EXPLORING THE NARRATIVES OF BLACK AND NATIVE AMERICAN WOMEN IN STEM

by

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A dissertation submitted in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY IN PSYCHOLOGY

2025

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For the women who came before me, who pushed boundaries and made space.
For the women working now, who build community, uplift others, and create opportunities for those yet to come.

ABSTRACT

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This research examines the experiences of women from groups traditionally underrepresented in Science, Technology, Engineering, and Mathematics (STEM) fields through two qualitative studies focused on young Black women and Native American women in educational and professional STEM contexts. Using an intersectional framework, these studies investigate how race, gender, and cultural identity shape participants' sense of belonging, persistence, and success in STEM fields.

Study 1 explores the educational pathways of young Black women who participated in a program preparing young Black women for Advanced Placement Computer Science Principles at the high school level, and their transition to various STEM fields at the undergraduate level. Participants in this study reflected on their participation in the preparatory program, as well as shared their personal challenges and successes in the pursuit of STEM.

Study 2 explored the career paths of Native American women in various STEM fields, at the undergraduate, graduate, and professional levels. Participants in this study described the profound impact that identity, culture, and history had on their pathways in

STEM, with attention to the roles of traditional knowledge and community in promoting resilience in the face of barriers.

The interviews were discussed to reveal similarities and differences in the experiences of these two marginalized groups. The studies highlight the importance of belonging, representation, and environments that affirm the identity of women of color in STEM, and shed light on distinct experiences of discrimination and the availability of representation that reflects participants' own backgrounds. These findings highlight the need for equity initiatives that consider the intersection of gender, race, and culture, to support and strengthen inclusivity in STEM.

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CHAPTER ONE
INTRODUCTION

The underrepresentation of Black and Native American women in Science, Technology, Engineering, and Mathematics (STEM) fields remains a significant concern despite progress toward gender and racial equity within these disciplines. In some STEM fields, gender gaps are extremely large (e.g., only 24.18% of professionals in earth, atmospheric, and ocean sciences are women), suggesting that the gains made in some fields (e.g., biological, agricultural, and other life sciences, in which 46.22% of professionals are women) are not necessarily widespread (National Center for Science and Engineering Statistics; NCSES, 2021). In science and engineering (S&E), Black and Native American women remain significantly underrepresented. In 2021, Black individuals comprised 14.3% of the U.S. population aged 20 to 34 years, however they earned only 9.2% of bachelor's degrees awarded in S&E (NCSES, 2024). Native American women are even more severely underrepresented: in 2021, American Indian or Alaska Native (referred to as "Native" hereon) students of all genders earned only 0.4% of bachelor's degrees in S&E, with Native women comprising an even smaller proportion (NCSES, 2024; see Chapter 4 for elaboration on the use of the term "Native" in the present work). Furthermore, women overall have lost ground in computer science with female students earning 21% of bachelor's degrees, compared to 29% in 1995 (NCSES, 2024). Additionally, Native individuals have also lost ground in S&E, earning 17% fewer bachelor's degrees in S&E in 2021, than they did in 2012. These statistics underscore the urgent need to address the compounded effects of racial and gender disparities in STEM, particularly for women at the intersection of both identities.

The objective of this research is to explore the experiences of young Black women (Study 1) and Native American women (Study 2) in STEM, with the additional goal of identifying nuanced similarities and differences between the two groups. To better frame the two studies I present here, I begin with a definition of race/gender intersectionality and the impact that it has on STEM achievement (Chapter 1), followed by a review of the literature on Black women in STEM (Chapter 2) and the historical factors shaping Native American women's participation in STEM and broader educational contexts (Chapter 3). Rather than adopting a deficit perspective, this work seeks to identify the cultural and personal factors that have enabled participants to pursue and persist in STEM fields despite the adversities they may have encountered. That is, the focus is shifted from what these individuals may lack to the strengths and resources that have drawn upon to succeed.

The intersection of being both Black and female presents unique challenges for aspiring Black women in STEM. Black women remain significantly underrepresented across all STEM fields compared to other demographic groups. Study 1 focuses on computing, an area in which women, and especially Black women, are severely underrepresented: In 2022, women comprised only 27% of professionals in computing, with an even more significant disparity for Black women, who held only 3% of those careers (National Center for Women & Information Technology, 2022). This study sheds light on the obstacles they face and the complex factors that contribute to their achievements despite these barriers. I will explore these challenges in detail, emphasizing the importance of understanding and addressing the persistent barriers that impede the full integration and success of women of color in these disciplines. Properly characterizing the challenges encountered by Black women pursuing STEM careers is critical not only for gender and racial equity in science and technology, but also for harnessing the full potential of diverse talent in STEM. I also focus on a program aimed at increasing interests, motivation, and persistence of young Black women in computing and computing-related careers. This program shows how creating inclusive environments that support the academic and career pursuits of Black women in STEM is essential for supporting their success and contributions to these fields.

Study 2 turns its attention to Native women in various STEM fields, a group that remains among the most underrepresented in both STEM education and careers. Native American women face numerous barriers in persisting and succeeding in STEM. Study 2 explores the educational and career paths of Native women in various STEM fields, at the undergraduate, graduate, and professional levels. Interviews elucidate how identity, culture, and community shape their educational and professional pathways, with attention to the integration of traditional knowledge and cultural values in their experiences. Participants' narratives also reveal the factors that supported or hindered their educational and career pathways.

Intersection of Race and Gender

De Weld and Laursen (2011) described the "Glass Obstacle Course" faced by women in STEM graduate programs, where complex and recurring barriers, along with a culture of exclusion, make them feel like outsiders within their own fields. Structural barriers such as lack of representation, gender inequities, and the conflicting demands of career and family further compound these challenges, leaving many women struggling to advance their careers (De Weld & Laursen, 2011). Similarly, Fouad and colleagues (2011) found that women in male-dominated engineering careers face additional obstacles, including encountering discrimination, facing harassment, and balancing professional and personal obligations. While these challenges are significant for women broadly, women of color in STEM face compounded difficulties as they navigate both gender and racial biases, making their experiences distinct and often more isolating.

The challenges faced by women in STEM are compounded by the intersection of race and gender, meaning that women of color experience unique barriers and biases, distinct from those faced by White women or men of color. These challenges range from individual biases and stereotypes to institutional and systemic barriers, all of which contribute to their underrepresentation and hinder their success in STEM fields. Women of color struggle to find role models and mentors that understand their intersectional identities, and they encounter limited opportunities for career advancement, unequal access to resources and funding, biases in hiring and promotion, hostility and discrimination in the workplace, pressure to succeed in male-dominated spaces, imposter syndrome (despite their qualifications), and feelings of a lack of belongingness in their fields (Cohen & Garcia, 2008; Good et al., 2012; Chemers et al., 2011; Fouad et al., 2011; Varma, 2009; Omotade et al., 2017; Ireland et al., 2018; Alfred et al., 2019; Johnson et al., 2019; Stitt & Happel-Parkins, 2019; Chrousos & Mentis, 2020; Henry Collins et al., 2020; Allen et al., 2021).

Alfred and colleagues (2019) examined the underrepresentation of women of color in STEM and highlighted societal and institutional barriers encountered as early as childhood and adolescence, such as deeply entrenched stereotypes about the ability of girls in mathematics, early academic performance assessments as a filter for students, and policies that systematically impact women of color, including disciplinary policies, lack of support services, and lack of access to advanced classes (U.S. Department of Education Office for Civil Rights, 2014; Crenshaw et al., 2015). These barriers lead to lower confidence and self-efficacy in STEM, reduced access to extracurricular opportunities and advanced coursework, and a lack of mentors and role models who can relate to their experiences. Together, the barriers perpetuate a cycle of exclusion by reinforcing the very biases and stereotypes that impede the engagement and achievement of women of color in STEM.

The Significance of Intersectionality

Kimberle Crenshaw's (1989) theoretical framework of intersectionality is an important resource for understanding the interconnectedness of categories such as race, gender, and class, and how these intersections result in particular forms of privilege and discrimination. Intersectionality emphasizes that individuals do not experience oppression in discrete categories, but rather as a result of interacting and overlapping identities (Crenshaw, 1991). Crenshaw's intersectional framework goes beyond other theoretical frameworks that often overlook the experiences of individuals with several marginalized identities. Intersectionality highlights the intricacy of systemic injustices and the need for nuanced ways of addressing inequities. Additionally, intersectionality highlights unique forms of discrimination that cannot be understood by simply adding the effects of racism and sexism separately.

Black women experience unique forms of discrimination and challenges, particularly in fields like STEM. Being at the intersection of gender and race, they face both gender-based discrimination and racial biases in STEM (Morris, 2007; Varma, 2007; Ireland et al., 2018; Leath & Chavous, 2018; Eaton et al., 2020; Fiske et al., 2022). For example, one study examining the evaluations of applicants for STEM post-doctoral positions found that physics faculty members differentially rated equally qualified women as less competent and hireable than men, and rated equally qualified Black and Latinx applicants as less hireable than Asian and White candidates (Eaton et al., 2020). When the interaction of race and gender was examined, Black women and Latinx women and men were rated significantly lower in hireability than all other groups, underscoring how their intersectional identities influence perceptions and evaluations, leading to disparities in opportunities based on race and gender.

In educational contexts, particularly in STEM classrooms, the intersection of gender and race can uniquely impact stereotypes and biases about Black girls. Traits that are beneficial to learning, such as confidence, assertiveness, and competitiveness, are often perceived negatively and seen as disruptive when displayed by Black girls (Morris, 2007). This negative perception discourages them from displaying these traits, which can impede their engagement and success in educational contexts. Morris (2007) observed various school environments, such as classrooms, lunchrooms, sporting events, and offices in a school located in a low-income area with predominantly Black students and faculty, and conducted interviews with faculty and administration about gender and race in education. Black girls tended to be competitive and confident in the classroom, speaking up as much as boys in science and mathematics and being highly achievement oriented. However, many teachers disciplined Black girls based on perceptions of them questioning authority, and being too assertive, or loud, demonstrating how these negative perceptions can directly affect Black girls' academic engagement and opportunities for success. Leath and Chavous (2018) surveyed women in STEM and non-STEM majors in college to compare the educational experiences of Black women to other women. Black women in STEM programs exhibited heightened uncertainty regarding their academic persistence compared to White women. Moreover, despite Black women in STEM programs demonstrating greater academic competence relative to Black women in non-STEM programs, they experienced lower levels of academic satisfaction than their non-STEM counterparts (Leath & Chavous, 2018). This disparity in experiences suggests the complex interplay of intersectional identities in shaping Black women's experiences and emotions in STEM education.

Qualitative studies with students in computer science programs, more specifically, reveal how the intersection of gender and race impact motivations and career trajectories. Varma (2009) reported that White women are more likely to pursue computer science due to intrinsic motivation, while women of color often pursue it for extrinsic reasons, such as better employment opportunities and higher pay. Reasons for enrolling also differed, with White women considering program details and university reputation, while women of color heavily weighed tuition rates, scholarship opportunities, and proximity to family. Women of color also reported feeling less prepared for computer science by their high schools than did White women. Additionally, both White and women of color were more likely than White males to work jobs unrelated to computer science while in school, and women of color were more likely to say that they had considered leaving their computer science programs due to difficulty, citing hostility from male faculty and peers, and not being taken seriously by faculty (Varma, 2009).

While intersectionality has frequently been applied to understand the experiences of Black women in STEM, Native American women face similarly complex, but distinct forms of marginalization at the intersection of race, gender, and culture. Native women's experiences are shaped by racism, sexism, and the historical erasure of Indigenous knowledge systems and identities. As noted in Crenshaw's intersectionality framework, the experiences of Native women in STEM cannot be fully understood without considering historical and cultural factors. Although Native women often hold leadership positions and are considered knowledge keepers in their own communities, in STEM fields these cultural roles are devalued or made invisible (Niehoff, 2024). According to Chakravery (2022), Native women in STEM report experiencing imposter syndrome related to their Indigenous identities. They attribute these feelings to an incompatibility between their cultural worldviews and the dominant Western knowledge systems and environments, as well as to common misunderstandings and misrepresentations of Indigenous culture by others (Chakraverty, 2022). This cultural disconnect impacts Native women's sense of belonging and creates challenges as they navigate the expectations of academic institutions and their own communities. Intersectionality holds promise for explaining how Native women's multiple aspects of identity impede their persistence and success in STEM fields.

The intersection of race and gender leads to unique challenges for women of color in STEM. Intersectional experiences influence opportunities in academic and professional settings due to distinct and overlapping forms of bias and discrimination. These experiences of discrimination result in barriers to achievement, including a lack of representation, limited opportunities for mentorship, and systemic biases. Overall, intersectionality illuminates the multifaceted nature of discrimination and challenges faced by Black and Native women in STEM, emphasizing the need for inclusive practices and policies that address the intersectional dimensions of inequality in these fields.

Author Positionality

I am Anishinaabe (Ojibway) and an enrolled citizen of the Sault Ste. Marie Tribe of Chippewa Indians. My father is Anishinaabe. I grew up in Bahweting (Sault Ste. Marie), where my tribe is located. That is where I spent most of my life before relocating for graduate school. I have been a non-traditional college student since re-entering post-secondary education after spending time working full-time in a job that did not require a college degree.

When I first returned to school to pursue tertiary education, I enrolled at a Tribal college near my home. I went on to earn an associate's degree there, before going on to earn a B.S in Psychology and a M.S. in Experimental Psychology. For most of my life, until shortly before finishing my bachelor's degree, I did not see myself as a scientist. I was however inspired by other Native women in my community that had earned graduate degrees before me. The further I have gone in my education the more I have embraced my Anishinaabe identity and been motivated to learn how other Native students can draw on their culture for strength and inspiration to achieve their goals.

My personal experiences inform and elucidate why this research is meaningful to me. I am using my personal lens to analyze the words of others in hopes that their individual voices can add to the collective experiences of Native women in STEM. I try my best to keep the original ideas of my participants, while acknowledging that the resulting highlights, organization, and interpretation of my research are shaped by my own personal experiences (Absolon & Willette, 2005).

CHAPTER TWO
BLACK WOMEN IN STEM

Black women and girls pursuing STEM fields face unique challenges stemming from the combination of their race and gender, which differ from those encountered by individuals facing discrimination based solely on their race or their gender. This chapter examines the research on the multifaceted hurdles faced by Black women in STEM generally, and computer science specifically, including stereotypes and biases, the representation gap, isolation, and intersectional discrimination. These factors highlight the intricate factors contributing to the underrepresentation of Black women in STEM, shedding light on the systemic issues that impede their full participation and success.

Stereotypes and Biases

Women of color in STEM often encounter stereotypes and biases that undermine their contributions and limit their career advancement opportunities (Henry Collins et al., 2020). A common assumption is that women in general are less capable in scientific fields than men, leading to lower expectations of their performance and contributions, resulting in them being overlooked and their achievements dismissed. Women of color often face stereotypes and biases questioning their abilities in STEM, leading to a lack of recognition and opportunities (Fouad et al., 2011; Charleston et al., 2014; Leslie et al., 2015; Smith et al., 2015; Smyth & Nosek, 2015; Bian et al., 2017; Alfred et al., 2019; Canning et al., 2019; Yamaguchi & Burge, 2019; Eaton et al., 2020; South Richardson et al., 2020; Nguyen & Riegle-Crumb, 2021; Mirakhur et al., 2024). These stereotypes and biases can manifest as microaggressions, overt discrimination, and assumptions of incompetence, and can affect confidence, sense of belonging, academic performance, and career progression (Cohen & Garcia, 2008; Galdi et al., 2014; Ireland et al., 2018; Henry Collins et al., 2020).

Underrepresentation in STEM makes women of color more prone to stereotype threat (the fear that their behavior will confirm the stereotypes about their capacities). Women of color are likely to find themselves alone in male-dominated settings, which may make them more aware of their token status, subsequently fear reinforcing these stereotypes, and ultimately result in decreased performance and motivation. In male-dominated fields (e.g., computer science, engineering, mathematics), women are more likely to encounter and internalize stereotypes that associate men with science ability than in fields in which female representation is adequate (e.g., health sciences, life sciences; Smyth & Nosek, 2015). This internalization can have a negative impact on performance, decrease motivation and achievement, and eventually reinforce the stereotype. Cohen and Garcia (2008) extended Claude Steele's foundational research on the impact of stereotype threat on the cognitive performance of African Americans (Steele & Aronson, 1995; Steele, 2003). According to this model, when individuals perceive that they are in a situation where others might attribute negative performance to their identities, they become more attentive to signals of bias. Because identities (e.g., gender, racial) are tied to an individual's self-worth, perceiving identity-based biases in situations in which performance is evaluated can trigger fears of confirming those biases and subsequently impact belonging, motivation, and achievement.

Strong science identification in women appears to protect against the effects of implicit biases that associate science with males (Smyth & Nosek, 2015). Thus, supporting women's STEM identities can counteract stereotype threat and support their success. Unfortunately, science identification can be difficult to encourage in a culture that typically associates science professionals with White men (Varma, 2007; Steinke, 2017; Miller et al., 2018a; Shakil et al., 2025). Stereotypes about the role of men and women in science begin to form during early education, even before they have explicit awareness of the stereotype. Galdi and colleagues (2014), for example, asked first graders to color one of three pictures: a boy correctly solving a math problem (stereotype consistent), a girl correctly solving the problem (stereotype inconsistent), or a landscape (control). Girls who colored the stereotype-consistent picture were less proficient at subsequently completing a math task, even if they showed no explicit stereotypes when asked whether a boy or a girl was better at math. That is, even in the absence of articulating explicit stereotypes, implicit stereotypes were affecting their performance. Bian and colleagues (2017) found that girls acquire stereotypes associating males with brilliance at a very young age, and that these stereotypes impact their interests in engaging in activities described as "for children who are really, really smart." The study found that five-year-old girls still exhibited positive views of their own gender, but by age six already had a bias attributing smartness to boys that impacted the activities in which they choose to engage. This implies that gender stereotypes are formed early in childhood, negatively impact identification with science, and influence the careers girls choose to pursue.

Fields thought to require innate intelligence or "brilliance," such as many STEM disciplines, often have lower representation of women and racial minorities (Leslie et al., 2015). This stereotype, which falsely assumes that women and people of color lack the innate capabilities needed for success in these fields, perpetuates gender and racial disparities. Leslie and colleagues (2015) surveyed faculty, postdoctoral candidates, and graduate students from a variety of research institutions in the United States on their perceptions of the innate intelligence they believe is required for 30 different disciplines and found that the more a field is believed to require innate intelligence, the more underrepresented women and racial minorities are within that field. These stereotypes can be especially damaging to Black women, who face the compounded effects of intersecting gender and racial biases, hindering their achievement in these fields.

Smith and colleagues (2015) suggested that science that is perceived as communal or valuable for its contributions to society and the well-being of others is particularly meaningful to women because it aligns with their motivations for pursuing science careers that have social impact (Guillory, 2009; Birmingham et al., 2017; Stitt & Happel-Parkins, 2019; Martin & Fisher-Ari, 2021; Chow-Garcia et al., 2022). They observed that stereotype threat in male-dominated STEM courses is associated with lower perceptions of the value in science for helping others, leading to less identification with science for women. Because students make decisions about the fields that they pursue based on their own expectations that they can succeed and the value that they perceive in those fields, highlighting the community impact of science may be essential to support science identity in women (Smith et al., 2015; see 'Community and Consequential Learning' below).

The stereotypes that are held about computing professionals can also impact women's desires to go into STEM and computing fields. High achievers in computing are often stereotyped as "geeks," typically White men who do well in math and science, are highly intelligent, and socially awkward (Varma, 2007; also see Shakil et al., 2025). Women tend to value interacting and connecting with others and when computing is thought of as an asocial career dominated by "geeks," it may not align with women's values, discouraging them from pursuing the field. In interviews with computer science students at Minority-Serving Institutions (MSI's), Varma (2009) found that women did not identify with the stereotypical computing culture, which was described as consistent with the "geek" stereotype, demonstrating how stereotypes can affect women's perceptions of belonging in STEM fields.

Ireland and colleagues (2018) examined 60 empirical studies highlighting common challenges reported by Black girls in STEM including racial microaggressions, gendered stereotypes and discrimination. Experiencing these challenges negatively impacted STEM identity, exclusion, feelings of invisibility, lack of belonging, low science and math efficacy, inadequate high school preparation for STEM courses in college, and psychological and financial barriers impacting persistence to graduation. Even successful Black women in computing report experiencing microaggressions, stereotype threat, imposter syndrome, and a lack of representation (Yamaguchi & Burge, 2019), as well as unwelcoming departments, assumptions of incompetence by professors and other students, and isolation, leading them to question their decisions to pursue computing careers (Charleston et al., 2014). Women in engineering also reported assumptions of incompetence by male colleagues and customers, who called their experience and education into question (Fouad et al., 2011).

In contrast to the negative impact of stereotypes on women's motivation and persistence in STEM, endorsing counter-stereotypic beliefs about STEM (or viewing scientists as collaborative and complex individuals with broad interests and talents) is predictive of intentions to pursue STEM fields. A longitudinal study of adolescents of color examined counter-stereotypic beliefs about scientists during middle school and intentions to major in various STEM disciplines in high school (Nguyen & Riegle-Crumb, 2021). Students who held more counter-stereotypic beliefs about scientists, such as the idea that scientists can work in communal settings, be creative, excel in areas beyond science like art and sports, and are not just “nerds” or “geeks,” were more likely to intend to major in STEM fields when asked about college in high school. Female students of color were particularly more likely to major in computer science and engineering if they rejected stereotypic beliefs about scientists (Nguyen & Riegle-Crumb, 2021).

The stereotypes and perceptions of educators may also negatively affect the achievement and success of groups underrepresented in STEM fields (hereafter underrepresented groups or URGs; Canning et al., 2019). Mindset theory suggests that individuals’ beliefs about their abilities impact motivation and achievement. Specifically, students who believe they can improve their intelligence tend to achieve more than those who believe intelligence is a fixed trait (Dweck, 2015). Canning and colleagues (2019) expanded on this theory to examine professors’ perceptions of their students, hypothesizing that stereotype threat combined with professors’ fixed mindsets would exacerbate achievement gaps. Their longitudinal study of 150 STEM professors and over 150,000 students found that Black, Latinx, and Native American students in classes taught by professors with fixed mindsets earned lower grades than White and Asian students, widening the achievement gap. In contrast, the gap narrowed in courses taught by professors with more flexible views of intelligence who are more likely to employ evidence-based teaching practices, such as active learning, offering constructive feedback, and providing clear expectations (South Richardson et al., 2020).

In addition to stereotypes and perceptions held by educators, subtle interactions and comments can further undermine the success of students from URGs. Microaggressions are subtle and often unintentional comments or actions that convey negative messages based on an individual's marginalized status. A microinvalidation is a specific type of microaggression that dismisses a marginalized individual's experiences of bias or discrimination. Although they may be unintentional, microaggression and microinvalidation comments made by colleagues, fellow students, and professors contribute to imposter syndrome in URG students in STEM. Imposter syndrome describes a sense of lack of belonging and questioning of one's own abilities that negatively impacts motivation and self-esteem, despite achievements and contributions that suggest competency (Chrousos & Mentis, 2020; Henry Collins et al., 2020; Omotade et al., 2017). URG graduate students describe comments indicating that others believe they were granted admission, positions, and awards due to their minority status, rather than as a result of their contributions and ability (Omotade et al., 2017). Comments such as these undermine the accomplishments of URG students and lead to feelings of isolation and inferiority, impacting future academic persistence and performance. These harmful narratives are even more concerning in the current political climate, where DEI initiatives are being scaled back or dismantled across educational and professional institutions, removing critical sources of support for marginalized students in STEM.

To summarize, the pervasive influence of stereotypes and biases on women in STEM, particularly women of color, which restrict their opportunities for success and limit their sense of belonging in these fields. Microaggressions, microinvalidations, imposter syndrome, stereotype threat, and assumptions about innate ability constitute barriers that contribute to the underrepresentation of women, especially Black women, in STEM disciplines. Additionally, the negative perceptions held by educators and the stereotypical portrayals of STEM professionals further discourage their participation in STEM fields. However, research shows that counter-stereotypic beliefs, strong science identification, and supportive learning environments that highlight the societal impact of science can mitigate these effects and support greater diversity and equity in STEM. Addressing these deeply ingrained biases is essential to creating a more inclusive and supportive environment where women of color can thrive and fully contribute to STEM fields.

Supportive Factors

Engagement and achievement in STEM fields are influenced by a combination of internal and external supportive factors. For example, a survey of 192 current or former successful mathematics students, consisting of Black and Latinx participants, revealed crucial motivators for pursuing math (Skultety & George, 2019). Intrinsic factors included interest, enjoyment, and confidence in mathematics, as well as an appreciation for the process and nature of math. External factors such as the perceived utility of mathematics to themselves, other fields, and society, as well as previous influential experiences and influential people in the discipline were also highlighted (Skultety &

George, 2019). Together, these internal motivations and external supports interact to drive STEM engagement and achievement.

Internal Factors

STEM Identity

Throughout their educational and career trajectories, individuals develop self-concepts regarding STEM. An individual's STEM identity is their individual conceptualization of their relation to the field of STEM. It is widely accepted that STEM identity involves three components: competence, performance, and recognition (Carlone & Johnson, 2007; Galdi et al., 2014; Bian et al., 2017; Kricorian et al., 2020). In what is arguably the most widely accepted model of STEM identity, Carlone and Johnson (2007) suggested that competence and ability are internal to the individual and recognition comes from acknowledgement by others.

STEM identity appears to be an important factor for engagement and achievement in STEM disciplines. Chemers and colleagues (2011) proposed a mediational model in which STEM identity and efficacy in one's scientific ability mediate the relationship between scientific support activities and intent to have a career in the field of science. They surveyed 665 members of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), including current students and recent graduates, and found support for their model, suggesting that STEM identity and science self-efficacy can serve to explain why some underrepresented minorities commit to a career in science. Additionally, for graduate students and postdoctoral fellows, efficacy in their ability to work in a team also mediated the relationship between science support experiences (such as mentoring and research experience) and commitment to pursue a career in science

(Chemers et al., 2011). A strong STEM identity appears to positively influence the career persistence and success of Black women in STEM (Tai et al., 2006; Carlone & Johnson, 2007; Cohen & Garcia, 2008; Chemers et al., 2011; Good et al., 2012; Galdi et al., 2014; Bian et al., 2017; Ireland et al., 2018; Alfred et al., 2019; Johnson et al., 2019; Kricorian et al., 2020; Allen et al., 2021; Nguyen & Riegle-Crumb, 2021; Mirakhur et al., 2024). This sense of identity not only shapes their aspirations but also plays an important role in navigating challenges and setbacks within STEM education and career tracks.

STEM identity begins to form early in childhood and experiences with STEM in childhood impact educational and career trajectories (Tai et al., 2006; Galdi et al., 2014; Bian et al., 2017; Alfred et al., 2019; Kricorian et al., 2020; Nguyen & Riegle-Crumb, 2021). Tai and colleagues (2006) examined longitudinal data from a national sample of 3,359 eighth-grade students who indicated their career intentions, finding that those who had intentions to go into science careers were more than three times as likely to go onto earn physical science or engineering baccalaureate degrees as students who did not indicate similar intentions. These results highlight the significance of introducing students to science at an early stage in their educational trajectories and how early aspirations can significantly shape long-term educational and career trajectories. In another survey of mostly women of color pursuing STEM careers, the majority of participants knew that they wanted to pursue careers in STEM as children (Kricorian et al, 2020). This early awareness and commitment to STEM careers highlights the importance of formative experiences that shape Black women's trajectories in STEM and emphasizes the need for early interventions that nurture interest and confidence in STEM subjects to create a foundation for educational and career success.

Belonging

Belonging in STEM encompasses one's sense of inclusion, acceptance, and support within the STEM environment. Belonging is associated with engagement and achievement in STEM disciplines, as it influences how connected and valued individuals feel in these fields (Cohen & Garcia, 2008; Good et al., 2012; Ireland et al., 2018; Alfred et al, 2019; Johnson et al., 2019; Allen et al., 2021; Mirakhur et al., 2024). Good and colleagues (2012) observed that women's sense of belonging in mathematics predicted their intentions to pursue mathematics, confidence in their mathematical ability, perceived usefulness of mathematics, and lowered math anxiety. Further, belongingness mediated women's perceptions about their math environments and all other outcome variables: confidence, perceived usefulness, lowered anxiety, and intent to pursue. Perceptions that resulted in decreased belongingness and math achievement were that of a fixed view (fixed mindset), rather than a malleable view (growth mindset), of math intelligence, and high gender stereotyping (Good et al., 2012). Belongingness can also be promoted by a role model with whom students can identify. Johnson and colleagues (2019) observed that, for Black women students who were highly conscious about stigma, having a Black woman professor as a role model led to them feeling more belongingness and trust within an academic setting. These observations are consistent with the stereotype inoculation model, a theoretical framework in which ingroup members, such as peers and experts, function as "social vaccines," helping to encourage belonging and protect individuals' self-concepts from the negative impacts of stereotypes (Dasgupta, 2011). The model explains how the presence of in-group members (e.g., role models with whom students identify) enhances resilience and demonstrates how in-group peers and experts promote engagement, persistence, and achievement in STEM environments.

Promotion of resilience against bias, and mechanisms of support of a positive self-concept and sense of belonging in STEM not only encourage participation, but also contribute to academic achievement. Educators can cultivate a sense of belonging and purpose among Black girls in STEM by nurturing their STEM identity early to inoculate them to persist and thrive in STEM fields despite systemic challenges and barriers. Proactive approaches align with research that highlights the importance of identity formation, especially in fields like STEM where representation and support are crucial for long-term achievement.

External Factors

Representation

The representation gap in STEM is a multifaceted issue that includes the underrepresentation of women and the lack of diversity among racial and ethnic groups. Research has consistently highlighted large disparities in representation across various STEM fields, with women of color significantly underrepresented compared to their male and White counterparts, including physical and earth sciences, mathematical and computer sciences, and engineering (Leslie et al., 2015; Canning et al., 2019; NCSES, 2024). This representation gap has negative effects not only on the diversity of perspectives and experiences within STEM, but also on innovation and development of solutions to problems. Diverse teams are more creative, generate better solutions, and are better at problem-solving due to a wider range of perspectives (Polzer et al., 2003; Hong & Page, 2004; Zheng et al., 2022). The underrepresentation of women and people of color in STEM fields limits the potential benefits of harnessing a wider range of thoughts and ideas.

Representation is critical for Black girls to see the pursuit of STEM careers as a possibility (Ireland et al., 2018; Martin & Fisher-Ari, 2021; Mirakhur et al., 2024). Seeing mentors, role models, and individuals in the media and everyday life who share their background and are successful STEM professionals can inspire underrepresented groups by providing evidence that success in STEM is attainable. Unfortunately, finding these role models can be difficult. A survey of a predominantly female group of STEM students of color, found that fewer than 30% of respondents could name a Hispanic or Black STEM professional, male or female. However, over 60% of participants were able to name a White male STEM professional (Kricorian et al., 2020). These findings underscore the importance of representation for students of color, given the influence of race and gender-match outweighing the importance of the educational background of the role model (Zirkel, 2002; see 'Mentors and Role Models' below)

Representation influences belonging, motivation, and confidence, while also combating stereotypes about who excels in STEM and what STEM professionals look like. In a study of predominantly Black female high school students in a summer STEM program, participants expressed the belief that the current lack of representation perpetuates a cycle that leads to further underrepresentation of Black women in STEM fields (Martin & Fisher-Ari, 2021). Indeed, lack of representation necessarily limits the availability of relatable role models and mentors in STEM, which can exacerbate the challenges women of color face in these fields (Alfred et al., 2019; Mirakhur et al., 2024). Not only may they believe that they do not belong in STEM spaces, but women of color may feel increased pressure to excel as representatives of an extreme minority, in what is commonly known as "tokenism" (Alfred et al., 2019). That is, women of color feel not only the pressure to succeed individually but also the weight of representing their entire group, which can be overwhelming to carry and increase feelings of isolation. In graduate school and moving into their careers, tokenism issues become even more pronounced, with the absence of visible role models and mentors, limited opportunities for advancement, and hostile or discriminatory workplace climates. Further, the lack of representation in STEM and computer science classes specifically, and the reluctance to be "the only one" in predominantly White male environments (Mirakhur et al., 2024) contribute to the intricate factors that may further discourage Black girls from engaging in the field.

Role Models and Mentors

Role models and mentors are important sources of inspiration and guidance for intersectional minorities in STEM. While role models are typically admired for their achievements, relationships with them can be purely observational, meaning that they can inspire those who look up to them without direct interaction (Johnson et al., 2019). Mentorship, on the other hand, plays a crucial role in providing guidance, support, and a sense of belonging for underrepresented students in STEM (Charleston et al., 2014; Ireland et al., 2018). Role models are effective in motivating and inspiring by example, while mentors help mentees navigate challenges, provide personalized guidance, and offer opportunities for skill development and goal achievement. For the mentee, this means not only gaining access to valuable advice and professional connections but also building a supportive relationship that encourages their confidence, resilience, and overall sense of belonging in STEM fields.

Blake-Beard and colleagues (2011) researched the importance of having mentors who share the same race or gender, particularly for women and minority students. In their survey of over 2,000 undergraduate and post-baccalaureate scholars in STEM and STEM-related business programs designed to prepare students for technology-related business sectors, gender and race-matched mentors were more important to women than men, and race-matched mentors were more important to non-White students and scholars than to White students and scholars. Similarly, women and non-White participants rated as more important having a mentor who understands how their gender and racial backgrounds impact their experiences than did men and White participants (Beard-Blake, 2011). Participants who had a gender or race-matched mentor experienced more psychosocial and instrumental support than those without such a match, and participants who had a race-matched mentor were more likely to view their mentor as a role-model than those who did not have a race-matched mentor. Longitudinal research has demonstrated the impact of race and gender-matched role models on adolescents' academic achievement and goals. Overall, students who had race and gender-matched role models had better academic achievement and more professional goals two years later than students who did not (Zirkel, 2002). Compared to students of color, White students were more likely to report having role models who matched their race and gender, and having such role models working in careers requiring a college education. However, regardless of being less likely than White students to have race and gender-matched role models with college backgrounds, students of color with matched role models had a higher number of educational and career goals than their White peers (Zirkel, 2002). These findings underscore the importance of representation in shaping educational and career aspirations, particularly for students of color who face additional challenges in accessing matched role models and mentors in STEM fields.

Women of color in undergraduate and graduate programs, as well as recent graduates pursuing STEM, indicated that gender- and race-matched mentors would be effective in encouraging them to persist in STEM fields, and reported having gender- and race-matched STEM role models outside of their families while growing up (Kricorian et al., 2020). Fiske and colleagues (2022) examined nine years of data, which included 814 students from a National Science Foundation program designed to broaden participation in computer science, to understand how different types of interventions impact different racial and gender groups. For Black women, faculty mentorship, collaboration with faculty members, and career awareness significantly impacted their intent to persist in computer science. No other gender or racial group reported that faculty mentorship and collaboration with faculty members significantly impacted their intent to persist in computer science. The scarcity of Black women in computing makes these interventions extremely important because successful Black women in computing have knowledge about the unique barriers that young Black women will encounter when entering the field (Fiske et al., 2022).

Representation plays an important role in shaping educational and career aspirations, particularly for students of color who face additional challenges in accessing matched role models and mentors in STEM fields. Mentors and role models empower Black women in STEM, as both observational inspiration and direct support through mentorship, helping to support their success and persistence. By providing tailored guidance and understanding the unique challenges faced by URGs, mentors and role models contribute significantly to improving representation in these fields. Despite the scarcity of role models in their STEM fields, many Black women in STEM can identify family and community members as important influences on their engagement and aspirations, further highlighting the importance of representation for inspiring women and racial minorities in STEM (Martin & Fisher-Ari, 2021).

Educational Experiences

Educational factors, such as research experiences, supplemental programming, and consequential learning, appear to support STEM engagement and achievement for URG students. A survey of high-achieving URG undergraduate students who participated in a biology program found that they credited supplemental biology instruction and research experiences for their decisions to pursue careers in biology (Villarejo et al., 2008). Research experience has also been found to support science learning and lead to science self-efficacy, leadership and teamwork self-efficacy, and science identity, which increase commitment to a career in science (Chemers et al., 2011). In addition to these higher education supports, Black women in STEM have also expressed the need for increased support over the course of their educational and professional journeys, specifically at the K-12 level, to develop mastery of mathematics, critical thinking, and problem-solving (Yamaguchi & Burge, 2019).

Historically Black Colleges and Universities. Historically Black Colleges and Universities (HBCUs) have been cited as environments that are particularly supportive for Black women in STEM. Black women often find themselves being “the only one” in

Predominantly White Institutions (PWIs), which often results in feelings of isolation and lack of belonging in STEM (Henry Collins et al., 2020; Ireland et al., 2018; Mirakhur et al., 2024), feelings of exclusion, and increased pressure to represent “all” Black women (Stitt & Happel-Parkins, 2019). HBCUs are more likely to have Black women faculty and students, attenuating the negative impacts of lack of representation experienced by Black women at PWIs. Indeed, a study comparing Black women STEM students at an all women Historically Black College (HBC) to their counterparts at a PWI found that the students at the HBC identified more Black women role models and reported higher sense of belonging at their institution and in STEM than the students at the PWI (Johnson et al., 2019). The students at the HBC were also more likely to report that White women and Black men role models were allies that cared about helping Black women succeed than did the students at the PWI.

Community and Consequential Learning. Forming supportive networks and communities can help women of color navigate the challenges they face in STEM fields and provide a platform for sharing experiences and encouraging a sense of belonging (Fouad et al., 2011; Ireland et al., 2018). Successful Black students in computer science programs and Black early-career faculty (researchers in particular) report that the presence of supportive peers and peer communities had significant impacts on their persistence and achievement in the field (Charleston et al., 2014).

By framing STEM as a field that can address and solve community problems, educators can support engagement among underrepresented students who value giving back to their communities (Guillory, 2009; Birmingham et al., 2017; Stitt & Happel-Parkins, 2019; Martin & Fisher-Ari, 2021; Chow-Garcia et al., 2022;). Framing science as a communal activity positively impacts women's persistence, belonging, and motivation in science. Undergraduate women who interacted in a friendly exchange before completing a tedious scientific task performed better at the task, indicated that they would be willing to continue or repeat the task, and expressed a greater interest in future scientific research, while the same intervention did not have an impact on undergraduate men (Allen et al., 2021). Black women engineering students who expressed facing difficult barriers to pursuing their degrees also expressed that they viewed their resilience to overcome those barriers to be an inspiration for Black girls that decide to pursue the discipline in the future (Stitt & Happel-Parkins, 2019).

Birmingham and colleagues (2017) explored the concept of consequential learning, which refers to learning experiences that have relevance to students' personal lives, families, and communities. Participants were adolescent girls from underrepresented and low SES backgrounds who engaged in science projects that addressed problems in their communities. After participating in this study, students displayed increased motivation and engagement with the science content and felt empowered to use their knowledge to uplift their communities. They concluded that consequential learning can engage students from underrepresented populations in STEM fields by making connections between STEM content, real world issues, and the needs of their communities.

Familial and Peer Support

Just as academic community support plays a crucial role in supporting academic motivation among women of color in STEM, familial encouragement and peer networks further amplify these effects, creating support systems that strengthen their educational engagement and achievement. Research consistently highlights the strong influence of family members and peers on students' educational motivation and success (Ryan, 2000; Yamaguchi & Burge, 2019; Kricorian et al., 2020).

In their survey of mostly women of color pursuing STEM, Kricorian and colleagues (2020) found that the majority of their participants had parents who encouraged them in their STEM pursuits. Participants in Charleston and colleagues' (2014) qualitative study of high achieving Black computer science students and professionals also indicated that support from families in the form of encouragement, as well as financial support and access to computer hardware and software, contributed significantly to their academic and professional achievement and persistence in computer science. In addition to support from parents, participants in Yamaguchi and Burge's (2019) study indicated that peer networks of other Black women in STEM were essential in supporting their motivation and success in the field.

Existing Programs Broadening Participation in Computing

Currently, there are multiple programs aimed at broadening participation in computing that have had some success in encouraging the participation of women and women of color. These programs are aimed at training K-12 educators to teach computer science, exposing K-12 students and their families to computer science, and/or training and preparing K-12 students to master computer science (Scott et al., 2016). Girls Who Code (www.girlswhocode.com) and Black Girls Code (www.wearebgc.org) are examples of two organizations that expose students and their families to computer science. In addition to these types of programs that target K-12 education, there are also opportunities for bootcamps and internships that train adults for the workforce and governmental policy initiatives.

In- and out-of-school programs targeting computer science mastery by K-12 students have demonstrated success (Scott et al., 2016; Miller at al., 2018b). Computer science preparation as part of the Summer Math and Science Honors Academy (SMASH; www.smash.org), a culturally-relevant summer STEM program for underrepresented high school students, showed increases in perceptions of computer science as relevant to participants' lives, positive attitudes toward computer science, access to supportive networks in computer science, familiarity with programming skills and languages, and intentions to pursue computer science (Scott et al., 2016). CS@SC Summer Camps at the University of Southern California (summercamp.usc.edu) expose K-12 students, who are primarily Hispanic or Black students from low income families, to computer science. Over three consecutive years, participants completing CS@SC Summer Camps have exhibited increased interest in STEM (Miller et al., 2018b).

CS for All. Initiatives designed to increase representation in STEM fields, such as the "CS for All" program aimed at promoting computer science education, have shown to be effective in achieving their goals. "CS for All" initiatives (www.csforall.org) involve efforts aimed at universalizing computer science education by ensuring access to CS curricula for all students, particularly focusing on mitigating barriers faced by underrepresented individuals in the field. Such initiatives may include mandates for introductory CS courses as part of high school graduation requirements, integration of CS instruction across grade levels or within interdisciplinary subjects, and providing CS exposure through extracurricular activities and community-based programs. Mirakhur and colleagues (2024) used mixed methods to understand the experiences, achievement, and enrollment in computer science courses of Black girls in a school district enacting "CS for All" strategies to increase exposure to computer science. Although the participation of middle school age Black girls in computer science doubled in the years that "CS for All" was implemented, Black girls still had the lowest participation rates when compared to other underrepresented racial and gender groups. Survey data showed that Black girls were confident and engaged in computer science, but they were less likely to believe that they belonged and were accepted in computer science courses than other groups.

The Current Research

Academic engagement refers to students' participation and investment in learning within educational settings (Wellborn & Connell, 1990; Kindermann, 1993; Ryan, 2000). It entails students' effort, curiosity, positive attitudes, and intrinsic motivation for learning. Ryan (2000) emphasizes that academic engagement is crucial for academic achievement, as active students gain a deeper understanding and mastery of content. Academic achievement refers to the mastery or completion of different educational goals or learning objectives (Wellborn & Connell, 1990; Kindermann, 1993; Ryan, 2000). It is measured by students' performance on assignments, projects, or exams, and is indicated by grades, test scores, and other assessments of their knowledge and understanding of the subjects they are studying (Ryan, 2000).

Study 1 aims to investigate the key factors influencing the academic engagement and achievement of Black women in STEM by exploring their experiences, obstacles faced, and factors contributing to their success. Participants were young Black women who participated in a cohort program in high school specifically designed to prepare them for success in a computer science course, setting the foundation for their academic journey in STEM fields. The cohort program focused specifically on computer science due to the acute underrepresentation of Black women in this field, aiming to address systemic barriers and increase pathways for inclusion in computer science.

There is a need for more research delving into the experiences of Black girls in STEM learning environments, and hearing from them directly has been suggested as a promising method of learning more about the barriers and supports that impact STEM engagement and achievement (Ireland et al., 2018; Mirakhur, 2024). In Study 1, we examine the narratives and experiences of Black girls in computer science, aiming to provide insights into the multifaceted journey of intersectionally underrepresented students' pursuits in computer science and STEM education. Through an exploration of their challenges and successes, we hope to contribute to the broader conversation on diversity and inclusion in STEM and inspire actions that support the achievement and representation of Black women in these critical disciplines.

CHAPTER THREE
STUDY 1

This study was conducted as part of the LEGACY project funded by the National Science Foundation (Awards #1759421, 1759197 and 1759262). The LEGACY project, completed over a 5-year period, prepared Black female high school students to take the Advanced Placement Computer Science Principles (AP CSP) class and examination for college credit. Over the course of 5 years, cohorts of Black female students from Alabama participated in peer-learning communities convening at both a PWI and an HBCU over the summer, as well as in-person and virtual support and communication throughout the academic year. AP CSP educators involved in the program were also Black women. The first year of the program was successful in increasing the number of Black females achieving qualifying scores in the AP CSP examination in the state of Alabama (Escobar et al., 2021). In total, 87.5% of participants in the first LEGACY cohort achieved qualifying AP CSP exam scores, compared to 56.9% of Black females nationally and 45.8% of non-LEGACY Black females in Alabama. Participants also showed increased computational thinking self-efficacy and attitudes that women and people of all races are capable of succeeding in CS (Escobar et al., 2021).

Research Questions

Interview questions were designed to address our research questions concerning participation in the LEGACY program, as well as challenges and supportive factors participants have encountered in their educational and professional trajectories (See Appendix A).

Research Question 1: What do former participants take away from their experience in the LEGACY program and what feedback do they provide for improvement of the program?

Research Question 2: What challenges or barriers do high achieving Black women in STEM report experiencing in their educational and professional journeys?

Research Question 3: What factors do high achieving Black women in STEM report as supporting their educational and professional journeys?

Methodology

Participants

Participants were 14 high school and college students who previously participated in the LEGACY project. Participants who had completed the LEGACY program two to three years before interviews were targeted to allow for participants to look back at their experiences in LEGACY and how these shaped where they were in their educational and career paths at the time that the interviews took place. Students in the interview sample were all 17 years of age or older (range: 17-20), ranging from twelfth-grade high school students to students in their second year of college. Parent or guardian permission was obtained for any participant under the age of 18. All participants were young Black women. Emails and text messages with information about the current study were sent to former LEGACY participants and virtual interview timeslots were scheduled with interested participants. All procedures were approved by the Oakland University Institutional Review Board (IRB).

Data Collection

Interviews were conducted online via Zoom Virtual Meetings. All interviews were conducted by the Principal Investigator, a Native female graduate student. Semi-structured interviews included questions about participants' current educational and professional lives, how participation in the LEGACY program impacted their educational and career tracks, challenges they had encountered since completing the LEGACY program, what they envisioned for their future educational and professional lives, and questions specific to their racial, gender, and STEM identities (See Appendix A). Interviews lasted between 20 and 39 minutes and were recorded and transcribed using Zoom Video Communications software. Upon completion of the interviews, transcripts were checked for accuracy, de-identified by the research team and recordings were deleted to maintain confidentiality.

Qualitative Analysis

Data were analyzed using Braun and Clarke's (2006) six step process for thematic analysis in psychological research as detailed below.

Braun and Clarke's (2006) first step for thematic analysis is for analysts to familiarize themselves with the data. The data was analyzed by the Principal Investigator (PI) and a team of three Oakland University student researchers trained by the PI. All interviews were conducted by the PI, who made notes of ideas for coding the data. The PI and a research assistant went through each artificial intelligence generated transcript, correcting errors, and adding punctuation to ensure that each transcript accurately reflected the words and meaning conveyed by participants. The research analysis team met regularly throughout the process of data collection and analysis to discuss the progress of the interviews and the PI's preliminary impressions of the data. At some of these meetings, literature concerning the research questions was read and discussed. The data collection, transcription, and meetings all familiarized the research analysis team with the data before the coding process began.

The second step described by Braun and Clarke (2006) is generating an initial list of codes. Each analyst independently coded every interview in the data set using NVivo qualitative analysis computer software. Analysts each independently produced a list of codes and tagged extracts throughout the data set. Analysts were instructed to tag extracts large enough to maintain the context of each extract, as well as to tag extracts to create an exhaustive list of codes. The coding process adhered to Braun & Clarke's (2006) guidelines for generating initial codes.

The third step for thematic analysis is searching for themes (Braun & Clarke, 2006). The research analysis team met to discuss and compare their independently created initial lists of codes. All codes were written on post-it notes and attached to a wall, where analysts discussed and arranged all codes into a thematic map, combining and eliminating codes as needed. Analysts discussed extracts and codes to come to a consensus, creating an agreed upon list of candidate themes and sub-themes.

Braun and Clarke's (2006) fourth step for thematic analysis is reviewing themes. Analysts reviewed each of the extracts in order to further refine the list and determine if each extract fit within its candidate theme. This process led to breaking some candidate themes into multiple themes or sub-themes or eliminating extracts from analysis.

Defining and naming themes is Braun and Clarke's (2006) fifth step for thematic analysis. Analysts worked with a faculty mentor to define themes and sub-themes according to literature on underrepresented groups in STEM and the aims of the LEGACY project. This involved discussing what each theme was about and why it was important. With background knowledge on STEM outreach, the faculty mentor guided the analysts in creating a refined thematic map to organize the themes that were developed through analysis. To complete this step, the PI listed the themes and one or two sentences to describe the content of each.

The final step of thematic analysis outlined by Braun and Clarke (2006) is to produce the report. This consists of writing a narrative to describe the results of the analysis. The report should describe each theme and sub-theme and provide evidence of each theme with data extracts to show that it is prevalent throughout the data. Supporting extracts should transcend merely describing the data by supporting an argument that addresses the research question or questions. This process will be done by the PI with feedback from the faculty mentor and will be presented as the results section of this manuscript.

Results

Table 1 presents the major characteristics of the 14 participants in this study. Each participant was assigned a pseudonym, which will be used to identify their statements.

Table 1
Participant Pseudonyms and Characteristics (Study 1)

Pseudonym	Occupation at the Time of Interview
Emily	College student pursuing a Computer Science degree
Madison	Third-year college student pursuing a Biomedical Sciences degree, with an emphasis in Neuroscience
Emma	Second-year college student pursuing a Bioinformatics degree
Olivia	College student pursuing a Computer Science degree
Hannah	First-year college student pursuing a Mechanical Engineering degree

Table 1 - Continued

Pseudonym	Occupation at the Time of Interview
Abigail	Student athlete pursuing degrees in Biology and Business Administration at an HBCU
Isabella	College student pursuing an Agricultural Sciences degree, with a concentration in Pre-Veterinary Medicine at an HBCU
Samantha	Second-year Reserve Officers' Training Corps student pursuing a Computer Science degree at an HBCU
Elizabeth	Second-year college student pursuing a Biomedical Sciences degree, with a concentration in Pre-Health Professions
Ashley	College student pursuing an Environmental Sciences degree
Alexis	College student pursuing a Computer Science degree
Sarah	High school student enrolled in four Advanced Placement courses
Sophia	High school student enrolled in her second Advanced Placement computer science course
Alyssa	High school student enrolled in a health science pathway program
Grace	First-year college student pursuing a Computer Science degree

Participation in the Legacy program had profound impacts, both at the academic and personal level, for participants. Participants reported multiple academic, social/emotional, and personal benefits from participating in the program, which impacted their academic performance and identity as STEM students and allowed them to form valuable relationships with peers and educators. The interviews also uncovered areas where participants perceived a lack of support needed to succeed in STEM, as well as the sources of support that sustained their pursuit of STEM education. Participation in the Legacy program impacted participants' motivation to stay in the STEM track and increased their awareness of multiple career paths and opportunities. Participants also revealed how life events and experiences impacted their STEM education path, and the different ways in which the learning community created by Legacy helped them overcome those challenges.

Themes that emerged in Study 1 were organized into four major theme groups, including the benefits derived from participation in the Legacy Program, needs and sources of support, career pathways, and personal and contextual challenges faced in participants' educational and professional journeys. Table 2 outlines the major themes found in Study 1. Each of these themes aligned with one of the research questions, as reflected in Table 2.

Table 2
Major Themes (Study 1)

1. Benefits Derived from Participation in the Legacy Program (R1)*
2. Needs and Sources of Support (R1, R2)
3. Career Pathways (R3)
4. Personal and Contextual Challenges (R2)

*Note: Each theme is followed by the corresponding research question in parentheses.

Benefits Derived from Participation in the Legacy Program

Participants revealed distinct benefits directly related to their participation in the Legacy Program. These benefits were categorized as academic, socio-emotional, and personal in nature. Each theme highlights the ways the program positively influences participants' educational pathways, relationships, and individual growth.

Table 3
Benefits Derived from Participation in the Legacy Program

Theme	Description
Academic Benefits	Participants experienced academic benefits derived from their participation in the Legacy program, including preparedness for AP CSP, acquisition of knowledge in an active-learning environment, exposure to the college environment, and better awareness of careers in STEM.
Socio-emotional Benefits	The Legacy Program cohort and residential experience had an impact on participants' lives through the development of peer relationships and a community of learners that persisted after program completion.
Personal Benefits	Participants experienced increased identification with STEM and computing careers, personal growth as developing professionals, and strong interpersonal relationships that were valuable throughout and after program participation.

Academic Benefits

Participants described numerous academic gains resulting from their participation in the Legacy Program. These included preparedness for Advanced Placement (AP) coursework, deeper engagement through active learning, and exposure to college environments and STEM career paths. Specifically, participants expressed that their involvement in the program left them feeling well-prepared for the AP Computer Science Principles (AP CSP) course and exam. They highlighted the importance of being familiar with key concepts, task requirements, and exam graders' expectations in advance of taking the class. Madison, a biomedical sciences major stated, "Actually doing some of the tasks that I knew were going to be expected of me [in AP CSP course], was way helpful. Especially doing it a whole summer before, that was helpful."

Participants also recounted positive experiences with the organized, structured, and project-based approach to learning within the Legacy Program. Emily, a computer science major, shared, "For the most part, they were very interactive with us, we got to do hands-on experiments, we got to follow along with the code." Additionally, participants noted how the program's flexibility allowed it to successfully accommodate individual learning styles, contributing to a more inclusive and effective learning experience, and highlighted the importance of the social and collaborative aspects of the learning process. Emily stated:

> I honestly don't learn by opening a study book and just trying to figure it out through there. [...] I had everyone around me, and then we partner up and stuff. It was just a big partner type of activity, that's how I thrive. [...] That's the way I love learning, and that's what helped me the most.

For several participants, involvement in the Legacy program solidified their interest in STEM fields, leading them to pursue career paths in computer science, engineering, and other STEM disciplines. The program provided them with experiences and resources that may not have otherwise been available to them, and which contributed to their educational and professional goals. Emily stated that she may not be in computer science if not for her participation in the program, commenting on how it empowered participants to pursue their passions and laid the foundation for their educational pursuits in STEM:

> If I wasn't able to get into the program, I probably wouldn't be still pursuing computer science, just because I was so new to the concept of coding and learning languages, and all the abstracts and the functions, and things of that nature. And it is a little bit overwhelming whenever you don't have constant practice, or a community to support you, anything like that. So, not being able to participate in Legacy and get that head start would probably scare me out of computer science, especially since there's so many other individuals who have been doing this since they were kids.

Participants often reflected on the impact of experiencing what life would be like as college students, emphasizing the exposure they gained to campus life during the program. Many participants, such as Samantha, a computer science major, noted that the residential component of the program provided participants with a valuable glimpse into the college experience:

> I do think my most memorable moment was getting an introduction to dorm life at an HBCU, specifically. [...] It was really cool getting the dorm life opportunity. Where it's like, rarely any AC. You know, the living quarters, working with other women in closed spaces. Which honestly, I ended up doing, because I went to [HBCU], which is an all-girls school.

Several participants specifically mentioned how being at an HBCU during the participation in Legacy influenced their college decisions, with half of the participants (N = 6) opting to enroll in an HBCU to pursue their bachelor's degrees. These students described the experience of being at an HBCU as meaningful, instilling a sense of pride and securing their identities as Black Women in STEM. Isabella, an agricultural sciences major explained how her participation in the program led to her decision to enroll at an HBCU:

> I didn't really have much experience with HBCUs [...] before Legacy, so going to Tuskegee was really something that made me realize… finalized going to an HBCU. So, [...] I would definitely say my favorite memory was the whole week of being in Tuskegee.

Socio-emotional Benefits

The Legacy Program led to lasting peer relationships and created a community of learners that supported participants socially and emotionally. Participants described their interactions and connections within the program, highlighting the importance of peer relationships in shaping their overall experience. Many participants described forging strong bonds and connections with one another. Emma, a bioinformatics major, recounted how the program created an environment where participants did not only engage in learning about computer science, but also a community of like-minded peers in which they fully belonged:

> There's so many good memories. For the second session, [...] we decided to all dress up in yellow and have a photo shoot. And that was just so much fun, and it was a great bonding experience for me and the girls. We all took individual pictures, and we all hyped each other up. I've never felt more loved by a community.

Further, many participants recalled their experiences in Legacy as fun and exciting, qualifying their interactions with one another as enjoyable and engaging, and stating that long-term friendships emerged from the program. When asked about memorable aspects of the program, Ashley, an environmental sciences major responded, "Probably all the fun I had meeting all the different girls, because most of them I'm still in contact with. Probably just meeting everyone, and having fun, and kind of like, just being there." Participants not only formed friendships, but their interaction contributed to a supportive peer network that continued even after the program ended. They often described the collaborative nature of their interactions and how this teamwork encouraged academic success and positive peer relationships. For example, Emma reflected on the benefits of collaboration in a field like computer science, and how participants transitioned from working in isolation to working in collaboration, with the consequence that learning became a communal effort:

> Oftentimes, when we were in the classroom, the professors would encourage us to turn to our neighbors and [...] compare answers. And especially within a [...] subject like computer science, you can never do it alone. You always have to consult other people, ask for other people's opinions, especially if there's an error in your code. I think it's very important to have a second set of eyes to look over it. [...] Teamwork is what made the dreamwork within Legacy.

Many participants described the sense of belonging, support, and shared identity that developed through these collaborative interactions. They often highlighted the cohort model and peer engagement as key elements that contributed to a positive and empowering environment. Being a part of a close-knit community allowed them to connect with others who shared similar backgrounds and aspirations. Emily described this interaction as particularly impactful, citing how the supportive community of girls like herself provided a source of encouragement and validation throughout the program, which were crucial for academic success and lasting engagement in STEM:

> Being able to connect with the girls was really great. It was a great experience because not only was I [...] getting to have a head start on something that I love and want to do for the rest of my life, but I also got to experience that with these girls that are also minorities, that are also pursuing computer science, and that have the same drive as I do. And it was really awesome because, even today, we still keep up with each other online whenever we can.

Personal Benefits

Many participants described how their participation in the program impacted their perceptions of diversity in STEM fields, specifically regarding seeing more Black girls and women in these fields. Emily described how she might have felt if she had not been exposed to other young women with whom she could identify through the Legacy Program:

> If I didn't have Legacy to show me that there are women like me that want to pursue a career like this… I would feel daunted because it is difficult to pursue something that you really want knowing that you don't have a leg up like other people would.

Ashley explained how inspiring it was to be surrounded not only by other young women like her but also by instructors who also were Women of Color, an experience that felt empowering in a field where their presence is often unexpected:

> It was really nice meeting a lot of different Women of Color in a field that… most people wouldn't expect us to be in. So, it was kind of inspiring… I guess it was

inspiring because you wouldn't expect to see that many young Black women doing coding… Even though class was long, it was still fun, because even our instructors were Women of Color.

Olivia, a computer science major, described how representation can make a path more appealing and shift perceptions about what is possible, emphasizing that seeing someone who looks like her in a field can inspire her to pursue it:

> A lot of the time when you're talking about, I guess inclusion, the narrative is that you're pushing Black girls to think that they can do it. I feel like it's not so much that, that's something I always knew I was capable of. I feel like any person is capable of doing math and science, it's something you study and you learn, but to see yourself in it, it makes it more appealing, I guess. Like, "okay, I see someone else in it, so I'll do it too. Why not?"

In addition to offering representation, participants described how the program provided visibility and recognition of their potential and achievements as students in STEM fields. For Sarah, a high school student enrolled in four AP courses, the value of recognition extended beyond personal validation, particularly when succeeding in an environment that may not always support her:

> It's always nice when someone recognizes your accomplishments, but especially when you're achieving in a world that doesn't want you to achieve what you do. It's always nice for someone to commend you for it and have that. And it really motivates you to keep on going and motivates you to keep on trying to thrive in this world that's not set up for people like you.

Elizabeth, a biomedical sciences major, explained how the program brought to light the presence of Black women in STEM:

> It really got to show you how many of us as Black women enjoy the STEM portion of it, because it's not shown much in school. They talk about it and they talk about… statistics and numbers… but there's never something to show for that…And that's what the program did, it showed you how many women did it, succeeded, and how many wanted to come back to it.

Participants also described the feelings of inclusion and acceptance in STEM spaces that resulted from participating in the program. According to Emma, "If I wasn't surrounded by people who look like me, I definitely would have felt insecure [...], but also because the [instructors] were Black women, it helped me see that I belong." She also recalled a volunteer experience teaching elementary and middle school girls about computer science, which reinforced her own sense of belonging by allowing her to see herself as both a role model and a valued member of the STEM community:

> I remember at one of the sessions, we asked them, [...] "What do you think a computer scientist looks like?" [...] And a lot of them said they imagined an older guy in computer science, and although that's what I thought at first, I was like, "This is a little bit heartbreaking." So, just being able to participate in this club and have little girls know that they belong in computer science, they are the next generation of computer scientists, was really touching for me, and it really helped me [...] know that I belong in computer science and that I want to continue it for the rest of my life.

The Legacy Program also instilled a sense of accountability through the development of responsibility, ownership, and commitment to their goals and learning. Hannah, a mechanical engineering major, reflected on her dedication to her engineering program and emphasized the importance of holding herself accountable to achieve her educational goals, stating “Just for me personally, I know not everyone likes being held accountable, but I was so used to it throughout my entire life, that now I’m like, ‘I need to hold myself accountable,’ which is something new to me.”

Participation in Legacy also strengthened participants’ belief in their abilities and their self-assurance both inside and outside of STEM spaces. Abigail, a dual major in biology and business administration, explained:

> Legacy helped me with confidence, number one. Just being in that environment, [...] taught me how to be confident and believe in myself, and that I have others around me pouring [...] positivity and telling me that I could do it. And that taught me to be more confident, and I took that confidence with me to the next school year. [...] I took that same confidence with me in my schoolwork, and I excelled. And I still have that same confidence now, and I feel like there’s really nothing I can’t do. So, I feel like the Legacy Program instilled confidence in me.

Sarah described how her experience in Legacy gave her the confidence to ask questions in the classroom:

> Legacy gave me the confidence to ask questions that I wouldn't normally ask in class because, without asking those questions, I would never be able to get the understanding that I would need to help get knowledge about that concept. But with Legacy, there was a space where you wouldn’t feel judged to ask your

> question, all questions are accepted. And with that space, so being able to ask those questions in that space, I was able to take that into the classroom and ask the teacher if I didn't feel like I fully understood something.

Samantha reflected on how her experience in Legacy gave her the confidence to pursue more opportunities:

> God moved some things around, and he was like, “no, you're definitely going to do [coding program].” And so, when I started it, I was like, “oh, been here, done that with Legacy, [...] on a larger scale for more time.” And when I got into it I realized, “this is amazing,” and I was a part of the first cohort for Legacy, and the first cohort for [coding program]. And so, seeing these things grow, and being a part of these groundbreaking and glass ceiling smashing experiments, to say the least, it was really monumental in my educational career, because not only am I now given opportunities that I wouldn't have been given before, but I know how to find them on my own, and I know that when I walk into a room I am worth being in that room because I was in Legacy, and I know my background. I was in [coding program], and I know my knowledge. I know what I’m capable of doing.

Emma described how her younger sister, who also participated in Legacy, felt confident enough in her ability and knowledge to start her own small business after completing the program:

> I actually encouraged my little sister to do Legacy and she was part of last year's cohort and now she's starting a small business dealing with computer science and she's building a website for this local business that's in our community, and

> because of the Legacy Program we were able to do these things without insecurities and feel like this is what I'm supposed to be doing.

Participants noted the many ways in which their involvement in Legacy strengthened their connections with others in the STEM community and provided opportunities for collaboration. Samantha described how the program taught her the importance of networking:

> With Legacy, it showed me what having people in your corner is like. [...] The biggest thing I took away from it was networking. So, if I had not done Legacy, I would not have networked as well as I did.

Participants described the strong bonds and support networks they established with their peers, which provided emotional support, knowledge sharing, and a stronger sense of belonging within the STEM community. Isabella described the personal impact of conversations with other young women in her cohort:

> The conversations that me and the girls used to have, once everybody got back [to the dormitory], it was really talking about our future plans and different experiences we've had, [...] just being a Black girl in America. And I think those conversations helped mold me the most, just because with me, talking to an instructor about something, they're not going to understand as much as a girl a year older than me would.

Participants also established meaningful relationships with teachers and program facilitators. These relationships were characterized by guidance and academic support that contributed to participants' personal growth. Elizabeth mentioned the guidance she received from the Legacy instructors, stating, "I wish I could carry the teachers that I had then at the Legacy Program with me to college now. They were always super helpful, always wanting to lend a hand, [...] any question you had, you could email somebody." Alexis mentioned the help she received from a specific facilitator:

> Ms. [name removed], she was part of the program. I don't know if you know her but, oh my gosh! She was a wonderful help. [...] She would make time for me, and get on Zoom, and really just help me out. And it wasn't like, "here I'm gonna show you," but she would actually walk me through the stuff, and I could really get it.

Needs and Sources of Support

Participants noted a variety of sources from which they received support in their educational and career journeys, as well as ways in which they could be supported further. These themes associated with support are divided into Sources and Needs.

Table 4
Needs and Sources of Support (Study 1)

Theme	Description
Sources	Resources that contribute to the advancement of participants' educational and career journeys, including social support from peers and family, as well as guidance from educators and various other instrumental educational resources.
Needs	Areas where additional resources would benefit participants in their educational and career journeys, including increased representation and mentorship.

Sources

Participants identified a variety of sources from which they received support, including social and educational sources.

Social Support. Social support came from peers, family, and diverse support networks. Many participants emphasized the significance of peer support in their academic journeys, including support within the Legacy Program. Supportive peers included fellow Legacy participants, current and past classmates, teammates, and members of professional networks and clubs. Hannah stated:

> I feel that the community that we built definitely helped me. Just being around other women of color who were also discovering coding, [...] we really built a group together that formed pretty good friendships out of it really. Just knowing that you had people behind you that were also supporting you as well and sometimes that's not always there.

Grace, a computer science major reflected on the support she received from a classmate while preparing for the AP CSP exam:

> Having my classmate, she was also a Black girl, [...] having her, and being able to talk to and work together on a project, because we were allowed to kind of help each other, [...] and I could help her and be like, 'maybe you should try this or do that.' But at the same time being able to kind of joke around and kind of relax a little bit. I think it made the test go by a lot easier, and it made the workload a lot lighter.

Family support was also important, with many participants describing the help they received from family members. In a somewhat unique case, Grace, whose father returned to school to pursue a computer science degree, discussed the mutual support that she and her father provided to each other as computer science students:

> My dad is actually going back to college to get his computer science degree. [...] I can use some of the stuff from Legacy to help him. [...] And we help each other. We bounce off each other. He's maybe a year ahead of me. So, when it comes to programming and stuff, I can help him. And then, when it comes to other basics, like calculus, or physics, or stuff like that, he can help me. [...] He comes home every evening. It's like, he's doing homework, and it's like, "oh, I have homework, too." and we just go in the kitchen, and we'll start doing our homework together.

Alyssa, a high school student enrolled in a health science pathway program described the confidence she gained from the support of her parents:

> I feel like I'm very confident that I'll be able to do it. Obviously, you know, along the way it will be kind of stress-inducing because of how much has to be done. But I feel very confident that I'll be able to do it, because I have my mom and my stepdad there to help me in case I, you know, happen to struggle on anything along the way.

Sophia, a high school student enrolled in her second AP computer science course discussed the encouragement she received from an aunt following the death of her mother:

> My Aunt [name removed] taught me many things. [...] She taught me never to give up. She told me [...] that "you should achieve and strive for what your mom wanted. [...] She wanted you to be the role model for your brothers," and that's what I did.

Some participants also highlighted the importance of diverse support networks, including both POC and non-POC individuals. Samantha explained:

> One thing that I really noticed about America in general is, this is going to sound really bad, but always have a White friend, because when I was watching this movie about this young Black entrepreneur, [...] and he was really good at what he does, but in order to make business deals he sent the White friend in, in order to talk to the people, right? So that his foot could be in the door, and then he could just walk through, you know? So, the people in Legacy that weren't of color, they were willing to open that door for people who were [POC], to make it happen.

Educational Support. Educational sources of support included educators and various instrumental resources. Many participants described the support they received from Legacy Program teachers, both during the summer session and throughout the school year. Madison discussed the value of this continued support:

> Knowing that throughout the year I'd have, because they're there, the three teachers. I'd had them to just talk to, you know what I mean? I'd have the teachers who worked with me over the summer. I have resources that they provided me and as well as their email, so I could like, "Hey, I'm really not grasping this fact. I'm in class. I have my teacher explaining it. I'm still not getting it. [...] Can you give me a refresher?" [...] I remember one of them literally sent me a video, she held her phone up and was like, "this is what I'm doing." Like having to do it one by one, on her iPhone with me. So, that was really helpful.

Support from Black women educators was particularly meaningful to some participants. Samantha shared:

> Having a White teacher tell me, “what are you talking about? you're good at this. what do you mean?” It's different from having a Black woman tell me, “what are you talking about? you’re good at this, what do you mean?” You know? Hearing my mom say it, it's more like a tough love type thing, and hearing a White professor say it, it's belittling, it's like, “oh, you expect me to work twice as hard to be just as good,” you know? But in Legacy we work twice as hard to be twice as good.

In addition to educators, many participants also mentioned the support of mentors, advisors, and counselors. Emma stated:

> Just being at [institution], I’ve been connected to a lot of professors, and I know that they will be there for me for every step of the way. Counselors too. My advisor, he’s amazing, and so I am completely confident, I can achieve the steps [to achieve educational and career goals].

In addition to educators and other key figures, many participants noted the instrumental support they received in the form of scholarships, research opportunities, internships, and participation in clubs and professional societies.

Needs

This theme highlights key areas in which participants believed that additional resources could enhance a sense of belonging and support educational achievement, particularly through increased representation and access to mentorship.

Many participants reflected on the importance of seeing individuals who "looked like them" in academic and professional spaces—something they found in the Legacy Program but often lacked elsewhere. Alexis shared how representation influenced her confidence and persistence:

> If there were people that didn't look like me, and I was probably one of the only ones with my complexion, it would have been way more discouraging. In my mind, if I was like, "well, I probably shouldn't be here, I probably couldn't amount to that," but actually having the representation around, it really helps.

In addition to representation, mentorship emerged as an important need. Emily spoke about the value of guidance from established professionals:

> I would say that being exposed to [...] professional Black women who are established and well known, having them come and talk to us and mentor would be very beneficial. [...] Come talk to us, mentor us on how to behave professionally, [...] "don't come into work with shorts and flip flops," and stuff like that, on how to navigate the workplace in general.

Isabella described the value of mentorship in providing perspective and encouragement through challenging times:

> Having a mentor or somebody to really just say, "stuff is not always gonna go how you want it to go. You have to keep going, because it happens to literally everybody, everyday." [...] Just having somebody who can really just tell you about real world experience and stuff that's really going to happen in your real life. I think it would definitely give me [...] more support, just about making decisions through my everyday life.

For many participants, representation and mentorship were not just beneficial but essential for navigating academic and professional environments. These elements provided a sense of belonging, guidance, and reassurance, reinforcing the need for structured support systems in encouraging long-term success. One of Legacy's activities was to have established Black STEM professionals give presentations about their career path and current challenges and successes, with opportunities for conversation. However, it seems that students would have benefited from more mentoring in all aspects of professional development, as well as long-term mentoring structures.

Career Pathways

During the interviews, participants discussed their individual educational and career trajectories, independent of the Legacy Program. These discussions highlighted both their professional aspirations and the mechanisms that supported their development. Two subthemes emerged: Inspiration/Motivation, which includes the driving internal and external factors shaping their goals, and Professional Opportunities, which describes the practical experiences and resources that helped them prepare for and pursue their career aspirations.

Table 5
Career Pathways (Study 1)

Theme	Description
Motivation	Participants' external and internal driving factors for achieving their aspirations, including passion, technology, making a meaningful impact, and financial security.
Professional Opportunities	Ways in which participants acquire new skills and knowledge for achieving their aspirations, including scholarships, internships, research opportunities, and extracurricular activities.

Motivation

Participants described their educational and career aspirations, highlighting a diverse range of interests. Among those already in college at the time of the interviews (N = 12), majors included computer science (N = 5), engineering (N = 1), environmental science (N = 1), and biological/health sciences (N = 5). High school participants (N = 3) all expressed aspirations to enter the health sciences field. Their long-term career goals reflected both technical and service-oriented ambitions, and spanned multiple fields, including cybersecurity, software development, mechanical engineering, medicine, radiology, pharmacy, and teaching. Some participants also expressed interest in military service or pursuing careers within the federal government. Participation in Legacy also exposed students to like-minded individuals, which helped solidify their budding interest in STEM. Emma shared how the presence of passionate peers deeply resonated with her, helping solidify her career interests:

> These women were really smart, and they were very, very passionate about computer science and it was beautiful to me because a lot of the times […] They talked about the disparities that are within the computer science community and how we don't have enough people that look like us, and [...] I'm not just talking about African Americans but women as well, so it applies to me and you. But I think just being surrounded by really smart individuals [...] it put a smile on my face.

Notably, even for those participants pursuing or thinking of pursuing a career outside of traditional STEM fields (e.g., health sciences), exposure to different uses of technology in the Legacy program played a key role in their academic decision-making. Some chose their colleges specifically because the institutions incorporated advanced technology into their curricula and learning environments, seeing this as essential to their future careers, while others were inspired by the opportunity to contribute to technological advancements. Emma later noted the importance of diverse contributions to the field of computer science, stating:

> Computer science isn't going to develop by itself, or it's not going to develop with one group of people, it takes [...] a village, it takes a diverse group of people to advance the community of computer science and just make a lot of technological advancements for the future.

Similarly, Olivia pointed to the field's continuous growth as a factor that motivated her to pursue a career in computer science:

> The reason I chose computer science is because I know that it's one of those fields that's always needed and it can only go up from here, you can only develop, and things can only be more technologically advanced. And if I can contribute to that, that would be amazing. I'm hoping that I'll be in a place where I'm able to contribute to that.

For some participants, the desire to make a meaningful impact on others' lives was a driving force behind their academic and career aspirations. Sarah, passionate about medicine, viewed research as a path to help others, "I know that I want to get that PhD to do research in the medical field, and that it's good for innovation and for research that would help hopefully improve the lives of others."

Financial security was also a motivating factor for some participants, and it influenced their decision to pursue STEM careers. Samantha explained her decision to pursue computer science as a means of achieving financial stability while still nurturing her personal passions, stating, “On the side I’m going to be doing the things that I love. But while I’m making money doing STEM, my money is going to be making money, because I’m also working on my passion.” Later adding, “If I become a software engineer, that's not a bad thing. I would love to do that. It's not my number one passion, but my number one passion is now my hobby, and who says I can't do both.”

Professional Opportunities

Participants described actively seeking and capitalizing on a range of professional development opportunities that aligned with their academic and career ambitions. Many highlighted securing scholarships as a means of financial support for their education, while others pursued internships to build connections and gain hands-on experience in their fields. Participants explored research opportunities and extracurricular activities, such as volunteering and club memberships, as ways to expand their knowledge, develop professional networks, and contribute to their communities. These opportunities helped participants gain valuable skills, develop support and professional networks, and prepare for future success.

Many participants emphasized the critical role of scholarships in funding their education, with some having already secured significant financial support. These scholarships not only alleviated financial burdens but also enabled participants to pursue advanced degrees. Samantha explained that she enrolled in the Reserve Officers’ Training Corps to help finance her education and secure future employment. She described how a scholarship facilitated her path toward a graduate degree in computer science:

> There is a 4 plus 1 program. So, I, with my scholarship that I received, I would just have to pay for that last year, So, I can go ahead and get my master's in computer science and go ahead and get into the industry and start doing big things.

Samantha also discussed the impact of a scholarship program designed specifically for STEM students at HBCUs, emphasizing its role in increasing diversity and expanding awareness of career opportunities:

> I was part of a scholarship group that was for STEM majors that go to HBCUs. It started with Spelman and Morehouse. It's called CodeHouse and their initiative was to invest in young STEM major students at HBCUs so that we can not only increase diversity in the STEM workplace, but close the gap between the knowledge of what they can do, what they're capable of doing, because nine times out of ten we're not given those opportunities of what's available to us.

In addition to scholarships, participants recognized internships as important for gaining experience, expanding professional networks, and advancing their careers. Some participants (N = 3) described actively applying for internships as part of their professional development strategy. Ashley shared her excitement about progressing through the application process, stating, "The second step [for my professional plan] was applying for internships through the USDA. So, I applied to those. I got an email back from one of the locations I applied to today actually, which was really exciting." Others (N = 6) described already securing or completing internships, underscoring their value in gaining industry experience. Samantha reflected on her recent internship with a major tech company and her ongoing pursuit of new opportunities:

> I had an internship this summer. It was this past summer with [company name removed] as a software engineering intern with the risk management team. So, that was pretty cool, too. So, I'm steadily looking for internships to fill my summers up.

For many, internships also served as a potential gateway to future employment, providing opportunities to secure full-time positions within the organizations they interned for. Emily described her hope to secure a future position based on her internship:

> A year from now I will probably still be pursuing computer science, of course. I hopefully will have secured a position at my internship to where I can possibly go back or maybe even try for an actual job there.

Many participants also expressed a strong interest in engaging in research, either as part of their immediate academic pursuits or as a long-term career goal. Some participants were eager to join research groups in the near future, recognizing the value of hands-on research experience. Emma shared her enthusiasm for joining a lab, stating, "I see myself definitely in a research lab. I've always been interested in conducting research or joining a research group." Others saw research as an essential component of their future careers, particularly in fields where advanced study and innovation play a crucial role. Sarah described her commitment to pursuing a Ph.D. as a pathway to conducting meaningful research in the medical field:

> I'm going to have to stay in school a bit longer than the average person. I know that I want to get that PhD to do research in the medical field, and that it's good

> for innovation and for research that would help hopefully improve the lives of others.

Beyond academics, participants actively engaged in extracurricular activities as part of their broader educational and professional development. Many described participating in student organizations, joining clubs, and volunteering, recognizing these activities as valuable opportunities to build skills, expand their networks, and contribute to their communities. Several participants discussed their participation in various clubs during high school and college. Grace highlighted how the Legacy Program gave her the confidence to join multiple clubs:

> But with Legacy, it kind of gave me the confidence, even now, to be in our Robotics Club, to be in Girls Who Code, to be in the Gaming Club, to get out there. And like I said, I have a competition next week, and without Legacy I definitely would not have signed up, and I don't think I would have been chosen. But here we are. I'm one of the four on [institution name removed]'s team. And it's kind of helped me branch out and get used to people more because they're doing big things up here.

Grace later described how her own experiences motivated her to encourage younger students—particularly girls—to explore STEM opportunities:

> As I've gotten older, I'm kind of like, why not be that role model for other girls? Because I have a younger cousin and [...] she loves dance, you know she's the typical girlie girl, and then she's like, "they have a STEM club at school and I really don't know if I want to get in it." I'm like "get in it. you need it," you know?[...] And so, I'm like, "there is so much you can do with STEM, get in it,

> we need more people like me and you, and that is really good for you, and it's going to benefit you down the line."

In addition to club participation, some participants emphasized the importance of volunteer work. Emma shared her commitment to community service and how it aligned with her passion for pediatrics:

> I see myself volunteering. I'm working with [organization name removed], which is an initiative to just help little, younger kids learn how to read and become more proficient in English, and I see myself continuing with that program, [...] since I'm so interested in pediatrics, I just see my gift as helping little children out. Just being something that benefits not only them but me as well, because I like to see the younger generation succeed.

For many participants, extracurricular involvement served as a meaningful extension of their academic and career aspirations, providing opportunities for leadership, mentorship, and community impact.

Challenges

The final theme of Study 1 captures the obstacles participants encountered throughout their educational and professional journeys. The challenges participants described were either rooted in their personal experiences or stemmed from the broader educational environments in which they were situated.

Table 6
Challenges (Study 1)

Theme	**Description**
Personal Challenges	Barriers to participants' engagement and achievement in their STEM field, including financial difficulties, health issues, and the loss of a loved one.
Contextual Challenges	Barriers to participants' engagement and achievement in their STEM field, including being the only girl or only Black girl, negative experiences in AP CSP, being a first-generation college student, and being underestimated.

Personal Challenges

Personal challenges refer to the internal or individual circumstances that hindered participants' academic success, such as financial hardship, mental or physical health issues, or personal loss. These challenges often occurred outside of institutional structures but had a profound impact on educational trajectories. Some participants described the overwhelming burden of having to provide for themselves financially. Madison explained how she faced significant financial challenges that disrupted her college journey and described how an unexpected family crisis left her entirely responsible for supporting herself. With no financial assistance from her parents and an unstable living situation, she entered her second semester of college uncertain about her future:

> I had one semester at [institution name removed] and then I have this huge family thing and I [...], all of a sudden, had to provide for myself completely. I did not have any, like my parents could not help me financially at all. And I did not have a stable [...], I didn't know where I was going to go, basically. I just, a lot of things happened from November to January. And I just entered my second semester my

> freshman year at [institution name removed] like, "Where am I going to live? How am I going to pay for college? Am I going to be in college? What, what am I going to do?"

To manage these challenges, she took on two jobs to save money for a car which was essential for her 90-mile commute to campus. This financial strain led to her taking a semester off, delaying her graduation plans:

> And so, I actually had to take a break from college [...]. I tried to do college and deal with that, but it was just so stressful because [...] I had to start working two jobs and I was working 80-hour weeks, so I can figure out, "how am I gonna get a car?" [...] So, I had to figure that out and that actually delayed me one semester, but it kind of [...] worked out because I had a lot of AP credits from high school. So, I'm still on track, but [...] I was on track to graduate a year earlier, but I'm just on track to graduate on time.

Emily described how an unexpected situation forced her to move out of her home, creating significant challenges in balancing school, work, and personal responsibilities. She reflected on the impact of this sudden transition:

> There's a situation recently, about a month ago that kind of was the catalyst to me moving out of my house, and I would say [...] that sort of setback my plans a little bit. Specifically, because the process of moving is so stressful and getting all my paperwork set up and trying to keep up with school and my internship and my job was a little bit of a setback. And it kind of threw a wrench in my plans but it's nothing that I can't come back from.

Several participants navigated serious health challenges during their academic careers. Despite these challenges, they demonstrated resilience and determination in their academic journeys. Elizabeth shared her experience of managing a serious medical challenge while in college and the academic accommodations that allowed her to stay enrolled. Already a kidney transplant survivor, she underwent her second kidney transplant as a college student. Determined to stay on track, she adjusted her coursework to make room for her recovery:

> I got my second transplant, and I was also doing online classes as well. So, I had to only do one credit. We had to work out this thing where I could just do one class online, because now I was in recovery mode from my second transplant and everything. So, after that got transplanted, it kind of took my class schedule, work-course down to just one course, which was fine. You know? I did it [...], and then I was able to come back [...] in the Fall [...] and [...] completely finished out all my courses that I needed to.

She emphasized her commitment to staying enrolled, even if it meant taking a single class, to maintain her academic progress:

> The really biggest thing was I just didn't want to have to stop school completely. I said, 'even if I could do a half a class, one class, something just to me still being in school," because that was the biggest thing I feared.

Mental health concerns also arose as significant personal challenges. Ashley highlighted the emotional toll of being a college student and the need for better mental health resources:

> Being a college student can be really stressful, and learning ways that I could cope with that stress or those mental issues that I face during the school year would be really helpful. My school does a good job at that, but just overall that would probably be my biggest thing is that emotional, mental health support throughout the school year, especially during midterms and finals.

Emily described how having ADHD made it difficult for her to grasp new concepts quickly. However, with the support of the Legacy Program, she was able to persist and develop her skills, even as the Covid-19 pandemic forced a transition to online learning:

> I'm sort of a weird learner. I have ADHD so I don't really quite grasp concepts as fast as other kids. So, whenever I started, the beginning of the year, I had a head start and I was able to continue and grow in my skills, despite not being actually in the classroom for the last half of the semester.

A few participants reflected on the profound impact of losing a close loved one, describing both the emotional challenges and the resilience that emerged from their loss. For some, this experience became a source of motivation, shaping their aspirations and determination. Madison shared how the loss of a family member inspired her to pursue a career in medicine. Sophia described how the passing of a loved one became a turning point in her journey, propelling her toward her achievements:

> If it wasn't for my mom's death, I don't think I would achieve doing the Legacy Program, getting these scholarships, getting recognition from my school. I don't think I would have ever achieved those big goals if it wasn't for that, and I think

> that's God's way of showing me, "[...] this is the path I've carved for you, this is the life I set out for you, and this is who I want you to be."

While many participants emphasized their ability to overcome the challenges they encountered and considered them a source of personal growth, these experiences remain significant. The challenges they faced not only tested their resilience but also influenced their perspectives on resilience and achievement. Madison reflected on the value of facing difficulties, highlighting her perception of how adversity supports growth and resilience:

> Any good person has to have a great deal of obstacles, you know? Because that's what makes you mature. [...] You don't learn life lessons the easy way. The only lessons you're going to learn, that are going to stick with you, are ones that you have to struggle to learn, or ones that [...] God has to force into you, over and over and over again. That's the only way you learn.

Contextual Challenges

Contextual challenges refer to systemic, environmental, or structural barriers participants encountered in their STEM pathways. These included issues of representation, discrimination, and a lack of inclusivity within academic programs and professional environments. Participants' experiences of challenges varied widely, but certain obstacles were common. Some challenges, such as being a first-generation college student, were discussed by fewer participants but were still notable. Nearly every participant described the challenge of "being the only one" (the only girl, the only Black person, or the only Black woman) in their academic and extracurricular STEM environments. Many expressed feelings of isolation in their programs or classrooms, yet also reflected on how Legacy and similar spaces provided a sense of representation and belonging. Emily described her initial surprise at how many Black young women applied to the Legacy Program, having felt so isolated in her usual STEM environments:

> Whenever I first heard about [Legacy], I didn't really think too many people would be interested because there aren't really very many young Black women in STEM at all. So, whenever [program administrator name removed] had told us that it was around 120 to 160 applicants for the first year, I was baffled. [...] Hearing that amount of people applied and only 40 got accepted, that was crazy. And then on top of that, being surrounded by people who look like me and think like me, have the same experiences as me, [...] made it a very comfortable environment.

Emily later described the stark contrast between Legacy and her usual STEM spaces:

> If I wasn't curious to know more about code, I wouldn't push myself to go into environments and spaces that don't usually host young Black women. An example of this would be the [computing club] that is at my school and the [cybersecurity club] at my school. Both of those clubs, one of them, the [computing club], I'm the only woman and I'm the only Black woman in that club. As far as [cybersecurity club], I'm just the only woman in that club.

Ashley expressed how surprising and empowering it was to see so many Black girls in STEM through Legacy:

> It was inspiring because you wouldn't expect to see that many young Black women doing coding, you know? That was probably the [...] most fun, even

> though the class was long. It was still fun, because even our instructors were women of color.

She later reflected on how this representation shaped her perspective:

> It was a big deal. It was kind of [...] empowering to know that everyone else was doing it, too. That even though our area that we were studying wasn't, it didn't have... It was mostly predominantly of White men. Not even [...] of women, just mostly men. [...] Looking back, I think it was a really big deal for me, seeing so many people that look like me at my age were studying the same thing.

For some, the Legacy Program gave them hope despite limited diversity in their programs. Emma explained:

> I would say that, even within [institution name], [Institution] is a very diverse campus, but within our computer science department, there's not a lot of diversity, and within the bioinformatics major, I am one of two Black girls in this program. But just knowing that I don't necessarily have to see to believe that there are people out there who look like me that are interested in computer science [...], and just knowing that there are girls out here, going to [another institution] from the Legacy community, or [another institution], or [another institution], anything like that. Or an HBCU. Just knowing, having the knowledge that there are girls trying to advance computer science for young Black women all over the world is just an eye opener for me and just gives me a lot of hope.

Olivia echoed this sentiment, describing how rare it is to see Black girls in STEM spaces and how transformative it was to be in a room filled with them:

> When there are STEM dedicated activities or projects or whatever, the people you see there are not usually Black girls. You don't really see Black girls in engineering. You don’t really see Black girls in STEM. You mostly see White and Asian men in STEM and even now, even in my current computer science classes, or math classes, or whatever, if I walk into a room, I’m seeing mostly White and Asian men. And that's okay, that's beautiful, but you know, we're not really in there. So, to see a whole room of just a bunch of smart Black girls with smart Black teachers, it was significant. It's like, “oh, well, I guess we do have a spot and we're just as capable as everybody else.”

Some participants shared negative experiences with AP CSP, particularly inadequate instruction and lack of support. Even though they acknowledge the strong foundation they acquired in Legacy, these negative experiences influenced their perceptions of computer science and, in some cases, their academic and career trajectories. For example, Ashley, who ultimately pursued biological sciences, described how her AP CSP teacher’s lack of support diminished her interest in the field. Despite initially being drawn to computer science and solidifying that interest in Legacy, her experience in the AP CSP course led her to change directions:

> I really wanted to do computer science going into school, but when I took the AP course my teacher wasn't very supportive, so I ended up switching. But I still use some of that background knowledge that I learned. I was undecided before Legacy. And then, when I was doing it I was like, “okay, I want to do computer science.” But then, when I took the AP course the following school year, that teacher kind of just drained my love for it, you know? And I've had that at times

> in different subjects. Like, for band, I had the same kind of thing. I was super into band, and then I had one teacher just kind of kill my aspirations.

Elizabeth described how a scheduling issue resulted in her taking AP CSP independently, with minimal support from her teacher. Despite these challenges, she credited the skills she developed in Legacy for helping her navigate the coursework:

> I'm not gonna lie, that was… it was kind of hard because [...] with my schedule, they kinda kind of got messed up. [...] I got put into a TA assistant role, but I also got put into the AP Computer Science course during the same time I was supposed to be the teacher's assistant. [...] Once we figured it out, there's nowhere to kind of put me. So, what I did was [...] during her class period, I would go up to the AP Computer Science class. But [...] the teacher [...] had a freshman class during that time. So, basically it was just me. I was doing the AP. Which was kind of hard because she really couldn't… Well, she tried to help me as much as she could, but she also had a class to teach. So, it was mostly just me, going [...] on the computer every day and trying to do my portfolio. [...] I will say the course did help me with the programming, because there were parts I would get stuck on. But then I would look back at my Legacy things and be like, "okay, well, this code line right here, there's an error, because I have a semicolon or something," or you know "the reason why the program isn't playing is because I put too many periods and everything." So, I will say the programming aspect did really come in handy with the portion of the AP Course.

Elizabeth reflected on being a first-generation college student and the need for spaces for people from similar backgrounds to come together and support each other, describing the support she received from her college's Black student union:

> It's not easy, and it could be quite intimidating, especially coming in for something that, you know, you're not used to as much. Like with me being a first-generation college student, coming to college was a big shock to me. And you know it was good that [...] on campus we have a Black student union. So, it was good to have people like me to just sit down, talk, hang out and share our experiences as not only college students, one, but just as Black people in general.

Finally, participants described navigating the reactions that they received from others within STEM spaces, such as being underestimated. Grace described her experience of being underestimated in her field:

> I don't want to call him something that he isn't, but there is this one guy who, he just thought he was everything. You know? [...] I would like to be optimistic and say that it wasn't because I was a Black girl, but I really can't tell, and don't make me lie. You know? But it's like, he would rub it in your face, and he's like, "oh, don't do that! Don't do this," but he would come over, and he'd take it out of your hands, and it's like, I just had to look at her, and I'm like, "get him away from me, because if I gotta tell him, I'm gonna hurt his feelings. [...] Let me figure it out. Let me do what I need to do." And it's kind of like being a Black girl in this field, people just kind of assume you're just kind of winging your way through, and it's like, I don't know everything, but I know the basics. You know? I can tell when something doesn't sound right. I can tell when people are trying to get one over on

me, and it's like, people kind of underestimate you, is a big thing. [...] Once you get there and you show them, then they're just so dumbfounded. They're like, "oh, my goodness! How did you? Oh my!" And it's like, it's the basics, it's what I have to learn to keep going.

Discussion

The findings from Study 1 provide insight into the participants' experiences in the Legacy program and the structural and interpersonal factors that influence their educational pathways. In response to Research Question 1, participants described the Legacy Program as valuable resource for computer science instruction, confidence-building, and peer support. They highlighted the importance of representation in shaping their STEM identity, and provided feedback, such as a desire for continued contact beyond the duration of the program. Addressing Research Question 2, participants identified challenges in the pursuit of STEM, including a lack of representation, isolation, microaggressions, and feeling the need to prove themselves in environments where their competence was questioned. Finally, in response to Research Question 3, participants described the importance of supportive networks of peers, family, and educators to their persistence in STEM. Additionally, resources like scholarships, internships, and research opportunities were helpful in developing professionally.

Summary

Participants from the Legacy Program consistently highlighted the profound effects that it had on their educational and career trajectories, as well as their personal and professional growth. Participants also cited that participating in the program helped them overcome obstacles that they had encountered since completing the program. The personal and contextual challenges experienced by the participants in this study illustrate the multifaceted nature of adversity experienced by Black girls and young women in STEM. The participants' resilience, however, underscores not only their strength but also the importance of supportive, inclusive environments that acknowledge and address those barriers. These results will be further discussed and integrated with the results from Study 2 in the General Discussion (Chapter 6)

CHAPTER FOUR
NATIVE AMERICAN WOMEN IN STEM

Study 2 is an extension of, and was inspired by, Study 1. Native American (Native) women in STEM face similar challenges to those encountered by Black women and girls and are more underrepresented in STEM education and careers than any other demographic. Native Americans comprise 0.7% of the United States population when identifying as Native alone, and up to 1.7% when including those who identify as Native in combination with one or more other races. Despite this, in 2021, Native individuals comprised only 0.3% of the STEM workforce (Connolly & Jacobs, 2020; NCSES, 2021). Because the Native population is a relatively small segment of the US population, limited research has been conducted to understand their experiences in STEM, with most large studies resulting in sample sizes too small to draw any significant conclusions (Faircloth & Tippeconnic, 2010; Ellard-Gray et al., 2015). In addition to the challenges discussed in Chapter 2, which are likely to impact both Black and Native women and girls, complex historical and cultural factors create unique challenges for STEM education in Native students. Chapter 4 provides a brief history of Indian education in the United States, educational research in Native communities, challenges faced by Native students, and recent promising avenues for research on Indian education and support for Native students.

It is also important to provide an explanation for the terminology used within this manuscript to reference American Indians and Alaska Natives, Native American, and Indigenous groups. Although using the term Indian to refer to citizens of Tribal nations within the United States is inaccurate and outdated, the United States government still refers to the original inhabitants of the continental United States and Alaska as "American Indians and Alaska Natives." These individuals are citizens of federally-recognized tribes that have a nation-to-nation relationship with the United States government. Terms such as "Indian Country" (e.g., land within the borders of Indian reservations, Indian allotments; U.S. Environmental Protection Agency, 2024) and "Indian education" (e.g., U.S. Bureau of Indian Education, U.S. Department of Indian Education) are still commonly used and accepted. "Native American" and "Native" are used to describe groups of people that are indigenous to the continental United States and Alaska, United States territories, and Hawaii. Further, the term Native American also includes United States residents who are indigenous to Canada, and Central and South America (U.S. Department of the Interior, 2017). "Indigenous" is sometimes used to refer to Native American people, but could technically include any person or group of people indigenous to any place. The terms "Native," "Native American," "American Indian," and "Indigenous" may be used throughout this manuscript, as well as terms that refer to specific Tribal groups (e.g., Anishinabe, Menominee).

Education and Research in Native Communities

The interactions of Indigenous communities and formal education must be understood within their historical context because, historically, formal education has systematically undermined the sovereignty and rich culture of Tribal nations (Adams, 1995; Bombay et al., 2014). The United States has used systems of education as a means of assimilation, and these systems have not only controlled the education of Native children but also the parenting of Native children. It is also important to note that the majority of research in Indigenous communities throughout history has not been done in the best interest of those communities (Travis, 1980; Segal, 1983; Foulks, 1989; Wolf, 1989; Drabiak-Syed, 2010; Garrison, 2013). Rather, researchers from outside these communities have approached their work by putting the interests of the United States government and their own academic careers ahead of the needs of the communities. Such research practices have led to reinforcing stereotypes and deficit views, misrepresentations of Native traditions and culture, and knowledge extraction without input or control from the communities under investigation. This historical disregard of the perspectives of Native communities contributed to the continuing injustices and deterioration of their identities and sovereignty.

Indian Education in the United States

The history of Native education in the United States is complex and consists of a series of legislation and policies that have had profound impacts on Indigenous communities. Tribal communities have always had systems of education, even before colonial schooling was imposed upon them. Examples of educational systems within Tribal communities include storytelling and oral tradition, land-based and experiential learning, and community-wide participation in the education process. Education was not confined to specific life stages or institutions, it was a lifelong process in which all members of a community played a role. Education involves transmission of knowledge, and it is broader than the settler colonial systems of schooling that usually come to mind (Brayboy & Lomawaima, 2018).

Colonial schooling refers to education systems imposed by the United States government and Christian missionaries, whose goal was to assimilate Native children into

Western, European-American culture. Historically, introduction of colonial school systems, such as with the boarding schools that were operated across the United States and Canada, involved separating children from their families, languages, and cultures, and reliance on manual labor performed by children to run the schools, and the imposition of Western religion (e.g., Christianity) and norms for the purposes of assimilation and cultural erasure. Most discussions of the current state of Indian education and the educational disparities found between Native and non-Native children are incomplete because they separate the education of Native Americans from its distinctive historical context. Viewing Native students as if they were homogeneous with other marginalized minority groups in education overlooks and diminishes the profound impact of historical factors and the principles of sovereignty and self-determination (Brayboy et al., 2015). Some of the greatest harms to Indigenous communities are the result of colonial schooling, including the historical trauma and cultural disconnection that resulted from physical, psychological, and emotional damage to Native children and their families through forced assimilation policies (Adams, 1995; Brave Heart, 2003).

Sovereignty and Treaty Responsibility

Tribal nations within the United States possess sovereignty, establishing a relationship with the federal government on a nation-to-nation basis, while their members hold citizenship in both their Tribal nation and the United States (Brayboy et al., 2015). Throughout the history of colonization, there have been numerous treaties between Tribal nations and the federal government, resulting in the transfer of more than one billion acres of land from Tribal ownership to the United States in return for government protection and provisions, including provisions for education (Brayboy et al., 2015).

According to over 100 ratified treaties between the United States and sovereign Tribal nations, the United States government has a responsibility for the education of Native students. Article VI, of the United States Constitution declares that treaties made under its authority are the supreme law of the land, and therefore hold its same weight (Clinebell & Thompson, 1978). Many of these treaties include stipulations specifically aimed at the education of Native children (Reinhardt & Maday, 2005) and, although some assured the establishment of schools on reservations or financial aid and scholarships for Native children, others were intended to assimilate them.

Treaties addressing education have fallen short of their assurances; due to inadequate funding resulting in educator shortages and substandard facilities, lack of cultural relevance in the curriculum, and absence of established accountability within these treaties (Faircloth & Tippeconnic, 2010; McCarty & Lee, 2014). More recently, laws associated with the United States government's responsibility for Indian education provide federal funding for programs tailored to Native children, grants for Native schools to support cultural and special academic needs, and the empowerment of tribes to determine their own educational and service requirements. Additionally, federal support extends to Tribal colleges and universities and efforts aimed at preserving Native languages within educational institutions, ensuring that educational environments honor and sustain Native culture and Tribal sovereignty (Reinhardt & Maday, 2005; for an overview of the complex tri-lateral responsibility for Indian education shared between federal, state, and Tribal governments see Reinhardt & Tippeconnic, 2010).

Boarding Schools

A substantial shift in Indian education occurred with the establishment of boarding schools in the late 19th and early 20th centuries. The idea behind these schools was to assimilate Indigenous children by forcing them to adopt Euro-American ways of life. The infamous Carlisle Indian Industrial School, established in 1879, with the motto “kill the Indian, save the man,” characterized this strategy (Adams, 1995). These schools sought to eradicate the cultural identity of Native children, contributing to the lasting trauma experienced by Indigenous communities. Children were forcibly removed from their families and communities, were assigned new names, had their hair cut, and were made to wear military-style uniforms. They were also Christianized, trained in gendered labor, forbidden from speaking their languages or practicing their cultures, and severely punished for not following the rules at the schools (Lomawaima, 1994; Adams, 1995; Child, 1998).

Federal policies drastically altered Indigenous education, resulting in lasting harm to Native communities and prompting eventual reform. The 1928 Meriam Report (officially titled “The Problem of Indian Administration”) harshly condemned federal schooling and boarding schools (Brayboy & Lomawaima, 2018). The report described schools that prioritized physical labor, used physical and emotional punishment and abuse, and provided children with inadequate living conditions that resulted in malnutrition and long-term health problems (Brayboy & Lomawaima, 2018). As a result of the publication of the Meriam Report, there was a shift toward understanding the importance of preserving Indigenous cultures and languages in education. The Indian Self-Determination and Education Assistance Act of 1975 was pivotal in allowing tribes more control over their educational systems and recognizing the importance of culturally-relevant education for Native students (Veile, 1989). Nonetheless, by the time the boarding school era aimed at assimilation ended in the 1980s, over 100,000 Native children had attended boarding schools in the United States (Little, 2023).

Educational reforms and policy changes, such as the Indian Self-Determination and Education Assistance Act of 1975, have allowed Native communities to establish and operate their own educational institutions (kindergarten through twelfth-grade [K-12] schools and Tribal Colleges and Universities) despite ongoing challenges, including inadequate and inconsistent funding. Native educational institutions prioritize the incorporation of Tribal history, culture, and language to ensure the holistic academic, social, cultural, and spiritual development of their students. As a result, Tribal communities possess a wealth of expertise regarding effective educational practices for Native students, including the integration of traditional Indigenous language and culture, active community involvement, and the use of observational learning, rather than a reliance on verbal instruction (Deyhle & Swisher, 1997). Unfortunately, although the boarding school era that caused irreparable harm to Tribal communities has ended, the continued imposition of Western beliefs and customs on education remains a problem for Indian education today (Bang & Medin, 2010), as reviewed in the subsequent sections. These ongoing challenges manifest in multiple ways, including declining academic achievement among Native students in later grades, threats to cultural identity, mismatches in learning and cognitive styles, and a critical lack of Native educators and mentors.

Disparities in Indian Education

Educational disparities between Native and non-Native students are rooted in historical factors, including colonization, marginalization, and the establishment of boarding schools. The clash between Native traditions and the imposition of Western values through deliberate attempts at assimilation caused problems in Native communities that have lasted for generations (Garrett & Pichette, 2000). These problems are magnified by the use of deficit lenses that view certain populations as lacking important qualities or abilities, leading to subsequent inequities in educational engagement and achievement. Deficit perspectives overlook the assumption that engagement and achievement are defined by cultural norms or standards, ignoring the diverse ways in which learners engage with and demonstrate knowledge (Bang & Vossoughi, 2016). The presumed deficiencies of Native communities and cultures, and the view that Indigenous ways of knowing are a hindrance to learning science and mathematics (Bang & Medin, 2010) can lead to biased teaching practices and limited opportunities for Native students. Addressing deficit lenses is important for ensuring that research accurately reflects the experiences and abilities of underrepresented populations, avoiding reinforcing stereotypes and inequities.

This section describes some of the findings from historical research, as well as some of the challenges unique to Native students. Earlier research focused on attempting to explain the crossover effect seen in Native achievement (Bryde, 1965; Saslow & Harrover, 1968; Hanemann Lystad, 1972; Martin, 1978; Deyhle & Swisher, 1997; Bang et al., 2007). Other studies have described the impacts of historical inaccuracy in content, the lack of representation for Native students in K-12 and beyond, and challenges such as invisibility, isolation, disconnection, racism, and damaging perceptions about Natives as a group that are held by teachers and other students (Benjamin et al., 1993; Fairweather, 1993; Guillory, 2009; Haynes Writer, 2001; Lopez et al., 2013; Tachine et al., 2017; Masta & Rosa, 2019).

The Crossover Effect

The crossover effect, or crossover hypothesis, is observed when Native students, whose performance was previously as good as or better than their White counterparts, begin underperforming at some point in their education (i.e., they “cross over” to underperforming; Bryde, 1965; Deyhle & Swisher, 1997; Saslow & Harrover, 1968). The timing of this crossover varies, but it is usually observed in the latter part of their K-12 education, does not reverse, and lasts as long as they are in school. Some research suggests that this crossover effect is due to cultural conflict experienced in adolescence, when negative self-esteem and questions about identity also arise (Hornett, 1990). Indeed, reinforcing Native identity and affirming Native self-esteem seems to protect Native students from this crossover effect, which is less likely to occur in institutions where Native culture, language, and identity are supported (Reyhner, 2017).

The evidence of this crossover effect, originally found in a group of Sioux students (Bryde, 1965), has been contested by some researchers. Havighurst (1970) argues that the initial tests of the fourth-grade Sioux students included many children who were already older than typical fourth-grade students and would therefore likely have higher achievement than expected for a typical fourth-grade student. Furthermore, although Native children probably do struggle with issues of identity and self-esteem at the onset of puberty, their educational achievement is likely affected by environmental factors that begin earlier in their lives. Despite these criticisms, evidence still suggests that students from lower socioeconomic backgrounds and those experiencing cultural changes are more likely to encounter the issues of identity and alienation suggested in Bryde's (1965) crossover hypothesis (Hanemann Lystad, 1972). One study of children across 22 different schools in Oklahoma found that Native students scored lower on measures of self-esteem than their White counterparts at eighth and twelfth-grade levels, but not at fourth-grade levels (Martin, 1978). More recent research found that in the fourth-grade, approximately half of Menominee children demonstrated proficiency levels in science, compared to the national average of 27%; however, by eighth-grade, this proportion significantly declined, with only 17% demonstrating proficiency levels (Bang et al., 2007).

Native Identity and Academic Achievement

In the 1980's, the National Institutes of Mental Health (NIMH) funded The Flower of Two Soils, a study that followed 200 Native children at four different schools over three years (Sack et al., 1987). Sack and colleagues (1987) observed high achieving children were more specific about their responses to the question of what they wanted to be when they grew up, and scored higher on the Wechsler Intelligence Scale for Children Revised than low-achieving children, but these two groups did not differ on the Draw-A-Person test. The Draw-a-Person test asks children to draw three pictures, including a man, a woman, and themselves, and is a non-invasive way of inferring children's cognitive developmental levels without the influence of language barriers (Harris, 1963). This lack of a difference in scores for the Draw-A-Person test, contrasted with differences in intelligence scores using the Wechsler Intelligence Scale for Children Revised suggests that disparities in academic achievement and standardized test scores may not reflect underlying cognitive ability, but rather external factors such as cultural incongruence or educational context, highlighting the need for culturally appropriate measures that account for diverse ways of thinking and learning. Additionally, Sack and colleagues (1987) observed that high achieving students were more likely than low-achieving students to have mothers with two more years of formal education, two-parent households where both parents were employed, a large family social network, and parents who were acculturated but also strongly identified with the values and traditions of their Native group. This connection between cultural identification and higher academic achievement supports the idea that a strong sense of cultural identity serves as a protective factor, providing Native children with a foundation that contributes positively to their educational success.

If identification with Native culture is relevant for educational achievement, one can conclude that Native children begin to encounter barriers to high achievement in their K-12 education within the colonial school system; these barriers include a lack of exposure to Native language, culture, and representation. The National Indian Education Study, which oversamples Bureau of Indian Education schools to obtain a nationally representative sample of Native students, found that among educators teaching Native students, 77-79% of fourth- and eighth-grade teachers are White, 77-80% do not incorporate any traditional Native language into their instruction, and 70-72% are unaware of Native standards or content (Lopez et al., 2013). This lack of cultural representation in the curriculum and among educators contributes to a sense of alienation and disengagement among Native students. Although progress has been made in centering Indigenous knowledge in education in some areas, sometimes even when good intentioned attempts are made to provide accuracy, the curriculum in K-12 education predominantly emphasizes historical perspectives that depict Natives as hostile and primitive; justifying the harms that were perpetrated by settlers (Masta & Rosa, 2019).

Native students have also not seen the same improvement in educational achievement that other groups have seen despite United States policies aimed at equitable education (Brayboy & Lomawaima, 2018). The National Assessment of Educational Progress (NAEP), which takes place every 2 years, showed a worrisome trend for Native students' reading and math scores as compared to other minority (Black and Hispanic) students: between 2000 and 2022, Native American's eighth-grade reading scores improved by 3 points, compared to 7 and 8-point improvements for Black and Hispanic students, and eighth-grade math scores for Native American students decreased by 3 points, compared to a 1-point decrease for Black students and a 4-point increase for Hispanic students nationally (National Center for Education Statistics; NCES, 2022).

Native students also have some of the lowest graduation rates and rates of persistence in college (Benjamin et al., 1993; Faircloth & Tippeconnic, 2010). The dropout rate has been described as a crisis, with less than 50% of Native students graduating from high school in states with high populations of Native students (Faircloth and Tippeconnic, 2010). Another study found that out of 166 Native students who enrolled at a medium-sized state university, 26 (16%) of the students had graduated by the end of the six-year study period (Benjamin et al., 1993). At the time this study took place, 40% of students enrolling in college nationally graduated in four years. Benjamin and colleagues (1993) also found that their Native sample was different in that many of the students who ranked high in their high school graduating classes did not persist in college, and an equal number of students with high and low ACT scores did not persist in college. Therefore, measures that are typically used for college admission, were not predictive of college persistence for Native students.

To better understand the factors that led to Native persistence, Benjamin and colleagues (1993) interviewed eleven Native students who had persisted through college. Participants who persisted in college indicated a cultural and familial responsibility and personal need to visit home. Despite the possible detrimental effects on their educational achievement due to increased time away from coursework, participants balanced the need to go home with their academic obligations, and indicated gaining motivation and support for their academic pursuits during their visits (Benjamin et al., 1993). Further, persisters indicated that they had decided they wanted to attend college early in life and saw themselves as able to adapt to the college environment while holding onto their traditional viewpoints (Benjamin et al., 1993). These findings suggest that common measures of academic readiness fail to capture the unique factors that influence Native students' persistence in college. The disproportionately low graduation rates among Native students indicate a need for processes that account for cultural commitments and the importance of family and community affiliations.

There is also a disconnect between perceptions about Native persistence, and the factors influencing persistence reported by Native students (Guillory, 2009). College and university faculty perceive that Native students' persistence is determined by their financial situations and the programs offered at their institutions, whereas Native students at the same institutions report that giving back to their communities, family support, and social support on campus are the major factors influencing their persistence (Guillory, 2009).The desire expressed by many Native students to give back to their communities are related to the communal values of Native culture that prioritize collective well-being over individual interests (Guillory, 2009). Tachine and colleagues (2017), conducted sharing circles with Native first-year college students at a non-Native university to examine experiences that impact belonging and persistence in college. These first-year students' sense of belonging was adversely affected by experiences of isolation, disconnection, stress, and racism. Conversely, the presence of supportive families and communities, and access to Native campus spaces, such as Native student centers, positively contributed to encouraging their sense of belonging in college (Tachine et al., 2017).

Representation and Academic Success

Native college students lack representation on most college campuses and, consequently, also lack opportunities for race-matched mentorship (less than 0.4% of faculty members on college campuses are Native; NCES, 2023). This lack of Native faculty impacts both Native students and the success of Native faculty themselves, as they may find themselves overwhelmed with excessive service roles, including mentoring and supporting Native students. Such service roles are important to Native students, but are undervalued in decisions about tenure and promotion and can result in long-term disadvantages for Native faculty, both in terms of rank advancement and overall financial stability. Indeed, across various types of academic institutions, non-minority assistant professors command higher salaries than their minority counterparts, and faculty dedicating more time to service-related activities then receive lower salaries than those who are less involved in activities such as student advisement (Fairweather, 1993).

The lack of Native representation in higher education affects how Native identity is perceived by both Native and non-Native students and communities. The scarcity of Native faculty contributes to the invisibility of Native identity in educational institutions, which in turn leads to a decreased presence of Native students (Haynes Writer, 2001). Underrepresentation of both Native students and educators perpetuates stereotypes and misconceptions about Native identity. When non-Native educators and students lack experiences with Native individuals in educational contexts, they do not have the opportunity to understand the complex nature of Native culture. This can lead to further isolation and more barriers to belonging, academic engagement, and academic achievement for Native students.

Stereotypes and misconceptions about Native culture and identities persist. When undergraduate students are asked to describe cues to Native identity, they use descriptors like long, straight, black hair, braids, dark eyes and skin, and jewelry. Further, the words that these students used to describe images that came to mind when thinking about Native identity included stereotypical items and traits, such as turquoise, feathers, moccasins, arrows, alcohol, buffalo, horses, reservations, casinos, loyal, somber, and drunks (Haynes Writer, 2001). Such stereotypes contribute to unwelcoming environments that affect motivation and achievement, reinforcing the cycle of underrepresentation for Native individuals.

Differences in Learning and Cognition

Research exploring the variations in cognition and learning styles between Native children and non-Native children has shed light on ways that aspects of education can be better tailored to teaching Native children. Some of these differences are influenced by cultural values and include preferences for collectivism and cooperation over individualism and competition, importance of context in understanding concepts, dependence on visual learning, reflective tendencies, and interconnectedness with nature (McShane, 1983; Pewewardy, 2002; Bang et al., 2007; Kisker et al., 2012; Bang et al., 2014).

Native cultures are collectivistic and value cooperation, which significantly impacts behavior management and motivation in the classroom. Effective behavior management strategies for Native students may differ from those for non-Native students, as Native cultures often emphasize explaining behavioral expectations in terms of community benefits rather than relying on punishment or external rewards (Pewewardy, 2002). Although the use of punishment or external rewards may be less effective across cultural groups, framing behavioral expectations in terms of community benefits is particularly culturally significant for many Native students, for whom relational accountability and collective well-being are central to socialization. These collectivistic values also include a preference for cooperation over competition in classroom settings (McShane, 1983; Pewewardy, 2002). For instance, Native cultures measure wealth by what can be shared with others, in contrast to White culture's measure of wealth in terms of what one can accumulate for themselves. As a result, Native students may feel uncomfortable being singled out for good performance and less motivated by competitive assessments, strategies that inspire non-Native students (Pewewardy, 2002). Native students' learning styles are also influenced by their group- and family-oriented cultures, which prioritize interconnectedness and relationships. Recognizing these distinctions is essential for developing culturally responsive educational practices that align with Indigenous worldviews.

One notable difference in cognition is their tendency for field-dependence, a cognitive style in which learners rely on external and contextual cues to understand information, integrating relationships and patterns within the environment. This contrasts with field-independence, where students can easily separate details from surrounding context and analyze them in isolation (Pewewardy, 2002). This tendency for field-dependence reflects the interconnectedness of life and its various relationships seen in Indigenous knowledge systems. In Native cultures, children learn by observing family members or elders, performing better in classrooms that incorporate visual teaching strategies and techniques (for an example see the Math in a Cultural Context curriculum discussed in Kisker et al., 2012). Incorporating visual learning can be challenging in conventional classrooms that predominantly employ oral instruction methods (Pewewardy, 2002). Native children also tend to exhibit a reflective approach to learning, waiting until they have gathered all the necessary evidence before reaching a conclusion and producing a response—a behavior that may be misinterpreted by teachers in Western classrooms as inattention or lack of engagement (Pewewardy, 2002).

There seem to be significant differences in the cognitive processes of Native and non-Native individuals, particularly regarding their perceptions of the natural world (Bang et al., 2007). For instance, studies on the mental models of Menominee and

European American children and adults found that young Menominee children are much less likely than non-Native children to draw distinctions between humans and animals, and more likely to apply characteristics observed in animals to humans (Bang et al., 2007). Categorization processes also seem to be impacted by culture. For example, in a fish classification task, Menominee fish experts sorted fish according to ecological factors associated with habitat and the whole lifecycle of the fish, while non-Native fish experts sorted fish according to human goals associated with adult fish, such as commercial and recreational fishing (Bang et al., 2007). Native individuals also seem to understand nature in a way different from non-Native individuals. When asked about nature, non-Natives often emphasize the necessity for human protection of nature and name outdoor activities where nature serves as a backdrop, such as playing sports, boating, or working outdoors. Conversely, Menominee individuals are more inclined to perceive humans as components of nature and name outdoor activities where nature is central, such as hiking, hunting, or gardening (Bang et al., 2007). This nature-culture divide significantly affects Native students in science education. Western science, with its emphasis on objectivity and detached observation, often conflicts with Indigenous ways of knowing, which stress interconnectedness and holistic understanding. As a result, Native students may feel marginalized and disconnected in classrooms that do not integrate their cultural perspectives, hindering their learning experiences and opportunities to excel.

Native students have distinct cognition and learning styles shaped by their cultural values, such as collectivism, cooperation, and interconnectedness with nature (McShane, 1983; Pewewardy, 2002; Bang et al., 2007; Kisker et al., 2012; Bang et al., 2014). As a result, they may not benefit from the individualistic and competitive nature of Western school settings. These cognitive and learning differences have important implications for effective teaching methods and behavior management. Understanding and integrating Indigenous perspectives can create more inclusive and supportive educational environments, encouraging better learning outcomes for Native students.

Changes in Research on Indian Education

Throughout history, researchers have often had a paternalistic attitude when working with Indigenous communities, believing that European American culture was superior to Indigenous culture. This led to research being conducted without coordinating with the communities being researched and often without consent. Research was guided by external priorities instead of addressing the actual needs and concerns of the communities being researched. This legacy of research in Indigenous communities has reinforced power imbalances and led to Native communities mistrusting researchers to this day. Research methodologies have also historically failed to recognize the uniqueness and diversity of Tribal nations, resulting in negative representations of Native communities, perpetuation of harmful stereotypes, and a view that Native communities are homogeneous rather than each representing a unique culture. Results of research on Indigenous peoples, as well as other minorities, have also been used to reinforce discriminatory policies and justify actions that have been harmful to the communities studied (Travis, 1980; Segal, 1983; Foulks, 1989; Wolf, 1989; Deyhle & Swisher, 1997; Lomawaima, 1999; Drabiak-Syed, 2010; Garrison, 2013).

Early research on Indian education was primarily done by non-Native researchers and focused on how to encourage Native students to adopt a Western perspective in learning science and mathematics. Indeed, research focusing on the need for educators to understand and accept Indigenous ways of knowing as valid was scarce until relatively recently (Barnhardt & Kawagley, 2005). Indigenous students can benefit from understanding a Western perspective of science and mathematics, but not to the detriment of their own knowledge and the ways in which they have gained that knowledge. Awareness of these issues has led to more ethical and inclusive research in Indigenous communities today (Ferreira & Gendron, 2011; Koster et al., 2012). Efforts are being made to engage in collaborative research involving the communities being studied and taking community perspectives into account. The goal of this community-based research is to move away from the history of exploitation and to establish true partnerships with the communities being studied, which respect the sovereignty, culture, and best interests of those communities (Bang & Medin, 2010). Community-based research incorporates Native communities and ways of knowing into its methodology and recognizes the importance of Native science and Indigenous epistemologies, leading to improvements in culturally-responsive education.

Incorporating Indigenous Ways of Knowing and Culture into Education and Research

Native communities have always had their own rich systems of knowledge and education. Specifically, Tribal communities have deeply rooted ecological and scientific knowledge and methods of sharing knowledge immersed in cultural practices and community life, including oral tradition or storytelling. This knowledge emphasizes the interconnectedness of living things and the importance of relationality in the learning process. Unfortunately, these ways of knowing have been undervalued in Western school settings and, although there are benefits to incorporating Indigenous ways of knowing, language, and culture into education, such incorporation is still lacking.

Cajete (2012, pp. 109-110) defines Indigenous Science as the “body of traditional environmental and cultural knowledge unique to a group of people which has served to sustain that people through generations of living within a distinct bio-region.” Indigenous (or Native) Science is also sometimes referred to as traditional ecological knowledge, as much of it was used to ensure the survival of Indigenous groups in the natural environments in which they lived (Cajete, 2000). Indigenous science continues to be critical as a holistic and sustainable approach to know and connect with the land and its ecosystems and to preserve ancestral knowledge. Throughout history, traditional knowledge has informed a variety of subjects including astronomy, mathematics, agriculture, medicine, justice systems, navigation systems, engineering, and technology (Pleat, 2012). Native science is participatory; it is based on the knowledge gained through participating with nature in a given place over generations, involving families, elders, and the whole community (Cajete, 2000). Storytelling is an important aspect of Indigenous knowledge systems, as a way to make sense of the world by weaving insights about science and nature with cultural lessons (Tzou et al., 2020). Incorporating traditional storytelling and learning activities that are in line with Indigenous practices can make science and mathematics more relatable for Native students, and can serve to create a more inclusive and effective classroom.

Within Western scientific discourse, there is an inclination to view alternative knowledge systems in a condescending manner (Pleat, 2012). Western science is commonly perceived as entirely objective; however, the inquiries and directions of research are shaped by the problems, perspectives, and values of the scientists' cultural context (Pleat, 2012). Further, the significant contributions of Indigenous peoples to mathematics and science are frequently overlooked, erased, or seen as inadequate. Often, these contributions are disregarded or undervalued within the broader mathematical and scientific fields, as well as viewed as solely historical achievements that are disconnected from contemporary Indigenous communities (Barajas-López & Bang, 2018). For instance, extensive agricultural knowledge, including companion planting techniques, such as the "Three Sisters" method of planting beans, corn, and squash together, is often viewed as an antiquated practice. However, the "Three Sisters" method has recently gained greater recognition as an environmentally sustainable environmental practice that provides insight for modern agriculture and food security (Kapayou et al., 2022). This suggests that Western science should consider the value of incorporating traditional knowledge systems and the benefits of expanding beyond settler-colonial epistemologies in learning environments.

Benefits of Incorporating Indigenous Ways of Knowing into Research and Education

Research

Research incorporating a community-based design involves collaboratively engaging with local communities to develop and implement educational strategies that are culturally relevant and responsive to their unique needs (Bang et al., 2014). An added benefit of community involvement in research is providing opportunities for individuals who are past school-age to engage in STEM activities and learning (Bang & Medin, 2010). Researchers engaging in community-based participatory action research might work in partnership with Native communities to improve educational outcomes for students in their schools. This approach emphasizes the active involvement of community members, educators, and researchers in co-designing educational interventions that honor Indigenous knowledge, traditions, and values by engaging community members as equal partners throughout the research process–from identifying research questions to dissemination of results–in ways that empower communities to address their own needs and challenges. Community-based participatory action research, a research framework widely acknowledged as an effective approach for research with Native communities, emphasizes collaboration, reciprocity, and respect for Indigenous ways of knowing and traditional values (Bang & Medin, 2010).

Education

Research implementing Indigenous ways of knowing often immerses students in activities that they would regularly encounter, promoting integrated and contextual knowledge that leads to a deeper understanding of scientific concepts (Bang & Medin, 2010). Integrating Indigenous perspectives into science education has been shown to increase student engagement and comprehension (Bang et al., 2014), suggesting that learning environments recognizing the cultural contexts and interconnectedness Native students bring to science not only validate their identities but also enhance their overall learning outcomes. Educational researchers refer to these cultural and experiential resources as "funds of knowledge"–the skills, practices, and understandings that historically marginalized groups carry with them into the classroom (Moll et al., 1992). For Native students, these funds of knowledge may include traditional ecological knowledge, storytelling, language, and cultural values rooted in community and family life. Recognizing and incorporating such knowledge into classroom instruction counters deficit-based perspectives and affirms students' cultural identities. By drawing on students' home-based knowledge and experiences, educators can create more inclusive and effective learning environments that promote engagement, belonging, and academic success (Moll et al., 1992).

Students can effectively integrate both Western and Indigenous ways of knowing, demonstrating an integrated understanding of the world around them. When given pictures of objects, including plants, animals, minerals, water, and artifacts, Native middle school students will answer the question of "which objects are living" differently based on the context. When asked what objects a science teacher would consider alive they will answer that the plants and animals would be considered alive, but when asked what an elder would consider alive they will include the minerals and water in addition to the plants and animals (Bang & Medin, 2010), showing how children are able to move between Western scientific and Indigenous knowledge systems.

Recognizing Native students' distinct cultural backgrounds and learning styles can help to promote a culturally-responsive learning environment. Incorporating Indigenous knowledge, traditions, and languages into the curriculum can enhance academic achievement and success for Native students. Integrating culturally relevant content in science and mathematics education can impact the learning outcomes of Native students (Bang et al., 2014; Tzou et al., 2020).

The method of culturally responsive teaching, according to Gay (2018), is one that emphasizes incorporating different cultural perspectives into its lessons and activities. It takes into consideration and honors the cultural backgrounds of its pupils by incorporating their values, customs, and experiences into the curriculum. This approach establishes a learning atmosphere that welcomes and affirms the experiences of students, particularly those from historically marginalized groups. To promote academic achievement and support a sense of belonging, educators must modify their teaching methods, materials, and assessments to suit the cultural diversity of their students, while recognizing their individual strengths (Gay, 2018). Incorporating culturally responsive practices into teaching science and mathematics to Native students is a promising method of addressing educational disparities, and promoting academic engagement and achievement. By recognizing Indigenous knowledge and integrating it into the curriculum, educators can create more inclusive and effective learning environments that empower Native students to thrive academically and culturally. The appreciation of culturally responsive epistemologies is a significant shift away from the deficit lens, which focuses on perceived weaknesses rather than the assets that marginalized students bring into the classroom.

Culturally-Integrated Curriculum. Math in a Cultural Context (MCC), is a curriculum created by integrating Alaska Native culture into math lessons, and has shown promising results for increased academic achievement for children in Alaska (Kisker et al., 2012). Kisker and colleagues (2012) conducted a randomized controlled trial of 50 rural and urban schools across Alaska and found that the MCC curriculum for teaching second-grade mathematics concepts significantly increased the performance of both Alaska Native and non-Alaska Native students. Performance increases in measurement, representing data, grouping, and place value ranged from 8.39% points to 16.02% points. Incorporating Native knowledge can have a profound impact on minority students, even when they are not themselves Native. Another study, taking place across four different universities (two research universities and two Tribal universities), used a hybrid course to examine the impact of Indigenizing a biochemistry course (Alkholy et al., 2017). The intervention group was co-taught by PhD lecturers and non-PhD Indigenous elders and the control group was co-taught by PhD lecturers. Additionally, the Indigenous elders included a lecture on traditional medicine and selected medicinal plants, as opposed to PhD lecturers who included a lecture on secondary metabolism and selected medicinal plants. Alkholy and colleagues (2017) found that students in the intervention group reported a higher interest in science post-treatment than did those in the control group, whether the student was White or racial minority. Further, pre-treatment, racial minority students identified less strongly as scientists than White students, but post-treatment with Indigenous elders as co-lecturers, there was no difference between racial minority students and their White counterparts in science identification.

Augare and colleagues (2017) examined data from three Native Science Field Centers (NSFCs), located in the United States, that were designed to engage Native students in STEM by blending Indigenous ways of knowing and language with conceptions of Western science. They found that Indigenous students who participated in NSFC programming were more likely to later engage in extracurricular science-related activities, as well as had acquired increased knowledge about the traditional uses and value of plants and animals, critical thinking, scientific inquiry and data collection, technology, and the contribution of their cultures to science. The knowledge and skills gained from their participation in NSCFs and their relationships with mentors gave the students confidence in their STEM abilities (Augare et al., 2017).

Storytelling. Native creation stories demonstrate valuable insight concerning human connections to the natural world (Pleat, 2012). In their participatory design research project, Tzou and colleagues (2020) ran a robotics workshop for families that was based on storytelling. Families used multiple technologies strategically, to tell stories that included important cultural lessons and land-based knowledge. Researchers observed families using their stories to teach lessons about places and lands that are important to them, using robotics and materials to provide accuracy to their stories, and working across different knowledge systems (Indigenous, Western science and engineering, and family-based) to build their stories. Another summer program for Indigenous youth highlighted the ways in which storytelling supports learning (Marin et al., 2020). McDaid Barry and colleagues (2023) explain how within their program, traditional stories served multiple purposes. Stories were used as a tool for teachers, while youth within their program used them to make sense of concepts and connect with one another. Stories helped learners understand changes in plants and the land associated with climate change, provided frameworks to support learning and contextual understanding, and supported the development of learners' identities and their understanding of reciprocal relationships with the natural world (Marin et al., 2020).

Health and Wellness. The impacts of a culturally responsive classroom go beyond just educational achievement. The positive impact of learning environments that embrace and value Indigenous language and culture can lead to other positive effects such as positive cultural affect and increased ethnic identity which have been shown to contribute to improved physical and mental health for Native youth (Middlebrook et al., 2001; Fleming & Ledogar, 2008; Gracey & King, 2009; Currie et al., 2013; Reyhner, 2017). Native communities recognize the interconnectedness of physical, mental, and spiritual health, acknowledging that they holistically contribute to overall wellbeing. Ceremonies and practices, such as smudging and sweat lodges, cleanse and purify the mind, body, and spirit. Such practices are essential for a strong sense of identity and belongingness that contribute to positive mental health outcomes. Furthermore, the incorporation of traditional languages in the classroom is intricately connected to the value systems of traditional cultures, with research reporting students in language immersion programs exhibit more discipline, respect, and better communication with their families and elders (Reyhner, 2017).

Social support systems, including strong ties to family and community, are pivotal in promoting health and wellness. Elders serve as invaluable mentors, passing down traditional knowledge and wisdom that help youth navigate the challenges they encounter. A holistic approach to health and wellness, encompassing traditional food, spiritual practices, and community engagement, contribute to resilience and aid in navigating the complexities of life while remaining connected culturally.

Indian Education Today

The Meriam Report started a shift toward understanding the importance of preserving Indigenous cultures and languages in education. The Indian Self-Determination and Education Assistance Act of 1975 was pivotal in allowing Native tribes more control over their educational systems and recognizing the importance of culturally relevant education for Native students (Veile, 1989). Unlike traditional schools, Native educational institutions prioritize the incorporation of Tribal history, culture, and language in order to ensure the holistic academic, social, cultural, and spiritual development of students. As a result, Tribal communities organically incorporate culturally-relevant practices that are proven to increase educational achievement in Native students (Deyhle & Swisher, 1997).

Programs implementing the values of Indigenous communities have seen great success. Brayboy and Lomawaima (2018) highlight three such programs. In Alabama, Calcedeaver Elementary School has a large population of Native students (87%) and many of their students also qualify for free or reduced lunch (90%). However, after working to improve their math and reading instruction and integrating Choctaw language and cultural resources into the school, all of the elementary students have achieved proficiency in mathematics, and 91% have achieved or exceeded proficiency in reading (The Education Trust, 2024; Brayboy & Lomawaima, 2018). In Arizona, Puente de Hozho Elementary School immerses their students in either Navajo or Spanish, eventually moving them into English. Regardless of regularly speaking and learning in Navajo or Spanish, they exceed the performance of many other schools in Arizona on standardized tests (Brayboy & Lomawaima, 2018). At Arizona State University, the Pueblo Doctoral Cohort Program is grounded in the development and strengthening of Tribal nations by incorporating courses focused on addressing challenges in Tribal communities. Students in the program have successfully graduated with doctoral degrees and even drafted policy briefs that have been enacted (Brayboy & Lomawaima, 2018; Terrill, 2018).

These successes, however, do not reflect a widespread trend in Indian education. Lopez and colleagues (2013) used results of the NAEP and the National Indian Education Study (NIES) to examine the association between American Indian/Alaska Native academic performance and cultural experiences. The NIES collected experiences of Native students in the United States regarding incorporation of their language and culture into their school curriculum, all of which are key components of culturally-responsive education (Gay, 2018). Lopez and colleagues (2013) found that those key aspects of culturally-responsive schooling were lacking for a large proportion of Native students.

Although Indigenous communities have always been scientists and have a wealth of traditional ecological knowledge, Native students are the most underrepresented group in scientific fields of study (Chow-Garcia et al., 2022). Recently, Chow-Garcia and colleagues (2022) used mixed methods (surveys and interviews) to explore the cultural and science identity, science self-efficacy, and intent to persist in science of Native high school through graduate school students participating in culturally-adapted summer research internships. To examine students' experiences in science, they interviewed a small subset of their sample. The survey results indicated that a strong science identity predicted higher science self-efficacy, intent to persist in science, intent to have a career in science, and a strong Native identity. The interview results revealed that the participants' identities as scientists were inseparable from their Indigenous identities. Further, some themes that emerged in the interviews included belonging, mentoring and support, science and Native identity, community, and giving back (Chow-Garcia et al., 2022). The relevance of intersectionality, as discussed in Chapter 1, is important to understanding how the intersection of Indigenous and scientific identities shape Native students' experiences in scientific fields.

Despite attempts by the United States government to better understand the state of Indian education, research on the experiences of Native students is still lacking. Small populations make large representative samples difficult to obtain, and many researchers cite the importance of qualitative methods in better understanding Native students and establishing knowledge in under-researched areas (Lopez, 2018; Rasmussen, 2023). There remains a need for more qualitative research that can provide nuanced information about the achievement and engagement of Native students in STEM, among other subjects. A systematic review of the literature on the persistence of Native students in college suggests that different factors that emerge from qualitative research are difficult to observe in quantitative research, such as Indigenous students' motivations to give back to their communities (upon completion of their degrees), the impact of family support, and the impact of community support (Lopez, 2018). These findings suggest that unique benefits remain for engaging in qualitative research on the topic of academic achievement by underrepresented populations, including a deeper understanding of their lived experiences.

There is research to show that some of the factors experienced by Black women in STEM and computer science (discussed in Chapter 1) extend to Native women in STEM (Lopez, 2018; Chow-Garcia et al., 2022). However, much less research exists examining this topic with Native women and, given the unique historical and cultural factors impacting Indian education, many questions remain. Further, lack of research often leaves Native students as "asterisk people" in studies that are unable to obtain large enough numbers of Native participants, as well as studies that have not taken into account best practices for working with Native populations (Faircloth & Tippeconnic, 2010). In Study 2, we examine the narratives and experiences of Native women, in an effort to elucidate the experiences of another intersectionally-underrepresented group in STEM. In

Study 2, we will not only explore challenges and successes of Native women, we will also explore how cultural factors play into their experiences.

Indigenous Research Methodologies

When working with Native populations, it is important to refer to the work of other Indigenous scholars. Indigenous research methodologies emphasize the act of locating oneself as a researcher, which involves recognizing and embracing one's own cultural background and position within the Indigenous community. This practice is crucial for building trust and conducting ethical and culturally sensitive research (Absolon & Willett, 2005; Kovach, 2009). Unlike Western scientific methodologies that insist on separating the researcher and the subject to maintain objectivity, Indigenous methodologies recognize the interconnectedness of the researcher and the community, and acknowledge that a researcher's background informs their research process (Brayboy & Castagno, 2008).

For more information on Indigenous research methodologies, refer to the significant works of Wilson (2001), Kovach (2009), and Masta (2018; 2022). The situated knowledges that arise from the standpoint of marginalized subjects, including women and traditional cultures, begin with methods that center the experiences of these subjects (Haraway, 1991; Harding, 1991, 2008; TallBear, 2014). Masta (2022) emphasizes the importance of using Indigenous methodologies, such as Red Pedagogy and Tribal Critical Race Theory, in educational research involving Indigenous populations. These methodologies honor Indigenous knowledge systems, engage the communities being researched, and provide a deeper understanding of Indigenous students' experiences that cannot be fully understood by quantitative research methods alone (Masta, 2022). The use of Indigenous methodologies in educational research is essential for decolonizing educational spaces, which involves challenging and changing systems built around Western values and perspectives so that Indigenous students are not forced to conform to systems that were not created with their cultural perspectives and needs in mind.

Incorporating Indigenous culture into the research process is also beneficial for those working with Indigenous communities. As an example, Masta (2018) illustrates how she applied the Seven Grandfather teachings of her Anishinaabe culture to her research career: relying on Native knowledge from the inception of her work, interacting meaningfully with the communities being researched, giving back to participants in the same way that participants give to her, respecting participants, communities, and Native ways of knowing, taking on risk in decolonizing research methods, honestly interpreting and representing participants, recognizing participants for their role in creating knowledge, and maintaining trust with the participants and communities involved (Masta, 2018). By integrating these teachings, researchers can conduct studies that are not only academically rigorous but also culturally respectful and beneficial to Indigenous communities.

CHAPTER FIVE
STUDY 2

Study 2 sought to extend the findings from Study 1 to a sample of Native women in STEM education and careers. Interviews were similar to those conducted in Study 1, with the exception of questions directly related to participation in the LEGACY project. Questions were also tailored to participants who might be further along in their career trajectories. Further, interview questions were informed by research questions specific to Native populations (See below and Appendix B).

Research Questions

Research Question 1: Where do the experiences of high achieving Native women in STEM education and careers fit within the research frameworks of culturally responsive education and community-based science education?

Research Question 2: How have traditional knowledge and Indigenous science epistemologies been incorporated into the learning of high achieving Native women?

Research Question 3: How do the experiences of high achieving Native women compare to the experiences of high achieving Black women in STEM?

Methodology

Participants

Participants in Study 2 were 10 STEM students or professionals working in a STEM field or another career that relied heavily on computing at the time of the interviews. Participants were all 18 years of age or older, Native women. Participants were recruited through social media and word of mouth. A social media post led interested participants to a demographic screener survey, which was used to reach out to eligible participants. Emails were also sent to targeted faculty members at colleges, universities, and teaching clinics asking them to share the study information with students who might be interested and eligible to participate. Participants reached out to the Principal Investigator by email to set up a time to meet virtually if they were interested.

Data Collection and Analysis

Interviews were conducted online via Zoom Virtual Meetings. All interviews were conducted by the PI, a Native female graduate student. Semi-structured interviews included questions about what participants were currently doing in their educational and professional lives, changes in their educational or career tracks, challenges they had encountered throughout their education or career, what they envisioned for their future educational or professional lives, if and how aspects of their Indigenous cultural backgrounds were incorporated into their STEM education or career, and questions specific to their racial, gender, and STEM identities (See Appendix B). Interviews lasted between 15 and 98 minutes and were recorded and transcribed using Zoom Video Communications software. Upon completion of the interviews, transcripts were checked for accuracy and de-identified by the research team and recordings were deleted to maintain confidentiality. Data were analyzed as described for Study 1.

Results

Table 7 presents the major characteristics of the 10 participants in this study. Each participant was assigned a pseudonym, which will be used to identify their statements.

Table 7
Participant Pseudonyms and Characteristics (Study 2)

Pseudonym	**Occupation at the Time of Interview***
Megan	College student pursuing a computer science degree/IT services coordinator at a higher education institution
Jennifer	Lead IT engineer at a regional company
Tiffany	Senior-level IT specialist at an international tech company
Stephanie	PhD student/Learning design specialist at a higher education institution
Melissa	Student pursuing a graduate degree in educational technology/IT systems engineer at a higher education institution
Nicole	College student pursuing a chemistry degree
Amanda	Student pursuing a graduate degree in Wildlife Biology/Intern at a nonprofit organization focused on conservation
Jessica	College student pursuing Biochemistry and Molecular Biology/Barista at a coffee shop
Mary	Medical resident with a graduate degree in engineering and previous experience working in a national research laboratory
Heather	PhD student in Medical Physics with experience working in a national research laboratory and federal defense agency

*Note: Some details have been omitted to ensure participant confidentiality.

Participants in Study 2 shared diverse experiences that reflected the unique intersections of their identities as Native American women in STEM. Their narratives highlighted not only the academic and professional aspects of their journeys, but also the cultural and community-based influences that shaped their educational pathways. Participants emphasized the importance of both institutional and personal support systems that helped them persist through barriers in often unwelcoming and isolating

STEM environments. These sources of support encompassed family, mentors, and culturally relevant practices that affirmed their identities.

Their narratives also shed light on the diverse and nonlinear career pathways that participants followed, frequently shaped by a combination of personal values, community and familial responsibility, and opportunities that aligned with their long-term goals to give back to their communities. Many participants described how their worldviews and commitments to their Tribal communities guided professional decisions and goals in STEM fields.

Participants also spoke about the personal and contextual challenges they faced as developing professionals, including racism, sexism, isolation, and caregiving responsibilities that complicated their educational and career trajectories. Despite these challenges, participants demonstrated resilience and adaptability in achieving their goals.

The themes that emerged in Study 2 were organized into four different groups. The first group of themes includes personal and contextual challenges faced by participants in their educational and professional journeys. Similar to Study 1, many themes emerged that were specific to needs and sources of support, which makes up the second group. The third group includes themes associated with personal and contextual challenges that participants faced in their educational and professional journeys. The final group of themes diverges from those found in Study 1 and relates specifically to participants' Native identities and reflections on culturally relevant experiences in education. Table 8 outlines the major themes found in Study 2.

Table 8
Major Themes (Study 2)

1. Needs and Sources of Support (R3)*
2. Career Pathways (R1, R2)
3. Personal and Contextual Challenges (R3)
4. Identity and Indigenous Education (R1, R2)

*Note: Each theme is followed by the corresponding research question in parentheses.

Some participants described the nature of STEM as somewhat incompatible with their identity. Megan, a third-year computer science student described computer science in relation to her identity, stating that "regarding Native identity, it's kind of cold and robotic—this field, whereas I'm not that kind of person. So, I mean some things I really enjoy about this field, but other things, they're so cold and rigid that I don't enjoy them, and I don't agree with them." Later, she described how pursuing computer science took time away from other parts of her life that are important to her identity, stating "I really do like working with people and [...] sometimes I do feel like I'm abandoning some things because I'm working full-time. I don't feel like I can enrich myself in cultural stuff as much. Sometimes that makes me feel like [...] I'm missing out."

Needs and Sources of Support

Table 9
Needs and Sources of Support (Study 2)

Theme	Description
Support Needs	Areas where additional resources would benefit participants in their educational and career journeys, including increased representation and mentorship.
Sources of Support	Resources that contribute to the advancement of participants' educational and career journeys, including social support from peers and family, as well as guidance from educators and various other instrumental educational resources.

Support Needs

This theme highlights key areas where additional resources, support systems, and structural changes are necessary to encourage a sense of belonging and support educational achievement for Native American women in STEM. A consistent theme across interviews was the importance of increased representation and access to mentorship. Many participants shared that their pathways in STEM were shaped by an absence of Native women in academic and professional spaces, which not only led to a sense of isolation but also motivated them to become the representation and support they wished they had. Their narratives also revealed how deeply meaningful it was when Indigenous knowledge, language, and experiences were reflected in STEM education. This representation will be discussed further in a later section.

Many participants in Study 2 mentioned the extreme lack of representation of Native women in STEM fields. Rather than feeling dejected by this lack of representation, some felt motivated to pursue their goals and become the representation that they never had. Amanda, a graduate student in wildlife biology described her desire to be the voice of Native people that has been lacking, stating:

> I would really like to become a Tribal liaison for the Fish & Wildlife Service in particular, and that is mostly tied to [...] our food sovereignty, because I believe that wildlife is a path forward for traditional food sovereignty for tribes. And so, being somebody at the table with a voice that can [...] have that biological training background, but also the policy weight behind the role to advocate for tribes to [...] manage their resources, and [...] not just manage them, but utilize them in a way that gives justice to the historical representation that's been lacking.

Statements like this also reflect the connection between professional goals and community-driven purpose. In the absence of representation, she chose to become that voice herself, especially in spaces where policy and science intersect with Indigenous land and food sovereignty.

The absence of available mentors can shift the focus toward becoming a mentor, particularly within one's own family or community. Stephanie, a PhD student working in the field of educational technology described her experiences with a lack of Native mentors and how she had taken on a mentorship role for her sister, stating:

> As far as Native women, there haven't been quite as many. There are a couple here at [institution name removed] that I know and look up to, of course. But you know what I do is kind of really different from what they do, and so it's… I don't know. I'm not really specifically on the lookout for Native women because there just aren't that many out there that do the same thing that I do. So, I guess I'm in kind of training to be that person for the next Native women coming up in this

> kind of career. Because my sister is also following [...] in my footsteps, she's now working on her master's in educational technology. And so having gone through that program before her, [...] I'm just kind of trying to act as a mentor. Yeah, I guess it's not super important to me to have somebody to look up to, as much as it is for me to be somebody who can be looked up to.

Others found mentorship by reaching outside their immediate environments. Amanda described the lack of Native women in STEM and how she strategically connected with mentors through professional societies, regardless of their field. She stated, "the representation for Native women in science wasn't really there at the Tribal College even, unfortunately. And it's definitely minimal at the university level as well. But through having mentorship opportunities in professional societies, I have been able to fill that void." She added that she also serves as a mentor to newer students with whom she crosses paths, stating, "I do my best to mentor incoming students that I'm exposed to." Her experience underscores how creating and maintaining relationships through broader networks, such as professional societies, can be a critical way to find guidance and community in the absence of others similar to you.

A few participants described how mentorship reduced daunting feelings about STEM environments. Megan described how, through mentorship, she became less intimidated by the field of computer science, stating "when I was younger, I just always enjoyed being on the computer and I think having a really good mentor helped me to feel like it wasn't this really big and scary thing." This highlights mentorship's potential for building confidence and shaping perceptions about what is possible.

Given the low number of Native American women in established STEM careers, participants emphasized the value of peer mentoring. Tiffany, an IT specialist at a large international company described her own mentoring, stating "I also do a lot of training and mentoring. So, training new technicians, but also training existing technicians on new technologies." Later, describing that although there are few Native women to be mentors, programs connecting more advanced students with newer students would be helpful. She explained:

> I would love to see mentoring programs and support programs for women who are studying. Even if it's not with someone who's already in the field, right, because part of the thing is we don't have a lot of people in the STEM fields. But even if it's just students that are at a higher level. You know, students who are seniors, mentoring students who are freshmen. "Hey? Yeah, it's difficult. [...] These things are a little more difficult to learn, but [...] you can do it. There are resources. Here's some tricks."

Tiffany's comments demonstrate a possible solution to the lack of representation, encouraging peer mentorship as a way to build supportive networks, promote shared learning, and offer encouragement, especially when senior role models are scarce.

For many participants, the absence of Native representation and mentorship in their academic and professional environments was a consistent theme. Without this representation, participants often had to navigate their STEM environments alone. This highlights the critical need for greater representation, as many participants expressed a desire to become the mentors and role models they never had, recognizing their presence could offer future generations the sense of belonging they themselves had missed.

Sources of Support

Social Support. Social support encompasses the various relational support systems on which participants relied to navigate academic and professional challenges. The majority of participants mentioned the importance of support from friends, colleagues, significant others, family members, and community, which often played an important role in participants' persistence and achievement in STEM. Participants described support and encouragement received from others, including through social media. Stephanie stated. "I usually post on social media when I've got my grades. [...] It's nice, it's uplifting when people comment on that. And they're like, 'Oh yeah! Go you! So proud!' And my bosses are also both very encouraging. They have both gone through PhD programs themselves, and they understand [...] what it is I'm undertaking, and they just want me to do the best I can."

Peer support can not only reinforced confidence, but also expanded access to resources and opportunities, helping students see themselves as capable STEM scholars, and opening up opportunities in STEM that would otherwise be out of reach, Jessica, a student in biochemistry and molecular biology described how her friend encouraged her to go into a supplemental STEM program in high school, stating:

> One of my friends [...] pushed me to go there, because originally, I was like, 'oh, I'm not smart enough. There's no way I can get in.' [...] But she pushed me to go, and then I fell in love with all of the labs and stuff that were available to me that wasn't normally available at my home school. And that pushed me to want to be more in STEM, definitely.

Most participants also mentioned the importance of receiving support and encouragement from family members, including parents, siblings, and extended family members. Melissa, a graduate student in educational technology working as an IT systems engineer, described how support from her parents encouraged her to pursue her degrees, stating:

> My parents have always been supportive of me getting an education, and my mom works in education. [...] I think she started [working] at [institution name removed] in 2011, and then she was teaching at an elementary school before that. So, seeing her in education and just knowing the importance to her and my dad, that made a big difference.

Heather, a graduate student in medical physics, recalled receiving early encouragement from her mom to attend college, stating:

> My mom saw how smart I was and was like, 'you know, you can go to college. You can go to college and you can do whatever you want, and I will be proud of you no matter what you do with your life, [...] but college is an option and if you want to go to college, I will support you.' [...] Definitely, my mom was my number one always.

Community was also an important source of support and encouragement. The communities from which support was derived varied in structure and origin, some were pre-existing, such as Native student groups and professional societies, while others were created intentionally through networking or shared experiences. Regardless of their form, participants described the importance of the encouragement and support provided by these communities throughout their educational and professional journeys. For example, Amanda described intentionally creating a “sisterhood” composed of other Native women in STEM despite not seeing other Native women in her discipline, stating:

> Even though the family side was maybe lacking, I did have the social support that I needed. Like I said, the representation for Native women in science wasn’t really there at the Tribal college even, unfortunately. And it’s definitely minimal at the university level as well. But through having mentorship opportunities in professional societies, I have been able to fill that void. So, [...] making sure that no matter where I am in the country I keep in contact with those ladies, [...] it helps create a sisterhood. And sometimes those sisters aren’t even in wildlife [biology], they’re just in STEM.

Mary, a medical resident with a PhD in chemical engineering and previous experience working in a National Laboratory, discussed the role her neighbor played in supporting her during her childhood, highlighting the impact of informal, place-based communities in creating a sense of stability, removing stressors often experienced by Native individuals, and which would have otherwise interfered with her educational achievement:

> We used to live across the street from them, and we would all get together at the end of the month [...] when everybody’s food was running out, we would pull together and have these potlucks and kind of help each other through, and it’s her daughters that gave my mom the clothes that I wore in school, because I had to wear hand-me-downs too when I was growing up. Unfortunately, I was much shorter than them, and so none of the clothes fit, but at least I had clothes that were in good shape. And so, we were really close.

Educational Support. Participants identified multiple sources of educational support that were instrumental to their persistence and growth within STEM fields. These supports were primarily found in the form of mentors, role models, and other individuals within educational systems. Participants explained how these figures offered guidance, encouragement, and a model for success when navigating male-dominated or unfamiliar academic environments.

Megan discussed the impact that a mentor in her program had on her persistence in computer science, stating:

> Having a good mentor helped me to feel that it wasn't this really big and scary thing. I think without that, [...] I don't think I'd be in this major. [...] I think having the right support was one of the biggest things that made it so I stayed in the program.

Further, she described how his encouragement inspired her to apply for a paid position at her institution, stating:

> I applied for my first full-time [...] job, [...] and I really didn't expect to get that position either, but I did. But I don't think I would have been as certain about putting myself out there for that if he didn't say, 'you should put in for this.' [...] I don't think I would have made it so far if I wouldn't have had such help from him, I think I would have seen a lot less for myself. [...] I just wouldn't have been able to think outside myself and see what good I can do.

This highlights how mentors can not only play an important role in encouraging persistence in higher education but also offer crucial encouragement at moments of uncertainty or self-doubt.

Participants also recalled earlier formative experiences with educators who served as powerful role models, specifically when these role models disrupted gender and racial stereotypes in STEM spaces. Heather described how an engineering teacher became a role model for her, stating:

> In my sixth and seventh grade classes, the engineering was taught by a woman, and that was passively empowering, because I was in this class with all [...] boys and I was the only girl, and we were being taught by a woman, engineering. And that never fazed me that I was in a class with a bunch of guys. I was just like, "Our teacher is a woman. She knows what she's talking about. I can know about engineering, there's nothing wrong with that." Because all the boys would try to be like, "Why are you in this class?" And I'd be like, "Because I want to learn." So, I would say that was one of my first role models as well. Her name was [name removed]. She was a Black woman that taught me engineering.

Heather's experience of having a Black woman engineering teacher at a young age reasserts the importance of visible representation in educational spaces. Despite being the only girl in the class, the presence of a capable female teacher helped normalize her own participation in the field. This early exposure helped to reinforce her right to belong in STEM spaces, highlighting how role models can play a lasting role in shaping self-perception and ambition.

Consistent with the findings of Study 1, many participants emphasized the role scholarships and tuition waivers played in their educational journeys. These forms of financial support alleviated stress and allowed participants to focus more fully on their academic work, engage in extracurricular and research opportunities, and consider educational pathways that may have otherwise felt inaccessible. For many participants, these resources made the pursuit of their degrees a reality and not a far-off dream, reinforcing the importance of equitable access to funding for underrepresented students in STEM.

Career Pathways

Themes related to participants' unique educational and career paths revealed both their ambitions and the key factors that contributed to their success. Two subthemes were identified: Inspiration/Motivation, encompassing the internal desires and external influences that guided their goals, and Professional Opportunities, referring to the concrete opportunities and resources that supported their preparation and pursuit of suture careers.

Table 10
Career Pathways (Study 2)

Theme	**Description**
Motivation	Participants' external and internal driving factors for achieving their aspirations, including early STEM exposure and experiential learning, financial and job security, extracurricular experiences, financial and job security, and the potential for making an impact through their work.
Professional Opportunities	Ways in which participants acquire new skills and knowledge for achieving their aspirations, including training programs, internships, research opportunities, and networking.

Motivation

Participants reflected on their educational pathways and current professional roles, which included a diverse range of STEM disciplines and employment sectors. The sample also included individuals at various stages of their educational and professional journeys, from undergraduate to PhD students, and early-career to established professionals. They represented different STEM fields such as computer science, biological sciences, educational technology, and environmental science. Participants also represented a broad range of employment sectors, including government, private industry, nonprofit organizations, healthcare, and higher education. Some were employed in federal agencies and national research laboratories, reflecting the public sector in defense and scientific research. Others worked in the private sector, specifically in technology and healthcare, occupying roles in engineering and IT. Several participants were employed by colleges and universities, including roles in educational technology, IT services, and instructional design. Additionally, nonprofit work in conservation and environmental science was represented. This distribution across sectors highlights the diverse professional environments in which women in STEM develop their careers.

Participants described various sources of motivation that shaped their educational and career paths. These sources ranged from personal interest to social responsibility and financial goals, reflecting a varied foundation for pursuing STEM. Many participants shared how early experiences, family support, and personal values played central roles in inciting their aspirations.

Early Exposure and Experiential Learning. Participants described how initial exposure to technology and STEM-related tools sparked their interest in STEM. This exposure often came in the form of personal experiences at home and with relatives, where curiosity set the stage for future academic and professional ambitions. Megan described getting her first computer as an adolescent, stating:

> My first computer was actually just like this old Windows 98-thing that the college was getting rid of, and I had fun being on it and being on the computer came easy to me. So, I guess I've always had, not a craving for knowledge, but when I was interested in something I found it easy to learn more on the computer. But I just wanted to investigate more. [...] I just was able to find things and figure out what to do on the computer easy. So, from there I just saw that as a strength since I was young.

Jennifer, an IT systems engineer recollected her enthusiasm upon receiving a typewriter as a child, stating "I remember being really excited because my parents bought me a typewriter one time for Christmas."

These experiences illustrate how exposure to technology served as a gateway to STEM, sparking and maintaining early interest in STEM. Participants also described how early exposure and experiential learning cultivated interest in STEM fields. Formative experiences in both formal educational settings and informal environments were described as catalysts for STEM interests. Participants described hands-on and exploratory activities in childhood and adolescence that served as entry points into STEM, as well as experiences in K-12 education that sparked their interest and shaped their academic trajectories. Structured school-based programs, such as Project Lead the Way, and engineering or computer programming courses introduced early as elementary school were influential. One participant credited a local math and science center with sparking her interest, while others described tactile and inquiry-based learning opportunities during early education.

Participants also discussed informal, often familial or independent experiences that nurtured interests in scientific thinking. Computer games, such as Oregon Trail, often accessed during school hours, as well as interactions with the natural world which played a role in nurturing scientific curiosity. One participant described crystal hunting with an uncle, while another attributed their interest in science to time spent in wild spaces.

Extracurricular Activities. Participants discussed a range of extracurricular activities that they engaged in which encouraged them to pursue STEM. These activities were often school-sponsored programs that offered insight into potential career paths. Heather's high school participated in an education program that trains educators to teach engineering. Through this program, she was able to take a course that exposed her to engineering career possibilities. She stated:

> In ninth grade, I took an intro to engineering design class, which is hosted by the project Lead the Way program. And that's a program that's in high schools and middle schools. Not all of them. But if the school decides to participate, the teachers go through this rigorous training to teach them how to teach engineering to young people. So, I took the engineering class and one of the projects was to research a type of engineer, like what their salary is, what they do, what kind of education you need to get to do it, and everyone else was doing like mechanical engineering, electrical engineering, computer engineering. And I was like, well, I don't want to do the same engineer as someone else. So, I chose nuclear engineering. And I learned about what they do. And at the time I was like, oh, clean energy! They make sure that everything's safe like that sounds like a really

> cool direction to go. And […] I liked it so much that I was like, I think that's what I want to do.

Heather's experience highlights how structured extracurricular activities can provide tangible insights into STEM professions and inspire long-term career goals.

Financial Security. For several participants, financial stability was a significant motivator in pursuing education and careers in STEM. The potential for steady, well-paying jobs in the field made STEM an appealing choice. Nicole, a second-year chemistry student described her motivation to go back to school, "I don't need a golden toilet seat or anything, but I would like to live comfortably, and that [...] is my main drive, is [...] just the security of it." This underscores how economic factors can be a strong, practical influence on educational and career choices.

Meaningful Impact. The majority of participants expressed a desire to make a meaningful impact, both within and outside of their careers. They discussed both the potential for their career to do good for their communities and their motivations to do good, sometimes relating this desire back to their own experiences and identities. For example, Megan mentioned the potential that computer science and technology have for cultural preservation, stating "things like language preservation, [...] being able to [...] record [...] and store that information is very important."

Mary discussed the importance of volunteering her time to help others, and her desire to continue that work even as she is busy in her medical career:

> I have always worked with the homeless. I've always done a lot with feeding them and providing blankets, and you know, coats and hats for them. And I definitely want to somehow find a way to continue to help the homeless and the

> underserved, [...] I feel like that's part of why I'm here on Earth is to help them. [...] I've learned from coordinating groups to feed them, that not everybody likes doing that, and I do. So, I feel like that's one thing that I really need to keep up with, because not everyone does that, and they really need it.

She later related her desire to give back to her own experiences of marginalization and discrimination, stating:

> I think that's why I love working with the homeless and with the underserved and [...] with prisoners, because I feel like I always kind of go towards the people who have had discrimination because I know what it's like, and they know what it's like, and people who have not been discriminated against have no idea what it's like. [...] So, I think that's why I always tend to want to help those who know what it's like to be discriminated against, [...] either for being homeless, or for being a prisoner, or being an ex-convict, or for being a minority, or for being a female in a certain role. And so [...] I think it's really important to do everything we can to promote STEM for females and minorities, because I think that in general, we have a lot going against us, even still.

Other participants discussed giving back to their families and those who had provided support for them throughout their educational journeys. Nicole described a desire to help her parents out, who had helped her by allowing for her to move back in with them as she pursued her degree as a non-traditional student. These experiences highlight the significant influence of community values and a sense of social responsibility in shaping participants' educational and career trajectories.

Professional Opportunities

Participants discussed a range of strategies they used to pursue professional development and training opportunities. These included obtaining scholarships to ease financial burdens, participating in internships to gain practical experience. And engaging in extracurricular activities to broaden their knowledge and professional networks. These efforts highlight a proactive approach to career preparation and a commitment to long-term professional growth.

Experiences such as internships and research opportunities lead to professional development alongside peer support and relationship-building. Amanda described how these strategies intersect with the social support that she gains from networking, stating:

> I've had many opportunities to gain support through clubs, through professional societies, through finding Native student cohorts. And then just nurturing those relationships. You know, one of my very, very best friends did a research experience for undergrads with me at the Tribal College. She wanted to be a science teacher. She is a science teacher. She has her master’s, and, you know, we got to do a wildlife internship together.

Internships and specialized training were particularly valuable opportunities for participants, providing hands-on experience and serving as a stepping stone toward their long-term career goals. In addition to professional training, these experiences build confidence and affirm their sense of preparedness for their future roles. Mary described how her medical training in her residency program gave her confidence to continue seeking career-advancement opportunities, stating:

> I feel confident that I will be able to do it [achieve career goals]. Because I'm looking at some programs that I feel like are really good programs. And I'm gonna keep looking at some other programs and make sure that I have some that I feel really confident would be good at training me to do the palliative care. And then Dr. [name removed], and all of the faculty at [institution name removed], [...] have really prepared me to do well with the family and care part of it, and I definitely want to be good at both. And I feel like I've been fortunate enough to be given the resources to do that.

Thus, formal training programs and structured and unstructured mentorship play an important role in preparing participants for specialized fields and reinforces the idea that access to professional development opportunities is instrumental in supporting professional confidence and competence.

Challenges

Table 11
Challenges (Study 2)

Theme	Description
Personal Challenges	Barriers to participants' engagement and achievement in their STEM field, including familial obligations, leaving home, and navigating non-traditional paths.
Contextual Challenges	Barriers to participants' engagement and achievement in their STEM field, including feelings of isolation and experiences of bias and discrimination related to being the only female or Native person in their STEM environment, the academic intensity of their STEM programs, and a lack of preparation by K-12 education.

Personal Challenges

Participants discussed a range of personal challenges they faced throughout their professional journeys. These included balancing family responsibilities with educational and career pursuits, leaving their homes and cultural support systems in order to give back to their communities through their work in the future, coping with health issues and the loss of loved ones, and navigating non-traditional career paths. Despite these difficulties, the majority of participants expressed confidence in their ability to achieve their educational and professional goals.

Participants discussed ways in which they dedicated time and energy to supporting their family members or raising children, balancing these responsibilities alongside their educational and career pursuits. Megan mentioned that she was expecting a child while working to obtain her computer science degree, and foreseeing the possible difficulties in balancing motherhood and her academic development "Right now, I just want to finish the bachelor's program. I'm currently expecting a baby, so [...] I'm afraid that's gonna not happen, but I'm really gonna try my best."

Many Native American participants described non-traditional pathways in their educational and career journeys. Whether that meant not going directly to college after graduating high school, taking time off of school before completing their degree programs, or changing career paths entirely after entering the workforce, the academic journey of participants in Study 2 differed significantly from those in Study 1. Native students were less likely to follow traditional educational paths due to economic and family pressures. Nicole, who returned to school as a non-traditional college student, doubted her capacity to succeed in this new educational endeavor, but her confidence in her ability was strengthened by her own academic success, stating "In the beginning I was not very confident at all, but I've been getting straight A's the last couple of semesters, so I'm pretty confident now" Similarly, Amanda whose achievements in the Western educational context provided confidence going forward, stated:

> I've had a lot of success in [...] my ability to communicate and write and pursue higher education. So, I think that [...] as long as I can maintain some semblance of motivation to keep pursuing higher education and kind of check off those boxes that our non-Native world makes you check off as a Native person, then I will definitely be successful.

When asked if she had always planned to pursue a career in STEM, Jennifer explained that she initially started school but left to take an entry-level job in computer science. Later, she returned to school to study STEM and further advance her career. She stated:

> I was going to [institution name removed] and cleaning hotel rooms. Actually, I was majoring in psychology when I was going to [institution name removed] and cleaning hotel rooms, and then an organization came to town that offered better pay, better hours. So, I dropped out of college, and I quit cleaning hotel rooms, and went to work for them.

Contextual Challenges

Most participants described the challenge of being the only one in their STEM environments, whether as the only woman or the only Native person. Many expressed feelings of isolation, along with experiences of bias and discrimination related to their race, gender, and age. These challenges often made them feel overlooked or underestimated in academic and professional settings.

Megan, who is pursuing a computer science degree at a TCU, discussed the loneliness associated with being the only girl in her program and her desire to see more students like herself in computer science, stating:

> As for on campus, I’m the only girl here. So, [...] it’s something I’d like to see, but it’s something that I haven’t seen too much of. At times it feels awkward because it’s kind of lonely. I don’t really feel like I can relate to other people. I think in other programs, they have a lot more women in them. I think it would be cool to see more in this field, in this program.

Similarly, Tiffany described the pressure of being a woman in a field dominated by men:

> I almost feel like an ambassador for women in the IT world. Where it took me a long time not to freak out if I didn't do things perfectly, because in my head I was like ‘I have to represent women, and if I’m going to prove that women belong here, I have to be perfect,’ because if I'm not perfect, then they're going to be like, ‘see, this is just proof that women don't belong here.

She went on to describe how working for an IT business, owned by her Tribe, in in which women made up more than half of the STEM roles, she still felt like a representation of her gender, stating:

> I still had that mindset of ‘I have to represent women, and if I'm going to do that, that means I have to be perfect, and I have to be good enough, and I have to do this, and I have to do that, and everything has to line up, because if I'm not good

> enough, then they're gonna use that as proof that women don't belong.' And again, that's something I put on myself, and I've done a lot of growing. Had some actual therapy on that, professional therapy.

Many participants discussed difficulties associated with the academic intensity or rigor of their STEM programs. Megan discussed feeling burnt out by their computer science program, stating:

> I just finished the semester, [...] and I do feel a bit burnt out. That was a rough semester." Later explaining that despite her feelings of being burnt out, she performed well in her course, stating "I knew the material, just to be honest, sometimes I'm so burnt out I don't even want to plug in a mouse. And that was it, [...] I didn't want to sit at the computer desk. [...] I knew the material, so I did fine on the quizzes and the essays and the final exam.

These difficulties were potentially related to a lack of preparation in their K-12 education for the rigorous work required by their STEM major. Megan stated:

> The high school I went to was just on the res[ervation], and it was just easy. They had us doing coloring pages. [...] I knew I wanted to go to college and everything, [...] and I don't want to say that other majors are easy, but [...] sometimes I feel like I'm doing physics or something.

She later described her ambition in relation to the environment that she grew up in, stating:

> I knew I wanted to go to college, but I didn't really have a lot of hope for myself as a kid. I mean, just growing up on the reservation, you see a lot of bad things. [...] I wanted to go into social work after all the things I had been through. [...] For

> a career, I kind of thought I was just gonna be stuck on the res[ervation]. I knew I wanted to go to college, but I didn't have a whole lot of hope for myself.

Native Identity, Culture, and Representation in Education

Through the interviews, participants discussed how their Native culture impacted their career choice and prospects. This theme reflects the multiple ways in which Native Identity and culture impacted participants' education and career development.

Table 12
Native Identity, Culture, and Representation in Education

Theme
Native Identity and Ties to the Community
Tribal College or University (TCU)
Native Culture in the Curriculum

Native Identity and Ties to the Community

All participants in Study 2 identified as Native American women. However, the impact that their identity had on their education and career choices was vastly different depending on whether they started their education in Tribal communities. For example, Megan highlighted that it may be difficult for Native women to leave their community. She considered herself lucky that she did not have to move for a job: "I'm also the IT Services Coordinator here. I was very lucky; I got a full-time position here. I think that's great, because I didn't have to move. I think that's one thing for Native women. I would feel so uncomfortable moving." In contrast, Jennifer did not consider that her Native identity was a barrier because she did not reside in her Tribal community until adulthood. "I don't know. I don't think of myself as like, you know, the Native American woman, because for so long I wasn't involved with that until I moved back. So, I always kind of thought that I could just do whatever I wanted to." Because she did not grow up in her Tribal community, she had career opportunities that would have otherwise been unavailable to her, noting the dearth of opportunities in the area:

> I'm back in [city name removed] now, I can totally see how people graduating from high school don't have a plan, and aren't interested in those things. Because there's really nothing here, to be honest. There's not any good employers here and a lot of times it's just about who you know.

Unfortunately, it seems that Jennifer may have viewed suppressing her Native identity as essential to advancing her career. For other participants, Native identity was internalized independent of residing in their Tribal community. Jessica who did not reside in her Tribal community at any time in her life, described how her Native identity was still important to her and how she felt connected through her grandmother, stating:

> My grandma is very vocal about the tribe and stuff, and she's kind of taught [...] me a lot about it growing up. Obviously, I wasn't necessarily there, but I still feel like a part of it. I got my little Tribal identity card and stuff, and I still bring it everywhere with me, even though I don't necessarily use it. You know what I mean? It's still a part of me, even if I've been away for so long.

Tribal College or University (TCU)

Many participants described the significant role of TCUs in their educational and professional journeys, emphasizing how these institutions offered culturally-affirming environments that supported their academic persistence and identity development. TCUs were described as spaces where Indigenous values and epistemologies were integrated into the curriculum and campus life. In addition to attendance, some participants described their roles as faculty or staff at TCUs, underscoring a commitment to giving back to their communities and advancing educational equity. Megan described the support that comes along with attending a TCU, stating:

> Outside my field I think that having cultural support that's separate from what I'm studying is so helpful. [...] Even having things like regalia making and things like that at the school. Those make me feel supported, they don't make me feel like I'm just alone in computing. They make me feel like I'm doing something that's culturally relevant, and that just kind of makes me feel like more of who I am, and that's just an important thing to my personal well-being. So, even though it's not related to my field, It makes me feel just a lot more, I don't know, human.

The centrality of TCUs in participants' pathways highlights the importance of these institutions in supporting the success and retention of Native students in higher education.

Native Culture in the Curriculum

Melissa reflected on her first experience of representation in her field in which Native experiences were implemented into her graduate level curriculum, lamenting that such representation came late in her life, and expressing how meaningful it was to her to see her culture represented in a first-person perspective video game. She stated:

> I know as a Native American woman that there's not a lot of Native American representation anywhere. So, my default is just kind of like… I never thought I'd see it. And then I saw it at [institution name removed]. [...] They have a place where they develop games, like serious games for learning. [...] It was this specific game we were looking at [...] you played in first-person following the

main character on the Trail of Tears. But they're being relocated from the east coast over to Oklahoma, [...] and in the game they include Anishinaabemowin language. But it was so cool to me, because they actually also included dialects of the language, which is an insane amount of representation that I never knew I needed. [...], and it was just really eye opening to get that in my master's course so much later in my academic career than it could have been, because if that resource was available earlier on, it might have put me on track sooner.

Some participants reflected on the impact of historical trauma, particularly related to the boarding school era and assimilation, and how these legacies shaped their own educational journeys. These reflections extended beyond personal or familial histories, as participants considered the broader experiences of Natives across Tribal nations. Rather than suggesting that this history be suppressed, Heather spoke about the importance of learning how historical and religious trauma impacted various Native communities differently, deepening her cultural understanding and sense of responsibility to acknowledge and respect the distinct histories of other tribes, beyond her own Ojibwe background. She stated:

> There’s different traumas involved with each group [...]. It seems selfish of me to only know about my Ojibwe heritage, and not how it’s interlaced with all the other groups. [...] Not understanding how [...] religion affected Oklahoma versus how it affected the [Ojibwe] area. [...] Which was a very big thing for me to learn about. [...] Because growing up, my mom made it very clear that the Catholic Church or the Catholic schools she was going to affected her greatly, and she had trauma from it. And [...] our grandmother was a boarding school survivor. [...]

> Religion was not a good thing for my family. [...] When I was in my master's degree [program], there were some people there that were from Oklahoma tribes. [...] I had a specific class on Native American religion and culture. And during those discussions, I got really humbled to the fact that there were people that did not have a negative religious experience. [...] That was so foreign to me because [...] there's a lot of religious trauma involved within my family. There's a lot of religious trauma involved [with] the Dakota and Ojibwe people, and I was hearing from a Choctaw person, they're fine with religion. [...] I shouldn't be offended that someone actually had a positive [...] experience having religion brought to them on their reservation. And that was a big thing for me to understand that there's tribes out there that have positive experiences with areas that other tribes had negative experiences in.

Melissa also noted the relevance of incorporating history into the curriculum. She described how her graduate program created space for deeper reflection on her culture and history, particularly in relation to the legacy of schooling for Natives. Through coursework that emphasized theoretical engagement over technical content, she found opportunities to explore the lasting impact of historical trauma, including her own family's boarding school experiences. She stated:

> I think I have a lot of opportunities to talk about my culture more. [...] Because it's less technical and more theoretical work that we're doing in the master's courses. [...] In the electronic assessments course that I took, I wrote quite a bit about historical trauma and not realizing that my mom's grandparents are boarding school survivors. [...] I think that was the semester that they found the

> remains at Kamloops in Canada. So that combination made it a lot more important to me, because historically, for Native peoples, school isn't a safe place. At least, you're not safe from the people who are supposed to be taking care of you and protecting you. But then, I don't know, with the current climate and school shootings it's also still not safe for other students. But it was especially so while boarding schools were still around.

Summary

The findings from Study 2 highlight the extent to which high-achieving Native American women in STEM have experienced the integration of their own cultural values and knowledge systems into their educational pathways. In response to Research Questions 1 and 2, participants' narratives reflected some integration of their cultures into their academic and professional experiences. Not surprisingly, TCUs were recognized as environments that acknowledged and respected their cultural values and histories. Addressing Research Question 3, while Native and Black women in STEM reported overlapping challenges such as underrepresentation, isolation, and discrimination, Native women more frequently described incidences of explicit racial, gender, and age discrimination. Native women also described more severely lacking representation and emphasized becoming the representation that they never had. These findings highlight the distinct aspects of navigating STEM as women of color and point to the importance of inclusion initiatives grounded in cultural context. These results will be further discussed and integrated with the results from Study 1 in the General Discussion (Chapter 6).

CHAPTER SIX
GENERAL DISCUSSION

In the present work, two studies investigated the experiences of women from minoritized communities in STEM. Study 1 focused on Black young women who had participated in the Legacy program, which provided preparatory experiences to facilitate their success in Advanced Placement Computer Science Principles (AP CSP). Study 2 focused on Native American women at different stages in their professional careers, from early college to experienced professionals. Although common themes emerged across studies, there were unique experiences that identified each population of women and girls navigating STEM education and careers. The data were analyzed using an intersectional perspective, understanding that women from minoritized populations are not a homogeneous group, and their experiences should be contextualized by their ethnic and cultural background. Across both groups, themes such as the need for instrumental support, representation, and mentorship, early STEM exposure, and barriers to persistence were prominent. However, the nuances of identity and cultural relevance point to important distinctions in how these themes emerge for each group.

Participants in Study 1 offered valuable insights into their experiences with the Legacy Program. They also describe both barriers to their educational attainment and sources of support that facilitated their persistence. Participants in Study 2 discussed their experiences with culturally responsive education and the extent to which traditional Indigenous knowledge has been incorporated in their education. Below, I address how the interviews inform the research questions for each study, as well as how these results can be integrated to better understand the STEM career paths of women from minoritized backgrounds.

Study 1

Research Question 1

What do former participants take away from their experience in the Legacy Program and what feedback do they provide for improvement of the program?

Benefits

Participants described a range of academic, socioemotional, and personal benefits that they attributed to their participation in the Legacy Program. These outcomes highlight how the program encouraged engagement, confidence, and the development of a STEM identity. These results are in line with prior literature on the effectiveness of educational interventions designed to broaden participation in computing among underrepresented groups (Scott et al., 2016; Miller et al., 2018b). Specifically, academic benefits such as preparedness for AP CSP, exposure to college environments, and increased awareness of computing careers reflect the goals of efforts like “CS for All” and programs such as Girls Who Code, Black Girls Code, and CS@SC Summer Camps. Like these initiatives, the Legacy Program provided participants with access to computing instruction and opportunities to visualize themselves in STEM fields. The Legacy Program similarly provided accessible computing instruction and helped participants envision themselves in STEM pathways.

Participants also took away important socio-emotional benefits, including the formation of supportive peer relationships and a sense of community within the field of computer science. These findings parallel findings based on culturally-relevant programs like SMASH, for increasing engagement with computer science content (Scott et al., 2016). The Legacy Program's cohort model and residential experience appear to encourage social connection and support on which participants continued to rely long after the program ended. This suggests that the development of communities of peers is an important consideration for initiatives seeking to promote STEM-engagement.

Participants also described personal benefits that included stronger identification with STEM fields, professional growth, and the development of meaningful interpersonal relationships. The Legacy Program was not only an opportunity for skill development, but also a space for identity exploration, where students could see themselves as scientists and computing professionals. The personal growth as described by participants includes the impact of role models and mentors in affirming belonging and countering stereotype threat, despite structural barriers (Johnson et al., 2019; Charleston et al., 2014).

The Legacy Program contributed significantly to existing educational efforts aimed at broadening participation in STEM and computing. By offering academic preparation, promoting interpersonal connections, and supporting identity development, the program aligns with, and contributes to evidence-based strategies for increasing the representation and success of underrepresented students in STEM. The benefits reported by participants reflect principles of the Stereotype Inoculation Model, which emphasize the role of exposure to peers and in-group experts in promoting resilience and sustained engagement in fields where one is underrepresented (Dasgupta, 2011). Within the Legacy Program, interactions with peers and mentors who shared similar backgrounds appeared to buffer against stereotype threat and reinforce their identification with computing and STEM. These findings reinforce the importance of culturally-relevant, community-based approaches to STEM education and suggest that programs like Legacy play an important role in addressing the representation gaps in computing fields.

Improvement Feedback

Participants in Study 1 provided limited feedback for improving the Legacy Program, as most participants reported high satisfaction with their experience. However, differences emerged between cohorts due to the impact of the COVID-19 pandemic. Participants from the first cohort (N = 10) completed the program in person over the summer before the COVID-19 pandemic, while participants from the second cohort (N = 5) completed the program virtually over the summer after the COVID-19 pandemic began. Participants in the second cohort mentioned the limitations of a virtual learning environment, including decreased engagement among peers, frequent distractions, lack of camera use, and reduced accountability in the online format. One participant expressed concern that some of her peers did not recognize the value of their inclusion in the program. Another participant noted that the impact of the program would have been stronger if it had been delivered in-person. Together, these comments underscore the importance of face-to-face interaction for promoting peer connection, maintaining engagement, and creating a sense of community within the program.

Beyond this, only a few minor suggestions were made by individual participants, rather than a broader consensus of areas needing improvement. These isolated comments concerned a desire for follow-up or ongoing contact with Legacy Program facilitators, additional time in the program to allow for a slower pace of instruction, and more opportunities for bonding outside the classroom. These comments did not indicate widespread concerns and the lack of substantial criticism suggests that participants were predominantly satisfied with their experience.

Research Question 2

What challenges or barriers do high achieving Black women in STEM report experiencing in their educational and professional journeys?

Study 1 revealed that participants encountered both personal and contextual challenges that significantly shaped their academic trajectories and identities as young women in STEM. While the participants frequently emphasized their ability to persist and grow through adversity, these obstacles were formative and stemmed from both systemic inequities and personal hardships.

Personal challenges, such as financial troubles, health complications, mental health concerns, and the loss of a loved one, unsettled participants' educational progress and demanded self-discipline and adaptability. For instance, some participants described becoming financially independent at a young age, and taking on multiple jobs to support their education and transportation. Similarly, medical and mental health challenges were compounded by a lack of institutional support or resources. Participants described overcoming these challenges through personal resilience and persistence.

Contextual challenges within educational environments were also significant. Participants often described the isolating experience of "being the only one" in classrooms, or entire departments, a pattern that is well documented in literature on STEM participation among Black women (Henry Collins et al., 2020; Ireland et al., 2018; Mirakhur et al., 2024). The sense of being hyper-visible and constantly having to prove oneself in the face of stereotypes contributed to emotional and academic stress. As one participant shared, the experience of being underestimated by peers demonstrates how gender and racial microaggressions act as barriers that challenge competence and belonging.

These findings suggest that the experiences of high-achieving Black women in STEM cannot be fully understood without consideration of both the personal and structural barriers they face. Although the participants consistently demonstrated resilience, it is important to recognize that resilience should not be treated as a substitute for the responsibility of institutions and educational systems to enact changes that ensure equity, support, and belonging for all students.

Research Question 3

What factors do high achieving Black women in STEM report as supporting their educational and professional journeys?

Participants in Study 1 described a range of social and educational factors that supported their persistence and success in STEM. These supports included strong peer and family networks, meaningful relationships with educators and mentors, and access to instrumental resources such as scholarships and professional development opportunities. In addition to identifying sources of support, participants also highlighted areas where further resources could be provided, such as increased representation and mentorship.

Participants described receiving social support from peers, family and diverse networks. Many highlighted how peer relationships with other young Black women helped reduce feelings of isolation. These supportive peer relationships provided opportunities for teamwork, encouragement, and a sense of belonging. Family members, such as parents and extended family, were another important source of support and encouragement. Participants described mutual academic support within their families, and emotional support. These networks of peer and family support helped to buffer against the challenges they encountered as students underrepresented in STEM spaces.

Educational support was also critical. Teachers and mentors played important roles in encouraging confidence, clarifying difficult content, and pointing participants to resources like scholarships and opportunities for professional development. Participants specifically mentioned encouragement from Black women educators who affirmed their presence in STEM spaces. Instrumental supports like internships, clubs, and professional societies were also described as important facilitators of success.

Study 2

Research Questions 1 and 2

Where do the experiences of high achieving Native women in STEM education and careers fit within the research frameworks of culturally responsive education and community-based science education? and Research Question 2: How have traditional knowledge and Indigenous science epistemologies been incorporated into the learning of high achieving Native women?

Study 2 suggested that these two questions should be addressed together. Native American identity, culture, and history profoundly influenced participants' educational experiences and pathways in STEM. These themes intersected with broader concepts of culturally responsive education by affirming Native students' cultural identities within academic settings, and reflected community-based science education through attention to place, relationality, and cultural continuity.

Native Identity and Ties to Community and Culture

Participants described varying relationships with their Native identities and Tribal communities, which shaped their educational opportunities and sense of belonging in STEM. For some, remaining physically connected to their Tribal community was central to both personal comfort and career choices. One participant's decision to pursue a STEM career within her community was tied to her cultural and familial obligations, and she expressed relief at not having to relocate for a position in her field. In contrast, others only came into close contact with their Tribal identity and community later in life. One participant who spent time away from her Tribal community early in life, described her career path as unaffected by her cultural identity. However, this separation from her Native background may reflect a belief that advancing in STEM environments requires downplaying or concealing one's cultural identity. These findings align with literature suggesting that Native students often navigate complex identity processes that are shaped by geography, family history, and access to culturally affirming education (Brayboy & Castagno). Another participant emphasized that her cultural identity remains meaningful, even though she is not proximally close to her Tribal land. Her connection through family, specifically her grandmother, reinforced a sense of cultural belonging and pride. These narratives reinforce that Native identity is not monolithic but deeply individualized, and that culturally responsive and community-based education needs to account for both urban and reservation-based learners whose relationships to place and culture differ.

Tribal Colleges and Universities (TCUs) as Culturally Affirming Spaces

A number of Study 2 participants highlighted the impact of attending or working at a TCU. These institutions served as culturally affirming spaces where Native identities were supported, respected, and incorporated into their educational and professional journeys. Participants described the importance of community, cultural programming, and the integration of Indigenous knowledge systems. For example, one participant's description of feeling "more human" through cultural activities at her TCU highlights how identity affirmation can promote persistence in STEM fields. This aligns with research showing that TCUs are critical to the retention and success of Native students due to their ability to provide culturally relevant and affirming educational experiences (Bryan, 2019; Washington, 2023). TCUs illustrate the principles of culturally responsive education by embedding Indigenous values into the curriculum and supporting Native student identity within educational spaces. Participants' responses demonstrate how TCUs prepare students for STEM careers and assert their role as contributing members of their communities.

Native Culture in the Curriculum

The integration of Indigenous culture into formal education at the postsecondary level emerged as a powerful, yet often delayed, source of affirmation for participants. One participant's account of encountering meaningful Native representation in a graduate-level course was both insightful and bittersweet. She recognized how earlier exposure to such representation might have sped up her engagement with STEM content. Similarly, other participants described how theoretical coursework in graduate school provided them with opportunities to explore the intergenerational effects of historical trauma, especially through the context of boarding schools. These responses illustrate how traditional knowledge and epistemologies were occasionally incorporated into participants' learning experience, but typically later in their academic trajectories. When they were incorporated, these perspectives deepened learning, encouraged reflection, and supported identity development. One participant's humility in learning the varied religious experiences of other Tribal groups highlights the value of diverse perspectives in deepening cultural understanding and encouraging meaningful discourse among students from different communities.

Together, these experiences highlight an important gap in education: the need for earlier incorporation of Indigenous knowledge and cultural representation in STEM curricula. This would validate Native students' lived experiences and emphasize the importance of education rooted in culture, history, and ways of knowing.

The following two sections address Research Question 3 from Study 2: How do the experiences of high achieving Native women compare to the experiences of high achieving Black women in STEM?

Shared Themes

Participants in both studies emphasized the importance of community support and the bonds they formed with other women, often describing it as a "sisterhood." In Study 1, participants described the sisterhood that emerged through their involvement in the Legacy program, highlighting the shared experiences, encouragement, and empowerment that created a sense of belonging and supported resilience in STEM. Similarly, participants in Study 2 discussed the importance of communities, described as sisterhoods, of other Native women across various fields, despite the persistent underrepresentation of Native women in their respective disciplines. Whether those communities were existing communities, created by the individuals through their own networking, or created with the purpose of providing a peer community of support, it was important for participants to have groups of similar others to share their experiences. These communities not only provided socio-emotional support, but also became a source of strength and affirmation, reinforcing participants' commitment to their professional aspirations and helping them navigate the challenges of underrepresentation and isolation. The persistent use of the term "sisterhood" across both groups highlights the importance of having spaces where women, specifically women of color, can connect with others who understand their experiences and provide encouragement. Previous studies have emphasized the experience of "being the only one" in a STEM environment (Yamaguchi & Barge, 2019), which emerged as a key theme in both of the current studies. These findings underscore the success of the Legacy Program and the critical need for similar interventions that create community and support networks for underrepresented women in STEM fields.

Participants across both studies also described various forms of support they received throughout their educational and career journeys, with special emphasis on the role of social networks in shaping their academic and professional trajectories. Emotional support was a recurring theme, with participants emphasizing the encouragement they received from family, friends, and broader social circles. This support included verbal affirmations, reassurance, and motivation to persist in their studies. Some participants specifically mentioned the role of social media in providing emotional support, noting that sharing their educational achievements online elicited encouragement from friends, acquaintances, and professional networks. This also suggests that support communities do not need to be made up of individuals who share the same physical spaces, but can span across geographical barriers, alleviating the academic isolation that is often associated with lack of representation.

In addition to emotional support, participants benefited from informational support, particularly from mentors, educators, and professional networks. Participants described receiving guidance on academic programs, career pathways, and opportunities for further development. Mentors, in particular, helped participants navigate important decisions about selecting courses or programs, applying for internships and jobs, and understanding expectations within professional environments. Although most participants mentioned the relevance of having mentors that reflected their own racial and/or cultural identity, others highlighted the role of individuals from majority backgrounds in helping develop their confidence.

Instrumental support was another critical component to the success of participants in both studies. Many cited financial assistance, such as scholarships and tuition waivers, as essential in enabling them to pursue their education without added financial strain. Additionally, some participants highlighted monetary incentives for academic excellence as motivating factors that reinforced their commitment to high achievement in school. Overall, these forms of support interacted in meaningful ways to facilitate participants' academic and career success. These findings underscore the importance of structured support systems, both formal and informal, in promoting persistence and success for underrepresented students and professionals in STEM.

Early STEM exposure and experiential learning emerged as significant factors in sparking participants' interests in STEM. These formative experiences, in both formal educational settings and informal, exploratory contexts, played an important role in shaping participants' academic trajectories. Curricular experiences provided early skill development and clarified technical content, framing STEM subjects as accessible and rewarding. Multifaceted, early encounters with STEM, whether introduced through formal instruction, play, or nature, can be impactful catalysts for long-term STEM engagement. Participants' narratives emphasize the need for accessible, hands-on STEM opportunities across diverse learning contexts to nurture sustained interest and participation, particularly among underrepresented groups. These experiences highlight the importance of expanding access to experiential STEM opportunities across diverse settings in order to promote early interest, STEM identity, and participation in STEM fields.

The role of minority-serving institutions must also be noted. Despite the large differences between HBCUs and TCUs, references to increased sense of belonging and integration of the participants' cultural background served an important role in maintaining motivation to persist in their educational pathway. However, the differences in age range between the two samples makes it difficult to draw direct comparisons about the impact of these institutions.

Distinct Themes

Although participants in both studies shared experiences of being underestimated, differences emerged in how they described discrimination related to race, gender, and age. Native American participants in Study 2 more frequently reported both implicit and explicit forms of bias related to their ethnic identities. In contrast, participants in Study 1, while acknowledging moments of being underestimated, did not explicitly describe experiences of racial or ethnic discrimination.

Several factors may explain these distinctions. First, there were differences in age and professional experience between the two groups. Participants in Study 2 were generally older and further along in their careers, exposing them to a wider range of professional environments where racial, gender, and age-based discrimination were more prevalent. In contrast, the younger participants in Study 1 may not yet have encountered discrimination or bias to the same extent, or may not have recognized these experiences as implicit or explicit discrimination. Indeed, ageism emerged as a unique challenge for Study 2 (Native) participants, either because they were considered too old to be included or taken seriously, or because they were seen as too young to hold the knowledge and experience needed to succeed in their fields. A second potential explanation involves the interview dynamics. Most participants in Study 2 were aware of the interviewer's shared cultural background, which may have led to greater openness in disclosing sensitive experiences. In contrast, participants in Study 1 may have felt less comfortable sharing experiences of racial discrimination, especially if they perceived the interviewer as an outsider or were not sure of how such disclosures would be received.

In both studies, participants emphasized the importance of representation in STEM fields as a source of motivation and belonging. Participants in Study 1 discussed the limited visibility of others like themselves in computer science educational spaces. However, when they did encounter other Black women and girls in STEM, even in small numbers, it was extremely impactful, reinforcing their identities as computer scientists and providing them with ideas of what possibilities exist. The representation found in the

Legacy program provided evidence that they were not alone and that success was attainable, as well as helping to fight the isolation associated with underrepresentation. Participants in Study 2 described a much more profound absence of representation. These participants often expressed that they had never seen another Native woman in their field. For many, the only examples of Native women pursuing STEM were within their own families (e.g., sisters, cousins), rather than within their academic programs or professional fields. This stark lack of visibility contributed to feelings of exclusion, and heightened the burden of being the sole representation of their gender, racial, or ethnic group. These distinctions suggest that while underrepresentation is a shared experience, the degree of visibility and access to mentors or role models can vary greatly between Black women and Native American women. These findings highlight a need for initiatives that not only increase representation for Native women in STEM, but also connect them to broader networks to reduce isolation and affirm their place in these fields.

Native participants frequently expressed a strong sense of responsibility to serve as mentors, often prioritizing their roles as supporters over discussing their own experiences of being mentored. This finding aligns with previous research on Native faculty in academia, who also reported feeling an obligation to mentor others due to the scarcity of Native women in their respective fields (Spafford et al., 2006). The limited representation of Native individuals in STEM and academia creates a heightened awareness of the need to support and uplift the next generation, encouraging a sense of communal responsibility rather than an individualized focus on personal career advancement. This emphasis on mentorship as a duty rather than a benefit underscores the collective and relational values deeply embedded in Indigenous cultures, in which success is often viewed through the lens of community well-being rather than individual achievement.

Another distinction between participants in Studies 1 and 2 was how almost all of the Native participants described taking non-traditional pathways in their educational and career trajectories. These pathways included delaying college enrollment after high school graduation, taking extended breaks between academic terms, or shifting career paths entirely after entering the workforce. In contrast, participants in Study 1 tended to follow more traditional educational pathways. This difference is possibly a reflection of the participant recruitment process. Study 1 participants were drawn directly from a structured program designed to support their engagement in STEM education during high school, providing them with early exposure and guidance. In contrast, participants in Study 2 were recruited through alternative methods and often did not have access to similar structured STEM programs, such as the Legacy program, that may have encouraged their initial interest in STEM fields. Nonetheless, the nontraditional path observed in Study 2 participants is consistent with previous research on high-achieving Native American students, in which the majority of participants were non-traditional and had experienced at least one break in their post-secondary education (Reyhner & Dodd, 1995). Indeed, Native American students are more likely than any other racial or ethnic group to pursue education through non-traditional routes. A study of one TCU found that only 36% of its students were under the age of 25, compared to a national average of 60% for students at two- and four-year institutions nationally (Castillo, 2011). As a result, the experiences of Study 2 participants may be more representative of the broader reality for

Native American women in STEM.

Although participants in both studies described the relevance of having strong support systems, community emerged as a central theme in the educational journeys of Native participants. Their motivations to pursue STEM were frequently tied to a sense of responsibility to support their communities, and many expressed a strong desire to give back by mentoring others. These findings align with existing literature showing that the importance of community, and the motivation to give back are key factors contributing to educational persistence (Lopez, 2018; Chow-Garcia et al., 2022). For Native students, the concept of community carries a distinct cultural significance, often rooted in Indigenous values that prioritize collective success and relational accountability over individual achievement (McShane, 1983; Pewewardy, 2002; Bang et al., 2007; Kisker et al., 2012; Bang et al., 2014). This communal orientation shaped how participants viewed their academic and professional roles, often emphasizing mentorship and giving back to their communities as a duty, rather than focusing on the benefits of receiving mentorship themselves.

Study 2 participants also described the presence of deficit-based narratives within their educational experiences. One participant recounted being encouraged by faculty to research alcoholism in Native American communities, a suggestion that reflects broader patterns of tokenism and the pervasive use of deficit lenses in research about Indigenous populations, reducing complex issues to simplistic stereotypes. Being singled out as an underrepresented minority in undergraduate education exacerbates feelings of tokenism, highlighting the tendency of many academics to overlook nuanced perspectives and perpetuate harmful narratives regarding Native populations (Masta, 2018; Masta, 2021).

Promising work has been done to show the benefits of creating classroom counterspaces, which are intentional educational environments that challenge dominant norms and allow Indigenous and other marginalized students to express their lived experiences, critically engage with established Eurocentric research methodology, and explore how their identities shape their educational output (Masta, 2021). The current study reinforces the value of these counterspaces by highlighting the psychological toll of underrepresentation and the burden of navigating educational systems that often lack cultural awareness, and support the adoption and expansion of culturally relevant programs, increased representation of Native faculty, and incorporation of Indigenous ways of knowing in STEM education.

These findings underscore the importance of recognizing that underrepresented students are not a monolithic group. While shared experiences, such as marginalization, underrepresentation, and stereotype threat are common, there are culturally specific factors that influence how different groups navigate STEM fields. Native students, for example, often approach education with a community-centered mindset, while other groups may gain motivation from different sources. Understanding these distinctions is essential for developing effective and culturally relevant STEM interventions that consider the experiences and values of diverse groups.

Conclusion

Participants in Study 1, who were former participants in the Legacy program, described the program as having a profound impact on their persistence in STEM, development of their identities as capable scientists, and the formation of lasting peer relationships that continues to provide social support long after their participation in the program came to an end. These outcomes support the value of expanding access to structured STEM pipeline programs that emphasize community-building and social support. Additionally, participants' experiences highlight the identity-affirming effects of representation and cohort-based learning. The success of the Legacy program suggests that similar models could be extended to a broader population of underrepresented STEM students, including young Native American women and more young Black women. A culturally relevant program designed specifically for Native students could integrate Indigenous knowledge systems into STEM education and actively engage Native communities in its development and implementation.

Taken together, the findings from these studies underscore the complexity of navigating STEM education and careers as underrepresented women, revealing both shared challenges and culturally specific experiences. While participants from both studies described the importance of specific factors in encouraging persistence, the ways in which these supports were experienced varied greatly between Black and Native American participants. These findings emphasize the need for intersectional and culturally responsive approaches to supporting underrepresented students in STEM. By acknowledging the commonalities and differences across groups, educators, program developers, and policymakers can design effective and inclusive strategies that affirm diverse identities and encourage equitable opportunities for success in STEM fields. Broadening participation in STEM requires not only addressing resource gaps but also transforming the cultural and structural landscape of STEM education to reflect the lived experiences, identities, and aspirations of all students.

The following quote from Tiffany highlights how representation, and its absence, shapes women’s sense of belonging in STEM:

> I remember when *Hidden Figures* came out, people were like, “Why are we only finding out about this now? This is a major part of our history and a major part of our science history that nobody ever talked about. Why?” And there’s still so much of that that I would like to see improved on because it would have made a difference. I wouldn’t have felt like such an outsider. I wouldn’t have felt like I was getting this information and this knowledge, and going into this career, despite being a woman. Because that was very much how it felt, is that I was doing this despite being a woman, despite not belonging. And I do belong. We’ve always belonged.

APPENDIX A

STUDY 1 INTERVIEW SCRIPT

Study 1 Interview Script

What are you doing currently in your educational and professional life?

Are you currently in college, or are you planning to attend college?

What are your career goals and aspirations? What sort of steps do you need to take to get there? [How confident are you that you can take those steps?]

Is what you are doing currently in your educational and professional/work life what you had planned to do? [What was your intended major?]

Are you still on that track or have your interests/goals shifted?

Did any of your experiences in Legacy help you with educational, work, or personal challenges that you have faced since completing the program? [Ask about their experiences taking the AP CSP class/exam specifically.]

Have you had any notable or major life events that have impacted your educational and professional/work plans?

Where do you see yourself in one year?

Where do you see yourself in 5 years?

What was most memorable about your participation in Legacy? [Ask about a favorite memory, anecdote, or story specifically.]

What aspects of Legacy made your experience especially positive? What aspects of Legacy were the most enriching, helpful, or useful to you?

What aspects of Legacy do you think were unnecessary, irrelevant, or unhelpful to you?

To what extent did Legacy influence the career choices you have made since completing the program? Do you think you would have made different career choices if you had not participated in Legacy?

In what ways could Legacy have been more helpful to you?

How important was it for you to be in a group of young Black women when participating in Legacy?

What kind of support did you have in Legacy that you are missing now and you think would be helpful to still have?

As a young Black woman, what sort of support and encouragement do you think would increase your personal and professional success?

How did Legacy help you overcome obstacles or help you better deal with uncomfortable situations that you may have faced since completing the program?

APPENDIX B

STUDY 2 INTERVIEW SCRIPT

Study 2 Interview Script

What are you doing currently in your educational and professional life?

What are your career goals and aspirations? What sort of steps do you need to take to get there? [How confident are you that you can take those steps?]

Is what you are doing currently in your educational and professional/work life what you had always planned to do?

Describe any notable shifts in your interests, goal, and educational track that may have happened in your life leading you to where you are now?

Have you had any notable or major life events that have impacted your educational and professional/work plans?

Where do you see yourself in one year?

Where do you see yourself in 5 years?

How did you develop your interest in Computer Science [or insert STEM career/major here]? [Ask for specifics – childhood memories, early educational experiences, role models]

How important was it to you to see other people who have similarities to you in Computer Science [or insert STEM career/major here] classes and careers?

What sorts of social support and relationships are [or were] present in your life that encourage [or encouraged] you in continuing your education?

How important is [or was] it to have educational experiences that draw [or drew] on and incorporate [or incorporated] your cultural background?

As a Native American woman, what sort of support and encouragement do you think would increase your personal and professional success?

APPENDIX C

IRB APPROVAL LETTERS

OAKLAND UNIVERSITY

Institutional Review Board

Date: April 29, 2022

Study #: IRB-FY2022-249

Study Tile: Legacy: Career Follow-Up

Submission Type: Initial

IRB Decision: Exempt

Research Team:
Martha Escobar
Noelle Mongene
Madelyn Hichme, Alexa Khacho

Based on applicable federal regulations, the above referenced study has been determined to be Exempt, with the following categories:
Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

Letter and Consent Document:
This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively.
The IRB date stamped consent document must be downloaded and used in consenting participants.

Permission from Research Sites:
Please note the following:

- This IRB exemption determination letter means that this research has met one or more of the federal criteria for exemption per 45 CFR 46.104- Exempt Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your files.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:
Any changes to this exempt project must be reviewed by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Record Retention:
Exempt projects will be retained by the IRB office for three years after the last action on the project.

You are approved to start the research. Please retain a copy of this notification for your records.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

OAKLAND UNIVERSITY

Institutional Review Board

Date: April 14, 2023

Study #: IRB-FY2023-253

Study Tile: Legacy: Native American CS Extension

Submission Type: Initial

IRB Decision: Exempt

Research Team:
Noelle Mongene
Martha Escobar
Haylee Majewski, Samuel Motzny, Madelyn Hichme

Based on applicable federal regulations, the above referenced study has been determined to be Exempt, with the following categories:
Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

Letter and Consent Document:
This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively. Please make sure to use the most recent IRB approved version of the consent form in consenting participants.

Permission from Research Sites:
Please note the following:

- This IRB exemption determination letter means that this research has met one or more of the federal criteria for exemption per 45 CFR 46.104- Exempt Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your files.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:
Any changes to this exempt project must be reviewed by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Record Retention:
Exempt projects will be retained by the IRB office for three years after the last action on the project.

You are approved to start the research. Please retain a copy of this notification for your records.

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Thank you.

The Oakland University IRB

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