, 'wow,' . . . 'these people are super old.' But number two, . . ., that's gonna be me one day. . . . My name is gonna be on a banner. . . . It wasn't [that the] banners related to [BEP], but it was banners related to like, something bigger. And I think that, for me, [it] gave me a lot of . . . admiration, and ambition to look forward to this thing that was ahead of me that like. Even though, if I didn't know it in the moment, . . . this program was going to put me somewhere else than other people.*

Kyra's Saturday at BEP had some moments where she simply hung out "in the [college] lounge," and at this moment with herself, Kyra realized the gravity of attending college and being successful. Though the "banners [weren't] related to [BEP]," the opportunity that BEP provided

Kyra resonated deeply. Kyra was able to see the "bigger" picture that BEP "was going to put [her] . . . [compared to] . . . other people," and this may have to do something with the resources BEP and other STEM PCPs provided her.

Before being asked to focus her responses exclusively on BEP, Kyra disclosed when discussing the likes and challenges of STEM:

> *I also believe that even at a young age, like I did programs, like [BEP], I did [another STEM PCP that BEP shared], . . . there were those resources, and I was exposed to those resources, that made it seem less scary and less daunting.*

Krya describes pursuing STEM as "scary" and "daunting." Despite this, Kyra credits BEP and her other STEM PCP as sharing resources that aided doing and participating successfully in STEM.

Kyra expanded on how BEP provided her in the form of resources when she shared:

> *Because I think there are not many resources for people from low economic backgrounds, and there's not a lot of resources for people who are minorities, . . . especially when it comes to STEM. I think when you're a kid, . . . you hear . . . the major things, . . . you could be a doctor, lawyer, or teacher. Like you don't really hear, . . . you could be an engineer, . . . you can like be a mathematician, you can be a scientist, you can do all these different things. You can like work in technology, you can be a computer kid, like all these different things. And I think, for me, that's what [BEP] was like. It was the first time that somebody was like, 'Hey, I know that there are so many stereotypes flying around about what you're supposed to do with your life, because of what your name is, . . . what you look like, . . . how much money your parents make, but we're here to tell you that you can dream so much bigger than any of that.' And I think to me, like I*

always look back at . . . the [BEP] program with like, such found and like admiration.

Kyra shares that there are career limits posed to young people. With the knowledge of becoming "doctor, lawyer, or teacher," young people, or "kid[s]," do not have much access to all the other professions that they can pursue. Along with limited access to career types, young people actively navigate "stereotypes flying around" about their academic and professional trajectories because of their racial, ethnic, and other salient backgrounds (i.e., first-generation and mental health statuses). Yet, BEP staff shared different versions of what students could become. BEP shared that Kyra and other students "[could] dream so much bigger than any of that." Therefore, BEP as a program intervention served as a dream production for young people at a critical juncture in their lives.

Lastly, Kyra shared that her "academic excellency" changed by attending BEP. Through "extra help" over the weekend, Kyra was "far beyond [her] peers [in school] by the time [she] was an eighth grader. Though existing literature acknowledges the ways STEM interventions can affect the psychological attributes and characteristics of URSs (Ashley et al., 2017; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2018b; National Academy of Engineering, 2018), Kyra moves beyond this literature to demonstrate how BEP impacted her. Thus, in addition to providing resources and helping Kyra to see the larger picture of her life, BEP "transformed the way [she] became as a student [and] fully transformed the way [she] thought about STEM." Therefore, BEP deeply altered the internal mechanisms of Kyra in how she saw herself and her long-term academic and career pathway.

Net stress engagement connection

Myra, Jamila, Nora and Kyra experienced e*arly exposure to STEM resources as foundational to STEM interests*. Each early exposure was foundational to each of their *STEM* *interests* later in life. Through the wealth of BEP resources (i.e., experiences, professions, and building access), each participant developed seeds of social support that protected them along their academic and professional trajectories (Spencer, 2007). BEP, independent of other learning experiences (i.e., schooling, college, and other STEM PCPs) bore the significant responsibility of doing so.

Although part of Kyra's aforementioned description aligned with aspects of SCCT (Kyra's trajectory is based on home environment influence on education), SCCT considers how low-income persons can access programs, like BEP, to expand and illuminate new career paths not considered before (Carpi et al., 2017). However, SCCT does not consider the role of race, stereotypes, and the choices URSs make when choosing a career filled with gender and race threats. Thus, PVEST, as a theoretical framework, does this by centering its model on race and young people navigating racially-charged and complex learning spaces. The following section discusses the function and importance of community in Myra, Jamila, Nora and Kyra's life.

Importance of community (as net stress engagement)

As participants considered their BEP experiences, the theme of *importance of community* arose. Each participant shared how their family members and other BEP community members were collectively impactful during their BEP program and beyond. Through forged "relationships" and being in a "community of other folks who were interested in STEM," BEP leveraged the availability of BEP community members to establish social support and provide invaluable lessons to Myra, Kyra, Nora, Jamilla, and other BEPs. Some participants developed advanced, internalized beliefs about the *importance of community* throughout their academic and career trajectories, and these beliefs carried through in their experiences beyond BEP.

BEP as a community of learners

When asked what was beneficial about BEP, Myra described, "What was particularly helpful was having a community of folks who were interested in learning and interesting and doing the best they could in STEM specifically, but just in general as like, wanting to be good students." Myra described the function of "community" as having "interests" and the will to do the best in STEM coursework. With everyone there on "Saturday" for an extra day of "school," "[participants] knew that [BEP] was for their benefit." Myra described how a "sense of camaraderie" also impacted the mindsets that students had during the program. For Myra, "camaraderie" and "hav[ing] more personalized relationships with some teachers" both "help[ed]. . .[her] . . . spirits going through the program."

Myra and other students were a part of a learning experience where high expectations and common interests aligned. The fact that other BEP participants were compelled to do their best, even if "folks didn't necessarily want to be there [because] their parents dragged them" demonstrates that there was some amount of buy-in from the majority of BEP participants. Considering BEP's impact on Myra's sense of community one step further, Myra shared at the end of the interview shared that:

> *[...] It was an honor, a privilege to be a part of that world, to be able to do life with my class, grow together with them, just be a part of their lives in a way that I know if I had never been part of this program [I] would actually . . . be apart of.*

As an Asian young woman then, Myra recognized that she was "in a minority program that was predominantly Black and Brown students." Looking back, Myra idolized not only her time in the program but also her time with her peers, to the point where she acknowledges it as "honor" and "privilege" to "be a part of their lives."

Myra's learnings and community exposure in BEP also helped her navigate some challenges in college, where she attributed BEP in helping her to "create a community around folks who are interested in certain things but also honestly were struggling with others." Myra added, "having to learn how to make friends quickly, if you're the only person that sometimes looks like me . . . I got to be able to do that better and faster when I was in college." Ultimately, Myra connects her valuation of and abilities to access community when she needs it to BEP, and her BEP helped her in this self-actualization.

Understanding professionalism

When prompted with what KABs did Kyra learned from BEP, Kyra shared professionalism. Kyra added:

> *I think you learn a lot of professionalism very quick[ly]. And I think it's because when you're in grade school, like yes, you have professionalism in the terms of, . . ., you don't talk back to your teachers. . . . But I feel like the majority of adults that a lot of [young] people might come across are like family friends, so they're . . . your aunts, . . . uncles, and . . . your uncle that's not actually related to you. But . . . it's never that sort of like professionalism outside of schoolwork. Whereas I think you meet so many people [in BEP]. . . . You meet so many people's parents. You meet so many [people], like volunteers. You meet all of these people that are constantly trying to help you and do different things, as well as you meet other [teachers].*

Kyra summarizes the breadth and depths of a nuanced social support system at BEP. By having so many adult stakeholders involved (i.e., "parents," "volunteers," teachers, etc.) in participants' lives, Kyra learned how to communicate with people outside of family and "family friends." As a practicing mechanical engineer today, Kyra considers these many entities in the social system as critical in developing and mastering "professionalism" at an early age, where Kyra and BEP participants develop relevant and vital communication skills to navigate their academic and professional journeys effectively.

Community beyond BEP

Both Jamila and Nora's college journey was not as straightforward as Myra and Kyra. Both took tumultuous "turns" and drops before ultimately completing their undergraduate degree programs. Despite their collegiate beginnings, both Nora and Jamila coincidently returned to the BEP's program college site for their graduate degree training. Separately, though Kyra's journey remains similar to Myra's, Kyra provides interesting additions to the importance of community beyond BEP. The following section explores how BEP influenced the community for participants Jamila, Nora, and Kyra, beyond BEP.

Support system. Kyra touched on a similar, yet different point about her BEP peers. Before college, Kyra's community was her BEP peers and friends. Kyra shared toward the end of the interview:

> *I think [my BEP peers] were by far the biggest, . . . support system. . . . We were all in this world that kind of just connected us for years and years and years. Because no other person can be like, 'I went to school on Saturdays.' Like, there aren't many of us, and [I think] that specifically . . . throughout BEP number ones, were in the program.*

Kyra truly valued the "community" of friends that she formed deep "connect[ions]" with. So much so to the point, where her parents asked if she wanted to drop out of the BEP program because she was enrolled in four other STEM PCPs and attended Sunday school, and Kyra did not quit because she "loved her friends," and she "want[ed] to see this through." Kyra's relationship with friends serves as a backdrop to understanding her thoughts on the issues and challenges of pursuing STEM on campus. Kyra shared:

> *I also think that a huge challenge is just the notion of what it's like to be a first-generation college student. And I think that for a lot of us at, . . . BEP . . . were first gen. . . . And I think that it's so much more daunting, when . . . you find people on campus that are also . . . the first in the family to go to college and might have a similar background to you. But it's so much less daunting when you know that you have friends at other universities who are experiencing the exact same feelings that you're experiencing and . . . the exact same fears about going away to college or being in college that you have because you were able to come up with them together. But you came up with them with the resources of having like, this is what like this is kind of what a college experience is like.*

Kyra points to her "first-generation status" as something that many BEP participants shared as a life experience. When attending college, Kyra disclosed that there is a burden and "daunting" effort when connecting with other first-generation students. However, this burden and "daunting" effort is reduced when Kyra has the knowledge of other people that she "came up with . . . the [same] resources of . . . what a college experience is like." Knowing that one of Kyra's friends attended other schools, "science," "pre-med," "[law]," and other fields, Kyra described "that this was a huge . . . for us." Ultimately, Kyra points to how her own BEP community continued and transcended beyond BEP as a program intervention, where Kyra developed "lifelong friendships" that served as a "social support system" even throughout college. Krya's ideas also connect to Morton's (2017) "sisters of struggle," where there is a network of others, especially other women, that Kyra checked in with and supported throughout college (p. 134).

Community through pipeline programs. Nora considered pharmacy school for her undergraduate studies for several reasons. One of them was her time in BEP and her ability to become a pharmacy technician through a BEP-partner program. Though her path today did not end with Nora becoming a pharmacist, her "[many] twists and turns" within her collegiate journey speak to her values and community awareness from her BEP experience.

Nora realized that her first college institution was not the one for "her." After her studies there, she returned home to "reevaluate." While doing so, she pursued an "associate's degree in psychology" before transferring to complete her "bachelor's [in] clinical psychology" at a 4-year public institution. Looking back, Nora shared that this time was "challenging," since she "didn't know fully" what she wanted to do. In addition to the pharmacy field, Nora had a "strong interest" in the "mental health sciences," but she found it "difficult [. . .to] see [her]self" because "there's not a whole lot of African Americans in the field." Therefore, Nora pursued "pipeline programs" similar to BEP, "which allowed [her] to connect with other minority students who were interested in similar psychology or public health interests." Also, it is important to note that Nora pursued "pipeline programs" similar to BEP, because "see[ing]" and "connect[ing] with "other minority students" with similar career interests served as her own attempt to persist in STEM fields. Nora added that the pipeline program "allowed [her] to connect more with students and see where [and] how [she] could . . . mix as well." Despite there not being many African Americans at her four-year institution she transferred to, this pipeline program effort assisted her in completing her undergraduate studies and spoke to ways that BEP programming ran parallel in supporting the completion of her undergraduate degree. Like participants of Rincon and colleagues' (2020) study, Nora leveraged relationships and college involvement and engagement to successfully resist postsecondary norms to survive and thrive in her college and major choices and interests.

Making seats at the table. Jamila took many "twists and turns." After failing freshman year of college for a nursing major, except for passing her "pre-calculus" course, Jamila faced more mental health challenges. By continuing her studies at a community college, she obtained an "associate in general studies," perhaps with aspirational momentum as Wang (2015, 2016, 2020) posits, before transitioning to a public, 4-year institution. Since she really liked "how different cultures perceive medicine and healthcare," she pursued "medical anthropology" to "do something that [she was] passionate for once." Jamila eventually obtained a master's degree in health information science, which she considered returning to obtain her master's in nursing. However, she determined that it was not "the right path" for her, so she pursued a degree in health informatics.

Jamila thought of the BEP program as a "safe space for . . . students to participate." Jamila acknowledged that "[staff] truly care 100%." BEP created a safe space for learning, while simultaneously acknowledging gross inequities in healthcare sciences. Jamila shared:

> *To me, it . . . highlighted that we needed more minorities [in] the science space, in STEM. I think, having a group of us, all Latinos and African Americans, I believe that was mostly what my class consisted of, [was] like, wow, eventually one of us is going to become a doctor. . . . Like the inspiration and the hope of bringing that diversity into health sciences, [it] changed me. It really did.*

Jamila's keen ability to outline the mission of BEP demonstrates the clarity in vision that BEP operated and shared this with BEP participants. The goals of increasing "minorities" in "science [and] STEM" fields and internalization that "one of us is going to become a doctor," exemplify shared and sustained understandings of her serving as a BEP participant and community member. Jamila's recognition of this mission has "changed" her and also reinforces Jamila's indoctrination into BEP's community goals. Altogether, this section reflects Jamila's goal restated by her later as "mov[ing] forward so that other individuals [like her] can also have a seat [at] the table," and she is actively working to do this within her workplace.

Kyra, Nora, and Jamila's journey and choices revolve around connecting with others passionate about pursuing and achieving STEM majors and careers. Rather it is sustaining, seeking after, or making community for other URSs, each participant tied their participation, understanding, and maintenance of community to the BEP as a program intervention.

Net stress engagement connection

Myra, Kyra, Nora, and Jamila shared experiences of recognizing the *importance of community*, and the collective meaning and essence of this shared theme support the role BEP programming and staff have served in creating social supports as a means to disrupt challenges that each participant experienced in their ecological system (Spencer, 2007). By encouraging a community of learners and developing young people's professionalism, participants carried the value of community in their lives beyond BEP (i.e., support system, seek other pipeline programs, and make seats at the table for others). The next section discusses divergent themes that appeared throughout the analysis.

Divergent themes

Some participants mentioned divergent themes that were not completely consistent with others' accounts, including *program timing as dreadful* and *creating a legacy for others*. This section briefly shares these themes.

Program timing as dreadful

Myra and Kyra shared aspects of the program timing as dreadful. For Myra, she recalled, "There were folks who didn't necessarily want to be there . . . like their parents had dragged them or whatever." Though all participants mentioned aspects of the program occurring on Saturdays, Myra points explicitly to the difficulty of encouraging young people to attend a weekend program. Having peers "dragged" in shows that there may have been challenges with buy-in from other BEP participants.

As mentioned before, Kyra initially perceived attending the program as punishing. She shared, "we're all stuck here together. . . . We're all stuck in this, . . ., whatever punishment our parents are putting us through, like, we're all stuck in this together." "For a long time," Kyra thought that "BEP was a punishment." She recognized how "sad" that sounds, but reflecting now, it was "one of the best things [she] ever did for [her]self." Despite her shift in perspective on BEP today, it is important to acknowledge how she, and other BEP participants, felt about being "dragged," "stuck," and "punish[ed]," and this is important to note when considering how other STEM PCP students may feel about their STEM PCP experience. Yet, despite the feelings that Kyra and others had then, Kyra supplants BEP as important for her life, as well as perhaps her perseverance and persistence.

Creating a legacy for others

Jamila, Kyra, and Nora brought up doing something for others like themselves. For Jamila, as mentioned earlier, she constantly considers how and in what ways she is making a space at the table now for others like herself. For Kyra, she observed how other BEP alumni return and share college life. Kyra recalled:

> *We got to talk to . . . current college students. A lot of alumni used to come back and . . . talk to us about. . . [how] . . . college isn't easy . . . I think it was one of those. . . I didn't have to be perfect in it.*

Because of connections and influence of BEP on other previous students, BEP "alumni" returned to share about academic journeys after BEP. This insight helped Kyra and others to see that they "didn't have to be perfect" while in college. Today, Kyra recognizes that BEP administrators delivered similar messages to her like:

> *"You're going to be a doctor one day, and . . . you're gonna forget about all of us and, . . . you're just going to come back one day. And we're going to be like 'Dr. [Kyra's last name].' . . . You're going to be [a] student alumni; . . . you will, [give] a presentation."*

Kyra's receipt of positive messaging shows how Kyra will "return" and give "back" to current BEP students in due time. Therefore, BEP administrators lay the groundwork for participants continually collecting and giving back when BEP participants attend BEP, which has already happened for Nora. Nora acknowledged:

> *On top of having former students come back and speak to us who might have been . . . going to college at that time and that were also a part of [BEP], . . .I know what we did a couple years ago, pre-pandemic. . . . It sets up the tone [for] what to think about going into college, and how to get help if you need it. And it's okay to . . . change your mind [. . . [and]. . . your major . . . once or twice, three times, whatever. You know, that's fine. So, yeah, being able to hear people that had students in those who can give real experiences, I think really [helped] me visualize how I can see myself in the future.*

Nora recalls having former participants describe their college journeys, and this information served as "set[ting] up the tone [for] what to think about going into college." Having others give back their time, Nora shared that she went back "pre-pandemic" for BEP participants. Her contribution to the cycle of giving and learning contributes overall to BEP supporting participants in establishing a legacy for and with others who look like them with shared interests in STEM.

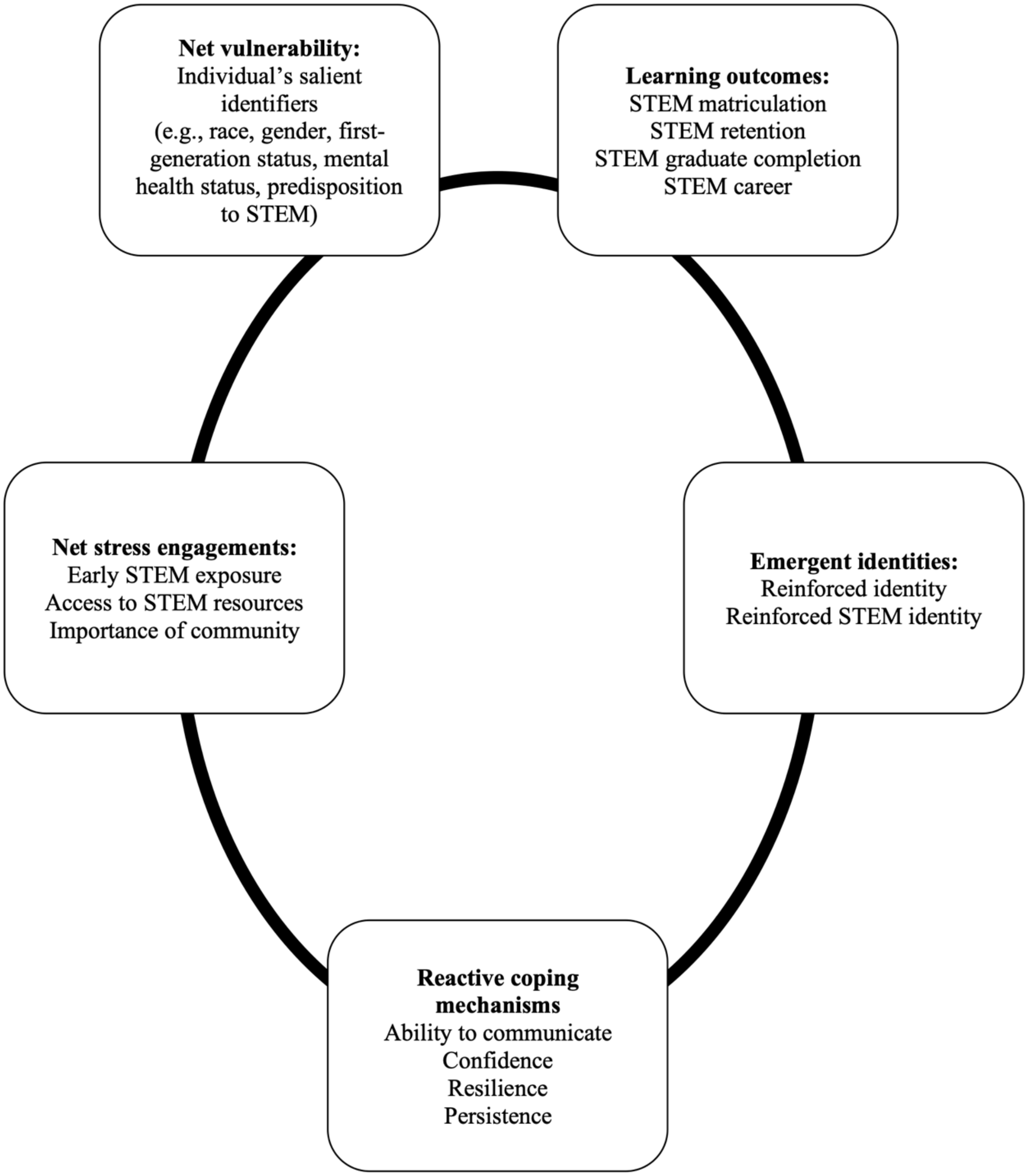
How do historically underrepresented students in STEM who participate in a STEM pre-college program situate these experiences in their personal and professional development?

Considering all aspects of participants' interviews and survey data (see Tables 3.1; 3.4), Myra, Jamila, Nora, and Kyra have accomplished much in their short tenures of 9 to 11 years after BEP participation. The sections above highlight superordinate themes of *overcoming self-limitations and being seen*, the *importance of community*, and e*arly exposure to STEM resources as foundational to STEM interests*. Ultimately, these themes manifest as ways BEP influenced participants' academic and career trajectories (see Figure 4.1). However, when answering how participants "situate" their experiences, it is also important to review linguistic choices that each participant shared during the interview.

Though some of the following phrases and quotes were interspersed throughout the findings above, it is important to revisit, acknowledge, and consider the ways Myra, Jamila, Nora, and Kyra define and make meaning of their experiences at BEP.

Figure 4.1

Modified model of PVEST to demonstrate the influence of BEP on former participants.



Note. Each of the five boxes represents a stage of the PVEST model where the subsequent text outlines potential components that would fit within those constructs. Adapted from Morton (2017).

Interact with the world

When asked what BEP means to Myra, Myra shared that "she didn't realize how much it was a privilege to be a part of "BEP." Myra continued sharing that despite not attending every class or doing all the homework, the program really "shaped how [Myra] interact[s] with the world." Through the program's "community and staff," Myra discovered things that she wouldn't otherwise. The BEP program offered Myra the chance to interact with others and texts in ways her traditional schooling or other programs had not. Myra shared that she "attribute[s]" her going to medical school "a lot" to BEP, and BEP was "very much a breed[ing]" ground for her" through the early exposures to STEM throughout her younger years.

Through Myra's account, her "interact[ion] with the world" shifted by attending BEP. However, I wish that I pushed her to provide more perspective on how and in what ways, the aforementioned points on Myra reveal that she interacted with texts and her peers in ways that she wouldn't have been introduced to or come across through her traditional schooling. Additionally, Myra's mentioning of BEP as a "breed[ing]" for medical school interests and pursuits demonstrate that she connects the early exposures to STEM resources as foundational to her STEM interests and continued STEM journey as a medical student today.

Bringing hope

Jamila answered in a different way to what BEP meant to her. For Jamila, having so many "Latinos and African Americans," was empowering. Jamila shared her feelings that "one of us . . . [will] . . . become a doctor" and bring "the hope of . . . diversity into health sciences." Jamila shared that BEP "really" "changed" her. Like Myra, access to STEM resources and courses impacted Jamila. Jamila shared that through these early exposures to STEM resources, Jamila "didn't see people like her" in health sciences fields, and despite not seeing others like Jamila, she was empowered to keep going. Jamila learned early on that she "need[ed] to continue" to so others "have a seat at the table" and "fill in the spaces." Through BEP, she learned her "voice" is important, and understood that through all of the "tours . . . and different events that [BEP]" took her and her classmates.

Ultimately, Jamila was empowered by having other "Latinos and African Americans" who were a part of a learning community. Through real-time exposure to disparities in health science fields, Jamila learned the importance of pursuing a degree in STEM. Earlier, I noted that Jamila "never diverted from healthcare," and having such clarity of vision despite multiple setbacks through her academic journey in college is powerful. Additionally, Jamila's determination to "fill" and "make" space for others shows that BEP exposed her difference and inequity. Without BEP, Jamila may continue her studies with others like her, but she may not have learned about available careers in "pharmacy," "nursing," and other health science fields. She may not have even considered a "health information science" graduate degree at BEP's college program site and decided to work at a health-technology job, and she may not have been able to return the "hope" that she got from BEP to her younger versions of herself today.

Foundational to development

Nora described jumping to help BEP administrators whenever because Nora understands BEP as the "foundation of [her] development." BEP encouraged her to persist throughout her middle, secondary, and postsecondary years and BEP taught her the importance of "intern[ing]" when possible. Nora shared that BEP "gave [her] interest" in research, and she "would not have known about [research] unless" otherwise. At the end of her response, Nora acknowledged BEP "had a tremendous impact" and "credit[ed]" for "everything."

Unfortunately, I did not lean into defining how Nora defined "everything." However, from earlier sections about Nora, I can deduce that BEP's math helped support her overcoming her self-limitations of being "shy" and viewing herself as "not the brightest." Through BEP's varied support network of staff, teachers, and alumni, Nora experienced additional forms of care and nurture that fueled her. BEP's early exposure to STEM resources also explicitly helped Nora "consider" a graduate degree and job in social and health services. Therefore, due to Nora's experience at BEP, her academic and professional trajectory was "tremendous[ly] impact[ed]."

From "punishment" to the "best thing" for self

Lastly, Kyra initially described BEP as a form of "punishment." However, with the ability to think retrospectively on the program, Kyra described her initial thought as "sad," since she today considers "[BEP] as the best thing [that she] ever did for [her]self" and "that [her parents]" were able to get [her] into." Kyra continued to share that her view of what she could become "shifted" because of BEP, and she experienced BEP staff communicate to her that "[she and other BEP students] can dream bigger than" any of the "stereotypes," labels, or assumptions others may have prescribed due to young people's race, gender, socioeconomic class, etc. Kyra noted her "admiration" for BEP.

Any fourth grader attending an extra day of school may have negative ideas and view the program as "punish[ing]," and for Kyra, she willingly admits how she felt about BEP when she was younger. However, with time, Kyra recognized the overall benefit of the program "as the best thing [that she] ever did for [her]self," which for her, this distinction is important. When Kyra could have quit or dropped out because of her commitments elsewhere, Kyra chose to stay in the program. Her "BEP" friends were a driving force to this decision, but also, she mentioned earlier around "want[ing] to see this through." Kyra's choice to remain with BEP demonstrates that she too internalized that she "[could] dream bigger" and achieve more through BEP's program assistance. Kyra may not have been connected with BEP's partner STEM PCP without BEP. Kyra may have accessed other STEM programs that partnered with her high school, but would this have been too late for a “12 year old” told that she would be “pregnant [by] 16?” In this life, with its intricate and complicated nature, we may never fully and truly know Kyra’s counterfactual tale, excluding BEP. However, we can continue to “dream bigger” with Krya. Where she will go next after her mechanical engineering career and what her next academic and career plans are because of BEP’s program exposure.

If focused on the isolated cases of Myra, Jamila, Nora, and Kyra, one may find measures of undergraduate college status (as enrolled or dropped out), undergraduate major type (as STEM or not), or GPA (as high or low), as insufficient indicators for how BEP as a STEM PCP influenced participants' lives during and beyond. Therefore, with each participant having successfully pursued a STEM undergraduate and/or graduate degree, or career, this qualitative design using IPA analysis and PVEST theoretical framework, provided rich, nuanced, and complicated tales of who participants were during BEP, how participants are doing now, and what lies ahead for their futures.

Serendipitous results

There are ways in which qualitative studies point to serendipitous or unexpected results or findings. In my work on exploring BEP, I obtained four female participants, which I had not expected this result. Doing so provided findings specific to these young women’s lived experiences. The following section hypothesizes how my sample came to be, shares overlooked analyses and potential theoretical lenses for this work based on my results.

As noted earlier in Chapter three, six people reached out total as participants; however, four women successfully set up an interview with me and completed the survey design of this study. The two people who did not successfully participate in this study were male-presenting individuals. Therefore, I speculate that these male-presenting individuals and other individuals of gender groups (i.e., transgender, nonbinary, etc.) did not participate in this study because either: a) the study materials discouraged their participation (i.e., no compensation for time, did not see the benefit of their participation, etc.), b) these individuals were not captivated by participating in such a study design due to gender dominance (or underrepresentation) in STEM fields and careers, and c) these individuals were no longer interested. An all-female participant study occurred without male and non-binary participation, yet the Beginning Early Program (n.d.) notes current male participation in the program as over 40 percent.

Despite these “female-“generated, serendipitous results, I did not change the title of my study or re-shift my theoretical framework or analysis because of the focus on STEM female participation because a) the BEP program did not focus exclusively on increasing female participation in STEM fields and careers and b) I did not direct interview questions based on gendered experiences of participants. Therefore, I did not have significant examples of participants exclusively discussing their gender in STEM or gendered experiences in my findings. However, it is essential to acknowledge that with premeditated changes to this research design, including critical gender and feminist frameworks. In doing so, additional findings may be uncovered related to the roles of the BEP administrators as majority women, the operation of the community as one of this study’s main themes, and the role of other female peers along one’s STEM pathway. Altogether, these serendipitous results point to the unintended role of gender in my study’s findings, and it is important to note these within the findings of this work.

Summary

This chapter confirmed the significant influence of well-established STEM PCP operations (with many years of operations, low turnover, etc.) over the lives of URSs. BEP staff were able to help participants to *overcome self-limitations*, provide *invaluable STEM resources* that drove both short- and long-term STEM interest, and share the *importance of community*.

Each Myra, Jamila, Nora, and Kyra were enrolled through parents to aid each participant to overcome some self-limitation (as self-imposed or imposed externally) that they had not known how to do alone. Through reading, writing, and math support as well as invaluable messaging for managing adversity and stereotypes, each participant felt seen and was able to overcome their unique self-limitation in due time.

Additionally, Myra, Jamila, Nora, and Kyra discussed how early STEM exposures to resources in hands-on curriculum, STEM professionals, and STEM building access created backdrops of STEM interests in majors and fields later in their lives. Each participant could "see" or "visualize" some aspect of themselves doing and continuing STEM work because of BEP's resources.

Lastly, Myra, Jamila, Nora, and Kyra discussed the *importance of community* and how a community of learners and supportive adults created conditions for participants to seek these experiences beyond BEP. Communities were also instrumental in supporting participants in successfully navigating their academic and career trajectories.

There were divergent themes of *program timing as dreadful* and *creating a legacy*. In these themes, some participants discussed the difficulties of attending an additional school day. Other participants discussed the importance of having other participants come to BEP and doing the same for future folks who look like them and have similar interests at BEP and other STEM spaces.

These findings tie into the theoretical framework of PVEST, where Myra, Jamila, Nora, and Kyra utilized BEP early exposure, resources, and community to develop strategies to communicate, build confidence, resilience, and will to persist in STEM coursework, majors, and fields. Altogether these coping mechanisms were foundational in participants' matriculation, retention, graduate degree completion, and careers in STEM fields.

CHAPTER 5: CONCLUSION

This study aimed to understand former participants of a STEM pre-college program and how they situate these experiences on their academic and career trajectories. This chapter summarizes and outlines the research problem and study findings. I discuss and analyze the study findings in light of current literature on URSs and STEM pre-college programs to corroborate, critique, and question the present literature. Using PVEST as a theoretical framework and IPA as a methodological analysis, I present key themes that demonstrate how former participants make meaning of these experiences and understand the effect of STEM PCP interventions on their life outcomes thus far. Thus, the section below also responds to the research questions posed, contributes to the literature on STEM PCPs and STEM retention and persistence, acknowledges this study's limitations and delimitations, and offers suggestions for future work.

Review of chapters

Chapter one identified that increasing STEM participation has been a long project of the United States since the 1950s (Thelin, 2011). Through continued and more focused efforts, STEM PCPs was designed as an intervention to address the unequal access to STEM careers and fields that URSs faced (Ashley et al., 2017; Institute of Medicine, 2013; National Academies of Sciences, Engineering, and Medicine, 2016, 2019; National Research Council, 2012; National Science Board, 2014). Since these interventions and programmatic efforts have lasted for some time, studies support that STEM PCPs can affect participants' short-term and immediate goals (i.e., STEM academic achievement, interests, plans, majors, STEM retention, undergraduate psychosocial goals, and undergraduate internships and engagement; Burack et al., 2019; Crutchfield et al., 2011; Findley-Van Nostrand & Pollenz, 2017; Kitchen et al., 2018; Winkleby et al., 2009; Yelamarthi & Mawasha, 2008; Zhe et al., 2010). Though there are quite a number of people who have participated in these program intervention efforts, there is a dearth of literature explaining how to do these programs affect participants long-term as well as how do participants understand these programs' impact on their life trajectories thus far (Swail & Perna, 2002b).

Chapter two expanded on the literature of this study, noting that other methodological undertakings have suffered from researching the effects of STEM PCPs on participants either:

1. during;
2. immediately after their STEM PCP intervention experience; or
3. significantly later, which the latter requires lengthy and costly methods (i.e., longitudinal qualitative, longitudinal quantitative, or mixed-methods designs; Creswell & Creswell, 2018).

Chapter two also discussed the use of PVEST as a theoretical lens for understanding the retention and persistence of diverse students from across P-16 settings, with some providing specific attention to retention and persistence in STEM fields (e.g., Collins, 2018; Morton, 2017; Ozaki et al., 2020; Spencer, 2007). Therefore, PVEST served as an appropriate lens to executing this work in understanding how a STEM PCP impacted its former participants' academic and life trajectories beyond its programmatic interventions.

Since there are large numbers of graduates from STEM PCPs and little understanding about how and in what ways former participants of STEM PCPs make meaning of their experiences long-term, Chapters three provided a unique methodological design to understand these phenomena using a cost-effective way. The following section summarizes findings from Chapter four. Chapter four highlighted superordinate themes of *overcoming self-limitations and being seen*, e*arly exposure to STEM resources as foundational to STEM interests* (i.e., experiences, professionals, building access, etc.), and the *importance of community* that each participant discussed during their interview as well as a few divergent themes. Chapter four also explicitly addresses the research question: how do historically underrepresented students in STEM who participate in a STEM pre-college program situate these experiences in their personal and professional development?

Overcoming self-limitations and being seen

Overcoming self-limitations explored each participant's burden (either as self or externally applied) as a young person enrolling into BEP. The participants of this study mentioned how:

1. salient identities of race, ethnicity, and gender;
2. statuses of socioeconomic, first-generation, and mental health;
3. predispositions to STEM

impacted them as learners before their initial enrollment in BEP (Spencer et al., 1997; Spencer, 2007). Through BEP's early STEM resources and community, participants discussed overcoming these self-limitations (i.e., reading and STEM skills, shyness, stereotype threat, and mental health) imposed by themselves or elsewhere within their ecological systems as young people. By being seen and supported by BEP community members, each participant described developing abilities to communicate, confidence, resilience, and persistence due to BEP program exposure. For without the existence of BEP as an intervention for these participants, they may have continued to view their identities as risk contributors, experience continued challenges navigating STEM, and develop maladaptive coping strategies along their academic and professional pathways. Altogether, participants' early self-limitations may have stifled their emergent STEM identities and led to a life today with STEM as an undergraduate degree, graduate degree, and/or career. Therefore, BEP aided participants in making progress on vulnerable aspects of their development at a critical and vital developmental period in their lives.

Early exposure to STEM resources as a foundation to STEM interests

Early to STEM resources as a foundation to STEM interests, as a net stress engagement, explored the participants' experience of BEP's programming interventions in this study (Spencer et al., 1997; Spencer, 2007). By exposing participants to STEM help and other STEM learning experiences, professionals, and physical buildings, BEP sowed seeds for them to have STEM knowledge and interests that may not otherwise be available in their ecological system. Through BEP's long tenure of 40 years, BEP established internal and external partnerships, which they leveraged for BEP participants and their family's sake. By intentionally recruiting and supporting URSs, BEP worked to address and solve issues of diverse access to health-science careers. This mission was so ingrained into the work of BEP staff that participants internalized and prioritized STEM-specific experiences that shifted their academic and career trajectories toward STEM. Corneille and colleagues (2020) discuss how programs like BEP address cultural and structural barriers that prevent URSs from successfully obtaining STEM majors and degrees using PVEST and other theoretical frameworks. Therefore, this work advances Corneille and colleagues' notion using meaning-making processes and perspectives of former participants. Additionally, Lane and colleagues (2020) note how programs like this can prepare URSs for STEM and college expectations. Altogether, this work corroborates the important role that STEM PCPs like BEP serve in adequately preparing students for STEM curriculum long-term.

Importance of community

As another net stress engagement, the importance of community explored this study's participants' basic and advanced understandings of the community as influential on their continuation on to STEM majors and careers (Spencer et al., 1997; Spencer, 2007). Through BEP's creation of a community of leaders, participants discussed how these learning conditions influenced their professionalism and ability to communicate with diverse stakeholders (i.e., professionals, parents, volunteers), value support systems throughout high school and beyond, and support the attempts and achievements of URSs pursuing STEM. Altogether, participants point to BEP's role in extending participants' social supports beyond schooling and home and the importance of establishing a community to achieve STEM goals and interests. Through the networks that BEP at their program's site as well as with former participants from different years, participants of this study remarked how they were able to learn more and see more as a result of BEP's networks and connections. Taken altogether, BEP contributed to participants' capital to advance their academic and career trajectories beyond the time of BEP as a program intervention (Massey et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2019).

Divergent themes of dread and legacy

One study participant mentioned how the program's timing over the weekend felt like punishment. In turn, this participant, and other attendees, did not enjoy the program during their earlier years. Other participants of this study discussed the role of BEP in creating conditions to support future URSs pursuits of STEM majors and careers through volunteering at BEP in the future or considering ways to diversify STEM pathways within their own life. Taken together, these divergent themes reflect ideological ways that this study's participants shared some overlap in understanding BEP's effect on their lives.

How do historically underrepresented students in STEM who participate in a STEM pre-college program situate these experiences in their personal and professional development?

This study's participants shared many comments that demonstrate the nuanced and varied ways this program impacted them over their academic and career trajectories. The superordinate themes of *overcoming self-limitations and being seen*, e*arly exposure to STEM resources as foundational to STEM interests*, and the *importance of community* acknowledge aspects of how BEP affected participants. However, what BEP meant to participants varied. From shifting how Myra interacts with the world to bringing Jamila hope, serving as a developmental foundation for Nora, and being Kyra's best thing for herself, BEP positively affected each study participant at their core. Through layered programmatic interventions and supports, each participant acknowledges the depth and breadth of BEP's program intervention. BEP expanded their view and bettered themselves. Altogether, BEP was foundational to their:

1. adolescent and psychosocial development;
2. STEM interests;
3. STEM undergraduate and graduate degree choices;
4. STEM career choices;
5. other aspects of their lives.

Contributions to STEM retention/ persistence, PCP, and PVEST literature

This study contributes to the STEM retention literature by offering an additional perspective. By following up and tracking participants of a long-standing STEM PCP, like BEP, this study shares insights and perspectives on how interventions should be designed and describes how programmatic features remain with participants long after their STEM pre-college programmatic exposure.

Even though the findings were limited to this STEM PCP site, this study design can be replicated for other STEM PCPs to ascertain further the insights about STEM PCPs nationally. You may also be wondering about my specific thoughts on which type of STEM PCP is best for URSs, given I subsume bridge and other college-outreach programs all under the umbrella term, STEM PCP. To this point, I believe that all financial and infrastructural commitments to remedy STEM inequalities and improve the educational conditions of URSs are equally important. Therefore, I support all types of STEM PCPs until (and if) research literature points toward one kind of PCP being more critical than the other. However, as for BEP, findings support that continued exposure through ongoing STEM intervention attendance in elementary and middle schools positively influenced the trajectories of URSs.

By centering the perspectives of former participants after almost 10 years beyond their STEM PCP intervention, this study corroborates the findings of other research on STEM retention and persistence. Through access to BEP's STEM resources and community, BEP affected participants' psychological attributes and success characteristics (Ashley et al., 2017a; Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2018b; National Academy of Engineering, 2018). BEP also provided validation of participants' STEM interests and capabilities (Burt et al., 2020) and increased their social network through access to other BEP participants, parents, teachers, and STEM professionals (Massey et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2019). BEP also provided STEM preparation and help in advance of participants' collegiate experiences (Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2019; National Academy of Engineering, 2018). Therefore, participants of this study successfully navigated on to STEM majors and fields long-term.

Beyond the corroboration with existing STEM retention and persistence literature and STEM PCP literature, this study also outlines the factors that STEM PCPs of today can do to support URSs. This study supports that STEM PCPs, over time with refined structure and operations and on-campus connections, can have an enduring impact on URSs' academic and career trajectories. Additionally, this study supports that STEM PCPs' treatment can have consistent effects on multiple participants over time.

Other studies point to STEM PCPs effect on participant's short-term (STEM academic achievement, interests, plans, majors) and intermediate goals (STEM retention, undergraduate psychosocial goals, and undergraduate internships and engagement; Burack et al., 2019; Crutchfield et al., 2011; Findley-Van Nostrand & Pollenz, 2017; Kitchen et al., 2018; Winkleby et al., 2009; Yelamarthi & Mawasha, 2008; Zhe et al., 2010). This study expands this point by demonstrating that STEM PCPs have a long-term effect on participants. Without requiring an overly complicated, lengthy, and costly methodological undertaking, this long-term effect can be examined to understand the vital features of STEM pre-college programming and early STEM exposure of URSs.

Lastly, this work contributes to PVEST literature by demonstrating that PVEST applies to diverse populations outside of African Americans and demonstrating that programmatic interventions early on in participants' lives can meaningfully impact URSs' STEM pathways (Spencer et al., 1997). Therefore, using the phenomenological-synergistic relationship between PVEST and IPA, this study offers a cost-effective, exciting way to understand URSs' persistence and retention and STEM PCPs. It is important to note that the studies above that this work corroborates cannot explain how to best support URSs' academic and career trajectories.

Therefore, STEM interventions that consider impacting URSs' ecological systems early on can be effective when done well (Spencer et al., 1997; Spencer, 2007).

Implications

This work reveals several implications for policymakers, practitioners, and STEM PCP stakeholders. Through this work, the BEP former participants reveal the importance of supporting a longstanding, intricate STEM PCP with strong, persistent, and consistent program leadership. Though this work does not uncover or explore the origin of BEP and its effects on former participants during BEP's program infancy, this work highlights that STEM PCP leadership, programming, and services can thrive through intentional, consistent, and enduring support from institutional partners (i.e., government, universities/colleges, etc.) and financial stakeholders. This work also demonstrates that established STEM PCPs can equip URSs with the knowledge, attitudes, and behaviors for successfully navigating STEM education after K-12 schooling.

As for STEM PCP practitioners, this work reveals the importance of connecting with all STEM PCP participants personally through the multi-prong work of administrators, teachers, parents, and STEM industry mentors. In doing so, young people obtain social safety nets that provide them opportunities to be vulnerable and able to overcome personal challenges and limitations. Additionally, this work demonstrates that practitioners who work actively to provide STEM exposure early on and repeatedly throughout a young person's life (as early as elementary and middle school) may adequately prepare and directly observe the fruits of labor by remaining in touch and monitoring the development of STEM PCP participants.

Lastly, with the current cartography of STEM fields, spaces, and practices dominated by Whiteness, hypermasculinity, and individualism, this work demonstrates the importance of shifting STEM spaces and practices toward a collectivist approach for increasing URSs' persistence in STEM fields and careers, which support findings also noted by the works of McGee & Robinson, (2020), Morton and colleagues (2019), and Saénz and colleagues (2013). This work shows that it is important to increase STEM retention via learning and implementing inclusive STEM education spaces and practices for all as well as important to un-learn individualistic, "weeding out" STEM learning tactics. Therefore, to best supplant issues of STEM inequality of URSs, this work demonstrates that practitioners who develop intentional programming and services that foster knowledge on STEM-field racial disparities, confidence, resilience and empowerment, collegiality, and community can shape how young people exercise important choices and decisions along their academic and career trajectories by shifting structural components of STEM fields overall.

Future Directions

This study has several suggestions for future work and directions, including sample size, methodology choices, and additional theoretical frameworks.

This study experienced difficulty with the recruitment of participants. This may have been the case because of the COVID-19 pandemic in addition to the fact that participants were not compensated for their time. I would strongly encourage paying participants to participate and contribute to one's study for future studies like this.

As a direction for this work, I hope that these methodological and theoretical frameworks catalyze other doctoral students and researchers to explore the effects of other STEM PCPs on former participants. Since this study purports the particular effects of BEP on their former participants, I think it would be interesting to learn about and understand the meaning that former participants of other STEM PCPs generate about their respective STEM PCP as well as demonstrate the necessary cost-benefit analysis to stakeholders to support STEM PCPs long-term (Rincon & George-Jackson, 2016). Additionally, although this study included individuals who successfully matriculated into STEM majors and careers, I would also be interested in future studies exploring how STEM PCPs impact former participants who do not persist in STEM careers and professions. Such a study may provide novel or additional insights that this study may not uncover.

This study was initially conceived as a mixed-method study design. Since qualitative methods may provide significant and robust findings, this study's dissertation committee consultation and peer debriefings led to the revision of my study. In still considering a mixed-method study design, I would:

- modify my survey instruments to learn more about participant's STEM orientation and other ecological factors;
- increase the sample of individuals up to 125 across multiple STEM PCPs;
- lastly, select up to 10 people from the survey design to interview in a semi-structured manner using PVEST and IPA as theoretical and methodological lenses respectively.

Thus, this change may assist in understanding the effect of multiple STEM PCPs and ascertain cross-regional perspectives regarding how STEM PCPs affect former participants' academic and career trajectories.

Lastly, in looking ahead, I would consider adding additional theoretical lenses to future work in this area. In particular, I recognize the contributions of critical race and gender theorists and discussions of capital through the lens of Yosso's (2005) work. These theoretical frameworks could uncover the social connections of participants and the greater BEP community as well as ascertain the impact of positive messaging and the role of race and cultural affinity when understanding and supporting participants' pursuit of STEM careers long-term. These would provide interesting perspectives and ideas that were not otherwise explored in this body of work.

Limitations and delimitations

This work did include some limitations and delimitations. Some readers may be concerned about the stability or accuracy of participants' memory recollection of their STEM PCP experiences, which could, in turn, affect data quality. Using a phenomenological approach to analyzing this work to understand the long-term effects of STEM PCP exposure, I am primarily interested in gathering how former participants make sense and situate their STEM PCP experience on their personal and professional development. By enacting "effective listening and hearing, seeing things as they appear and as they are, not judging them [one learns] to describe experience rather than explain or analyze it," a phenomenological analysis recognizes the need to "[lift] out the qualities, constituents, and significant horizons of [an] experience" (Moustakas, 1994, p. 17). Therefore, my research interest and goal are mainly to provide how participants situate their experiences rather than labor over achieving memory accuracy or perfection.

A delimitation may be the generalizability of my study's findings due to its small, homogenous sample size. This sample size fits the methodological recommendations for doctoral IPA studies (Smith et al., 2009). Indeed, I expect some of my study's findings to relate to the narrowed experiences of URSs in STEM PCPs across the United States past and present. However, I would offer that it is appropriate if findings from this study only apply to former BEP participants. In doing so, this specific qualitative inquiry offers essential information that clarifies the impact of BEP on its intended audience, which may clarify and refine ways to strengthen other STEM pre-college programming long-term. Another delimitation related to my study's findings may be attributed to all of my study's participants (including my pilot study) identifying as women. As aforementioned, IPA studies are typically homogeneous, and this gender homogeneity aligns with other IPA studies (Smith et al., 2009). However, future studies should attempt to include other genders to understand how STEM PCPs, like BEP, impact male, nonbinary, and other URSs.

Summary

This study aimed to understand how former participants situate and make meaning of their STEM PCPs long-term. The body of literature on STEM retention and persistence reflects various interventions and strategies that are well documented as crucial for affecting URSs' STEM retention and persistence. However, we know less about how former participants of these interventions understand, internalize, and make meaning of their STEM PCP experiences. By using IPA and PVEST, this study provided the researcher an opportunity to steward and share the ways four former participants think about their STEM PCP experience as the impact on their lives today. IPA and PVEST were selected because participants reflected diverse salient identities that required the researcher to focus on the phenomenology, hermeneutics, and idiography of former participants in STEM PCPs (Smith et al., 2009).

The small, homogenous sample size highlighted how BEP helped overcome self-limitations, helped participants feel seen, exposed participants early to STEM resources, found interests in STEM coursework and professions, and the value of community. This study highlights how long-standing STEM PCPs can affect the academic and career trajectories of

URSs by offering social support and aiding students to develop adaptive coping strategies to persist in STEM majors and careers as well as academically and professionally.

Other STEM PCP stakeholders can learn more about STEM PCPs' effect by utilizing this cost-effective and novel way to explore the impact of their STEM PCP on former participants. This study also offers a great deal of importance for STEM PCPs that continue to refine and improve their operational structures for URSs, which they support. This study significantly contributes to STEM retention, persistence, and PCP literature by centering the perspectives and experiences of former participants as valuable contributors to this body of work. Thus, this study offers that pre-collegiate outreach that considers positively disrupting and expanding young people's ecological system early on can significantly affect URSs' long-term academic and career trajectories.

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APPENDIX A: INTERVIEW PROTOCOL

Zoom Checklist
Before Interview
- Set up private meetings
- Create meeting password

During Interview
- Disable screen-sharing,
- Enable the waiting room
- Disable chat feature to limit file transfers
- Lock the meeting after participant arrival
- Record audio to the computer

Research team script for former participants before beginning interview:
Interview Script
Thank you for your willingness to speak with me today. I know that you received an informed consent letter, but I wanted to check with you about consenting once more. It outlined general details about the study and the contact information of myself and my supervising professor. Before continuing to the interview, I wanted to receive your verbal consent to participate in this study. Do you consent to participate in this study?
Just to let you know, you are able to stop our conversation at any time without any consequences, and you can also decline an answer to any of the questions I ask today. Remember also that your participation is completely voluntary and will have no effect on your relationship with the [Upper Midwest University (UMU) or the UMU Beginning Early Program]. I wanted to let you know that I will be recording today's session by audio and notes in a private location. Our session should take 45 min – 1 hour of your time If anything happens, feel free to let me know. If you are ready, I will begin recording now.

Former participant's interview
About You
1. In an elevator pitch, can you describe for me your current job? Tell me what your current job consists of on a typical day?
2. What aspects do you enjoy most about your job? What kinds of things frustrate you?
3. What made you choose your career path?
4. What was your college major? Did you decide to attend graduate school, and if so, what did you receive your degree in?
5. What is (or did you find) difficult about STEM? What do (or did) you like about STEM?

Not many people have the chance to attend and experience a STEM pre-college program. I wanted to know if you could take us through your experiences when you were younger, share about the impact (if any) your STEM pre-college program has on your life, and discuss your current career and life experiences.

STEM Pre-College Program Experience
6. Describe for me the name(s) and type(s) of the STEM pre-college programs that you attended when you were younger?

7. Walk me through what you remember about your first day at your STEM pre-college program?
8. What emotions or reactions did you have while attending your STEM pre-college program?
9. Who decided to enroll you in your STEM pre-college program?
    a. Probe: What were your parents thoughts about your school and its curriculum? What were your guardians' perceptions of your local school district at the time? Did your school have honors/IB/AP math and science programming?
10. I'm curious to learn from your perspective what the STEM pre-college program has meant to you? (How did it affect you academically? Beyond the classroom?)
11. How did the academic content at your STEM pre-college program compare to the lessons you learned in school? (Probe: How did the "beyond the classroom" lessons at your STEM pre-college program compare to the lessons you learned in school?)
    a. STEM pre-college programs provide enrichment or complementary academic content to the learning that you might receive in school. Could you share what kinds of things you have learned through your involvement in the STEM pre-college program?
12. Can you give me an example of how a teacher from your STEM pre-college program has positively impacted you? Why did you choose to share that memory in particular? (Probe: Negatively impacting experience)
13. Can you give me an example of how an administrator/ parent volunteer from your STEM pre-college program has positively impacted you? Why did you choose to speak about that memory in particular? (Probe: Negatively impacting experience)
14. What aspects of the Beginning Early program do you feel are effective or beneficial? Ineffective?

STEM pre-college program, college, and beyond

15. Can you tell me a bit about your college experience? What do you think are issues and challenges faced by students pursuing STEM majors and careers on your college campus?
16. How important is it that you get satisfaction from participating and doing STEM work?
17. How much did you know about needs and challenges as a STEM college student?
18. How does the Beginning Early Program help to address challenges navigating college?
19. What effect (if any) did attending the STEM pre-college program have on your college decision? Major decision? Interests in graduate school? Your current career? Other future career interests?
20. Explain to what extent your participation in your STEM pre-college program contributed to your persistence in STEM-related coursework? Major? Career?
    a. Probe: Can you explain to me what factors contributed to your decision to no longer pursue STEM-related coursework, major, career, or all of the above?
    b. Probe: Why did your participation matter in this instance?
21. Explain to what extent your participation in your STEM pre-college program contributed to your persistence in collegiate coursework? STEM collegiate coursework?
    a. Probe: Why did your participation matter in this instance?
22. How did it make you feel when you decided not to continue STEM? (continue on to a STEM major/career)

    a. Probe: Explain to me what was in your mind when you decided to continue to pursue (or not) your STEM major/ degree?
23. What knowledge, attitudes, and behaviors did you develop as a result of your STEM pre-college program?
    a. Probe: What effect (if any) did your STEM pre-college program have on your self-beliefs? Self-Worth? Self-Value? How did this differ from the messages your peers at school heard or received?
24. What effect (if any) did peers from your STEM pre-college program have during the program? In your life?
25. What advice should educators give to encourage young people like you to pursue STEM?
26. Is there anything else you think I should know about these topics?

APPENDIX B: CONSENT FORM

STEM Pre-college Program Effects
You are being asked to participate in a voluntary research study. This is a research study designed to investigate the experiences of former participants of a STEM pre-college program. Participating in this study will involve consent, interview, and survey completion, and your participation will last up to 90 minutes. Risks related to this research include no more risk of harm than you would experience in everyday life; benefits related to this research include learning about the implications of early-STEM exposure on K-12 students and teachers to improve future STEM-equity and inequality program interventions. The alternative to participating in this study is to decide not to participate in this study.

Principal Investigator: William Trent, Professor of Education
Co-investigator/student investigators: Amari Simpson EdM
Department and Institution: Education Policy and Organization Leadership, College of Education, University of Illinois Urbana-Champaign
Contact Information: atsimps2@illinois.edu

Informed Consent: Hello, and thank you for considering participating in this research. This consent letter will tell you about my study, explain that taking part is voluntary, describe the risks and benefits of participation, and help you to make an informed decision about whether to participate. Participants in this study must be 18 years of age or older. Contact information is listed below, or you can email us at atsimps2@illinois.edu.

Purpose and Benefits: This is a research study designed to investigate the experiences of former participants of STEM pre-college programs. This research can be valuable to those concerned with STEM pre-college program effects on the personal and professional development of historically underrepresented students in STEM. The findings from this research may provide the P-20 schools with information for improving upon STEM instruction experiences for current students.

Procedures: Participation in all the study activities will take between 45 to 90 minutes total of your time. The following lists the projected types of data to be obtained along with the estimated time needed for completion of each research activity.

- Interviews: Participants will engage in 1 interview that is projected to take up to 1 hour. Interviews will be audio/ video recorded. This interview will be performed via phone or an online conference platform like Zoom.
- Surveys: After participating in the interview, we will provide you a unique ID to complete an online survey. Surveys are projected to take up to 30 minutes. Both the interview and research will focus on the STEM pre-college program, early-STEM exposure, and schooling and family STEM messaging.

Risks, Stress, or Discomfort: To the best of our knowledge, the things you will be doing involve no more risk of harm than you would experience in everyday life. A risk of this research is a loss of privacy. We will take every reasonable precaution to protect your data though we cannot guarantee that your data will be protected.

Confidentiality: There will be no identifying information attached to your responses from the interview. All answers will be kept confidential. Only the researchers will have access to your data. We will make all reasonable efforts to keep your personal information confidential, though we cannot guarantee absolute confidentiality. When this research is discussed or published, no one will know that you participated in this study. But, when required by law or university policy, identifying information (including your consent form) may be copied by:

- The Institutional Review Board that approves research studies;
- The Office for Protection of Research Subjects and other university departments that oversee human subjects research; and
- University and state auditors responsible for oversight of research
- Federal regulatory agencies such as the Office of Human Research Protections in the Department of Health and Human Services

Data Retention: Your de-identified information could be used for future research without additional informed consent. Data, including audio /video recordings, will be retained until 3 years after the beginning of this study (or December 2024).

Remember:

- There are no costs to you for participating in this research. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time, or to decline to answer any of the questions in the interview.
- Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the researcher, the University, or the [Upper Midwest University Beginning Early Program]. If you decide to participate, you are free to withdraw at any time without impacting those relationships.

Questions: You are free to ask questions concerning the procedures of this study. This study is approved by the IRB approval as it is directly supervised under William Trent (wttrent@illinois.edu), professor of Education. If you would like more information, please contact Amari Simpson, atsimps2@illinois.edu.

If you have any questions about your rights as a research subject, including concerns, complaints, or to offer input, you may call the Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or e-mail OPRS at irb@illinois.edu. If you would like to complete a brief survey to provide OPRS feedback about your experiences as a research participant, please follow the link here or through a link on the OPRS website: https://oprs.research.illinois.edu/. You will have the option to provide feedback or concerns anonymously or you may provide your name and contact information for follow-up purposes.

Table B.1

Research questions in relation to interview questions

Research questions	Interview questions
(1) What effect does early-STEM exposure have on underrepresented participants' academic trajectory and STEM-career orientation?	3, 5, 10, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24
Background questions	1, 2, 4, 5, 6, 7, 8, 14, 15, 16, 25, 26
Phenomenological variant ecological systems theory questions	3, 5, 8, 9, 11, 12, 13, 15, 17, 18, 20, 21, 22, 23, 24

APPENDIX C: IRB LETTER

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research & Innovation
Office for the Protection of Research Subjects
805 W. Pennsylvania Ave., MC-095
Urbana, IL 61801-4822

Notice of Exempt Determination

June 23, 2021

Principal Investigator	William Trent
CC	Amari Simpson
Protocol Title	*STEM Pre-college Program Effects*
Protocol Number	22030
Funding Source	Unfunded
Review Category	Exempt 2 (ii)
Determination Date	June 23, 2021
Closure Date	June 22, 2026

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Office for the Protection of Research Subjects (OPRS) has reviewed your application and determined the criteria for exemption have been met.

The Principal Investigator of this study is responsible for:

- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Requesting approval from the IRB prior to implementing major modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

Changes to an **exempt** protocol are only required if substantive modifications are requested and/or the changes requested may affect the exempt status.