"It solidified my position that I should be in science": a case study on how participating in a STEM Intervention Program influences the science identity development of low-income students in STEM at a community college.

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ABSTRACT

“IT SOLIDIFIED MY POSITION THAT I SHOULD BE IN SCIENCE”: A CASE STUDY ON HOW PARTICIPATING IN A STEM INTERVENTION PROGRAM INFLUENCES THE SCIENCE IDENTITY DEVELOPMENT OF LOW-INCOME STUDENTS IN STEM AT A COMMUNITY COLLEGE.

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Northern Illinois University, 2023
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Individuals coming from low-income backgrounds, particularly women and people of color, are disproportionately underrepresented in STEM fields. The low representation is often attributed to low enrollment and completion rates in STEM programs. Community colleges play a crucial role in increasing diversity in the workforce. However, there is not much information about how community college students’ experiences in STEM academic programs support their science identity development. The purpose of this case study was to understand how participation in a STEM intervention program assisted low-income students in their science identity development. Science identity development has been used to understand how students’ interactions with the field influence their interest, engagement, and sense of belonging to science. The STEM Community program was a STEM Intervention Program (SIP) that provided low-income students, many that held other minoritized identities, with financial, social, and academic assistance. The case study included semi-structured interviews with 17 program participants and 2 program mentors, and the program coordinator, document analysis of end-of-the-year student reflections, and observational data. The findings from the study suggest that early intellectual curiosity, early exposure to science, encouragement to pursue a career in science, and personal
goals play a major role in sparking interest in science. Hands-on experiences, mentoring, and
guidance increase the sense of competence and performance in science. Engaging in
undergraduate research opportunities and scientific conferences substantially increases students’
sense of recognition and belonging in science. This study also found that finances, privileges,
representation, and access to STEM professionals play a role in how students experience STEM
programs, thus influencing their science identity development.

*Keywords*: underrepresented students, STEM, science identity, community college
“IT SOLIDIFIED MY POSITION THAT I SHOULD BE IN SCIENCE.”: A CASE STUDY ON HOW PARTICIPATING IN A STEM INTERVENTION PROGRAM INFLUENCES THE SCIENCE IDENTITY DEVELOPMENT OF LOW-INCOME STUDENTS IN STEM AT A COMMUNITY COLLEGE.

BY
Manuel Rodriguez
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE DOCTOR OF EDUCATION

DEPARTMENT OF COUNSELING AND HIGHER EDUCATION

Doctoral Director:
Dr. Carrie A. Kortegast
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DEDICATION

To my family, Jeremy, Liam, and Kendrick, whose unconditional love and support inspire me to be better every day.
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The aim of this dissertation project was to gain a better understanding of how participation in a STEM support program assisted low-income community college students, many of whom held other minoritized identities, and fostered their science identity development. This case study researched the experiences of seventeen students in STEM at a community college. Participants were part of the STEM Community program which was focused on increasing representation in STEM by providing students with financial, social, and academic assistance. The community college was located in a small rural area in the Midwest. The chapters in this dissertation discuss the evolution of this project, from the project proposal, research methods, findings, conclusion, and a scholarly reflection of my journey and learning through this study.

Chapter One contains an introduction to my study. This introduction is based on my dissertation proposal, which was defended in October 2022. This chapter describes my initial approach to this study. The chapter outlines previous research on the topic, focusing on the importance of STEM in society, consequences of the lack of diversity in STEM, the role of community colleges in STEM education, current initiatives in STEM programs, and the development of a science identity. The chapter also discusses my initial research plan, which outlines interviews conducted with program participants, mentors, and the program coordinator; document analysis of program and course materials; and demographic data. Like many qualitative research studies, there were modifications to the design, which are addressed in Chapters Two and Three.
Using an academic paper model, Chapter Two discusses the findings from the study as well as provides recommendations for improvement. The findings of this research suggest that intellectual curiosity and personal goals are the main drivers of interest in science. Hands-on experiences and immersive experiences in science played a major role in increasing the perceived level of competence, performance, and recognition in community college students in STEM. Additionally, finances, family support, access to STEM professionals, and mentoring and guidance played a role in the students’ sense of belonging in science. As a result, the study recommends that resources must be allocated towards increasing access and exposure to science, especially at schools serving underrepresented students, to increase interest in STEM. Higher education institutions must provide holistic mentoring, advising, and guidance programs to ensure students are well equipped to navigate higher education. Finally, colleges and universities must address the disparities in access and opportunities in STEM by providing resources and support for low-income, first-generation, and diverse students in STEM.

Chapter Three is a scholarly reflection of my journey throughout my education at NIU and through this dissertation. This chapter describes how my study evolved through the dissertation process and highlights the changes I went through in my education. Through my doctoral education, my views on research and truth shifted, which reflects on how my approach to answering the research questions changed. This chapter also includes the relevance of my findings and how I plan to use those findings to continue helping increase representation in STEM.
Science, Technology, Engineering, and Math (STEM) professions are among the fastest-growing areas in our nation’s workforce. In addition to providing job security and job mobility, STEM careers provide professionals with high-paying jobs (Bureau of Labor Statistics, 2022). Due to the high demand for STEM professionals in the job market, STEM careers can provide low-income and diverse individuals with a pathway to social and financial mobility (Ice et al., 2022; Starr, 2018).

Currently, the STEM field is one of the least diverse workforces (Fry et al., 2021; Kennedy et al., 2021; Li, 2022). Most of the benefits of being part of STEM are clustered in a small sector of the U.S. population. As a result, while STEM professions can provide financial security to any community member, only selected groups of our nation are currently benefiting from the financial advantages associated with STEM careers. Blacks, Hispanics, and women currently have the lowest representation in STEM (Fry et al., 2021; Kennedy et al., 2021; Li, 2022). Current studies suggest that one of the primary reasons contributing to the low representation of these groups in the STEM workforce is their low enrollment and completion rates in STEM academic programs (Kennedy et al., 2021; Snyder & Cudney, 2017).

Higher education institutions have implemented many initiatives aimed at addressing the low graduation rates of Blacks, Hispanics, and women in STEM programs. Many of these initiatives have been focused on aiding the financial needs most minority students face when attending college (Ghazzawi et al., 2021). Yet, these initiatives have only had limited effects on
the percent of Blacks, Hispanics, and women obtaining STEM credentials (Clark & Esters, 2018). The lack of effectiveness of these initiatives has motivated many institutions to explore novel ways to address the needs of these groups. One area currently getting more attention is the study of how cultural, structural, and institutional barriers influence the decisions of underrepresented students to enroll in and complete STEM programs (Tsui, 2007). These types of studies have highlighted how social, cognitive, and environmental factors can influence the decision of individuals to enroll in and complete a STEM credential (Hazari et al., 2013). However, even though there is an increase in awareness of the importance of environmental factors on student enrollment and retention in STEM programs, there is limited data on how these experiences influence the students' perceptions of STEM programs and themselves as scientists (Kim & Sinatra, 2018). The data is even more limited for underrepresented students in STEM attending community colleges, which often experience entirely different social and financial environments compared to students attending four-year institutions (Rodriguez et al., 2019).

Problem of Practice

Many higher education institutions and federal agencies have been allocating large amounts of resources to finding ways to address the lack of diversity in STEM (Li et al., 2020; Tsui, 2007). These resources have been mainly used to implement initiatives to address pre-identified needs, such as financial insecurity and lack of academic readiness (Dennon, 2021; Li et al., 2020; Mervis, 2018). Many of these initiatives have shown promise to address the needs of low-income, Black, Hispanic, and women students in STEM (Ghazzawi et al., 2021; Li et al., 2020). However, only a limited number of these initiatives have been used to explore the social
and environmental underlying factors preventing low-income and underrepresented students from fully integrating and becoming part of the STEM community (Kim & Orrell, 2022).

Hispanics constitute approximately 17% of the U.S. workforce and Blacks constitute approximately 11% (Fry, 2021). However, only 9% of the STEM workforce are Black, and only 8% are Hispanic (Fry, 2021). Similarly, 7% of all STEM graduates are Black, and 12% are Hispanics (Tichenor, 2021). This suggests that the lack of diversity in the STEM workforce can be traced back to the low graduation rates of underrepresented individuals in college STEM programs. Several factors have been identified as the major contributors to the lack of student diversity in STEM programs. This lack of diversity is often referred to in the literature as the “leaky pipeline” (Hinton et al., 2020; van der Hunk et al., 2018). The leaky pipeline metaphor for STEM education is used to illustrate how low-income, Black, Hispanic, first-generation, and female students interested in STEM programs are lost at different points of their educational journeys (Hinton et al., 2020). Authors have identified leaks at all levels of education, from high school preparation to college experiences and expectations (Hinton et al., 2020).

Authors have identified several social and financial factors provoking leaks in the STEM pipeline. One of these factors is the under-preparedness of underrepresented students to meet STEM program demands. This lack of readiness is sometimes caused by inequitable academic offerings in minority-serving districts. In 2018, it was reported that 25% of Black- and Latinx-serving districts did not offer Algebra II, a course needed to meet course requirements for many STEM programs (Milgrom-Elcott, 2020). Other authors have reported that many minority-serving school districts do not offer any AP math or STEM-related programs (Lichtenberger & George-Jackson, 2012). In 2020 it was reported that more than 90% of school districts primarily
serving Black and Latinx students had reported issues with recruiting and retaining proficient STEM teachers (Milgrom-Elcott, 2020). This lack of access to equitable education often results in students not meeting the requirements to enroll in STEM programs or being able to complete college-level STEM courses successfully. These are examples of how issues in the K through 12 systems often result in underrepresented students “leaking” away from the STEM path (Hinton et al., 2020; Lichtenberger & George-Jackson, 2012; Milgrom-Elcott, 2020).

Post-secondary institutions do not have control over the inequalities diverse students experience during their K-12 education. However, they do have control over what they offer students after enrolling at their institutions. An approach many institutions have taken to improve college readiness is the addition of developmental courses (Harrington & Rogalski, 2020). However, even though the approach is well intended, institutions have not been able to collect evidence to support that adding these developmental courses increases college readiness or completion rates of underrepresented students in STEM (Pennamon, 2019). Furthermore, the data collected from students participating in developmental education suggests that this approach hinders access from underrepresented students to STEM credentials by increasing the length and cost of college education (Pennamon, 2019).

Academic readiness is only one of the many factors contributing to the leaky pipeline in STEM. Kim & Sinatra (2018) and Le et al. (2019) have shown that the decision of a student to enroll in and complete a STEM credential is a multifaceted process. Hinton et al. (2020) found that many students leaking from STEM programs are first-generation students as they often lack a basic understanding of the academic world (Hinton et al., 2020). Additionally, most first-generation students often lack mentoring and support from their relatives throughout their
academic journey (Martin et al., 2020). As a result of the lack of diversity in the STEM field, most students coming from underserved communities are first-generation students (Hinton et al., 2020). This suggests that the lack of support and understanding of the academic enterprise is a major factor contributing to the leaky pipeline of minorities in STEM programs (Hinton et al., 2020; Martin et al., 2020).

A third contributor to the leaky pipeline in STEM is environmental factors such as STEM stereotypes, self-efficacy, motivation, belonging, and engagement (Kim & Orrell, 2022; Le et al., 2019; van den Hunk et al., 2018). Some authors consider these affective characteristics to be the strongest predictor of STEM enrollment and retention rates (Martin et al., 2020; van der Hunk et al., 2018). Authors have evaluated how affective characteristics influence the leaky pipeline by measuring the student’s social capital (Martin et al., 2020). Social capital refers to the emotional gains a student experiences due to social interactions and relationships in the discipline (Marin et al., 2020). Studies have shown that low social capital can be linked to STEM pipeline leakage (Martin et al., 2020). This suggests that the college culture and the way students interact with peers and college personnel can play a crucial role in the STEM pipeline leakage.

Hinton et al. (2020) identified several ways to patch the leaks of underrepresented students in STEM programs. These efforts included a greater focus on experience-based training such as early exposure to research, internships, mentoring, collaboration or group work, and awards as effective strategies for increasing retention and completion rates of underrepresented students in STEM programs. Hinton et al. and others have shown that these activities can improve recruitment and completion rates of diverse students at the college level (Hinton et al., 2020; Martin et al., 2020; van der Hunk et al., 2018). However, most of these studies evaluated
the success of the initiatives solely in terms of retention and completion rates. The focus on recruitment and retention rates often leaves a gap in data on how these experiences influence students’ social capital, such as their perception of themselves as a scientist and their sense of belonging to the scientific community. To better understand how to serve underrepresented students in STEM programs, it is important to understand how these experiences influence the social and cultural capital of underrepresented students in STEM.

Purpose Statement and Research Questions

The purpose of this case study is to explore how student involvement in a community college STEM program influences their science identity development (Chen, 2022; Hazari et al., 2013). The program STEM Community was designed to support low-income and underrepresented community college students pursuing STEM academic programs and careers. The following sub-questions will guide this study:

(1) How do students’ perceived participation in the program influence their interest and engagement with the STEM field?

(2) How does participation in the program influence students’ academic competency and performance in STEM-related courses and programs?

(3) How does participation in the program influence students’ identity as scientists over time?

The goal of this study is to better understand how student experiences through the STEM Community program influence their perceptions, sense of belonging, and interest in STEM. Specifically, this study will focus on how the program’s cocurricular activities influence the science identity development of low-income and underrepresented students in STEM at a
community college. This study will provide valuable information on how low-income and underrepresented community college students internalize the events they experience in the first two years of their college STEM education. This information will provide evidence for STEM programs at community colleges to improve their recruitment and retention initiatives targeting low-income and underrepresented students in STEM.

Review of Literature

This review of literature begins by discussing the importance of STEM in higher education and the consequences of the lack of diversity in STEM. These topics will be followed by a review of the role of community colleges in STEM education, the most prominent initiatives in higher education focused on addressing the lack of diversity in STEM, and the relevance of science identity development in retention and underserved individuals in STEM. This review will close with an overview of the theoretical framework guiding the design and goals of the project.

The Importance of STEM in Society. Science, Technology, Engineering, and Math (STEM) professions are the most rapidly growing sector of the United States workforce (Kennedy et al., 2021; Ouimet, 2015). Prior to the pandemic, the United States Bureau of Labor Statistics predicted that employment in STEM-related fields would increase by approximately 17% between the years 2020 and 2024 (Ouimet, 2015). This predicted increase in job employment was significantly higher than the 12% predicted increase in non-STEM employment (Ouimet, 2015). The U.S. Bureau of Labor Statistics adjusted its employment predictions to account for changes caused by the COVID pandemic. This review resulted in the Bureau of Labor Statistics (2021) identifying between a 4.1% and 8.4% additional increase in the STEM
workforce as a direct result of the increase in computer and internet dependence due to the pandemic. The updated predictions pushed the expected STEM job market increase to almost 26% in the next eight years.

The expectedly large increase in labor in the STEM fields is motivated by a combination of factors. One is the increase in technology-based companies and platforms such as Facebook, Amazon, and Apple (Ouimet, 2015). The U. S. Bureau of Labor Statistics identified the expansion of internet-based items as the major contributor to the increase in STEM positions (Zilberman, 2021). These companies, which operate mostly online, have high demands for programmers, web designers, and other computer-technical professionals to function and meet their customers’ demands. The increase in online demand has not only been observed by these three companies. Many companies have been moving their services online as a way to remain competitive, meet customer expectations, and decrease expenses associated with having a physical location (Kelly, 2020; LaFleur, 2020). However, the accelerated growth in reliance of everyday items such as appliances, watches, alarms, sensors, and communication devices that rely on internet has been the main driver pushing the current and expected growth of STEM careers in the U.S. (Zilberman, 2021).

The increase in demand for STEM professionals has consequences in addition to job security. In 2022, it was reported that STEM-related professions saw an annual mean wage of over $95,000 compared to approximately $40,000 in non-STEM professions (Bureau of Labor Statistics, 2022). This represents approximately a 140% increase in salary from non-STEM professionals and STEM professionals in the current job market. This shows that, in addition to job security, STEM credentials provide financial stability and socioeconomic mobility. However,
the wages are not evenly distributed within the different populations of professionals in STEM. Blacks, Hispanics, and women earn on average less than white men (Fry et al., 2021; Li, 2022). In 2019, the median earning for men was $90,000, compared to $62,200 for women (Fry et al., 2021). This represents only 74% of the median income based on gender. Similarly, the median income for Black workers in STEM in 2019 was $61,100 and $65,00 for Hispanic STEM workers, which are 78% and 83% of the median of a typical White worker, respectively (Fry et al., 2021). This discrepancy in median salary between gender and ethnicity is significant and must be addressed. However, STEM professionals, regardless of their background or gender, still experience annual median incomes higher than most non-STEM professionals.

**Consequences of the Lack of Diversity in STEM.** The current job market and the continued increase in demand for STEM professionals highlight the significance of credentials in STEM. Graduates in STEM experience higher job security, increased job mobility, and higher incomes (Fry et al., 2021; Kennedy et al., 2021; Ouimet, 2015). Overall, STEM careers can provide individuals with job security, competitiveness in the job market, and access to prestigious and high-paying jobs (Bureau of Labor Statistics, 2022; Starr, 2018). This suggests that access to STEM credentials from low-income and diverse communities can provide members of these communities with a path to social and financial mobility—and, thus, better living quality (Starr, 2018).

STEM fields are one of the least diverse fields in the workforce (Kennedy et al., 2021). The lack of diversity in STEM is observed not only in the United States but all over the world (Li, 2022; van der Hunk et al., 2018). Even though the number of initiatives aimed at increasing the number of diverse individuals obtaining credentials in STEM fields has increased over the
years, the percentage of diverse graduates remains stagnant. In 2021, the United States STEM field demographic breakdown was 9% Black, 8% Hispanic, and 13% Asian, compared to 67% White (Fry et al., 2021; Kennedy et al., 2021). These values are even lower in many specific STEM fields. Health-related fields have the highest representation of women, Hispanic, and Black within all STEM professions. Women constitute about 75% of all STEM health professionals. However, women’s representation drops rapidly when looking at other STEM fields. Women constitute 40% of the physical sciences, life sciences, and math professionals, 25% of computer scientists, and only 15% of engineers and architects (Fry et al., 2021). The representation of Black and Hispanic people in most STEM fields is even lower than that of females. Black people comprise approximately 11% of the overall STEM workforce; 7% of computer scientists and 5% of engineers and architects are Black (Fry et al., 2021). Similarly, Hispanic people comprise 17% of the overall STEM workforce but only 8% of the STEM workforce outside health professions (Fry et al., 2021). These numbers bring to light the lack of diversity in most STEM fields and how leaky STEM pipelines are leaving behind underrepresented communities.

Increasing diversity in STEM has implications beyond providing job security and financial stability to individuals. Increasing the representation of individuals from different backgrounds in STEM can strengthen the field by allowing the exploration of new and innovative ideas (Gibbs, 2014). This aspect is very significant as it is imperative for the United States STEM field to remain innovative and cutting-edge for the nation to remain competitive in the global STEM market. Remaining relevant means that the nation will retain its global status and will benefit from the employment and financial opportunities provided by technological
advancements (Gibbs, 2014). To help the nation continue to benefit from innovation and competitiveness in a technologically dependent world, it is important for colleges to identify mechanisms to identify, prepare, recruit, retain, and graduate underrepresented students with STEM credentials. Additionally, the low representation of diverse individuals in the STEM workforce shows how only a selected group in our nation is benefiting and will only continue to benefit from the advantages associated with the increased demand for STEM professionals.

The Role of Community Colleges in STEM Education. Community colleges have been shown to be one of the most effective higher education institutions at increasing the number of diverse professionals entering the workforce (Chen, 2022; Hoffman et al., 2010; Lesesne, 2013; Schwartz, 2020). The open access policies, lower tuition rates, specialized training, and flexible schedules community colleges offer attract a large section of their populations that, without these opportunities, would not be able to pursue post-secondary credentials (Chen, 2022; Hoffman et al., 2010; Lesesne, 2013). Traditionally underrepresented groups and non-traditional students are often the community members that, without community colleges’ benefits, would have no access to post-secondary education (Lesesne, 2013; Lucore, 2012). As a result, most students from underrepresented backgrounds disproportionally enroll in community colleges (Chen, 2022; Lucore, 2012). Hispanics represent approximately 22% of the community college student population and only 13% of public four-year institutions (Ma & Baum, 2016). Similarly, Blacks represent 14% of community college students, compared to 11% of the students enrolled at four-year colleges (Ma & Baum, 2016).

One of the reasons community colleges serve a larger percentage of Black and Hispanic students is due to their affordability, flexibility, and open-access policies (Baylor, 2016). These
policies increase access to higher education to non-traditional students and adult learners, which are often members of underrepresented groups. Approximately 44% of community college students are 25 or older, compared to only 20% of students in public four-year institutions (Ma & Baum, 2016). Additionally, approximately 8% of the students taking courses at a community college have already completed some post-secondary education (Chen, 2022; Lesesne, 2013). This group includes students who have already completed bachelor, master’s, and doctorate degrees (Chen, 2022). These non-traditional students often lack the time or financial support to be able to enroll full-time at a four-year college, thus relying on community college flexibility to achieve their educational goals (Baylor, 2016).

The high number of underrepresented students attending community colleges is only one of the reasons these institutions have the potential to diversify the STEM workforce (Zdravkovic et al., 2022). Community colleges often partner with local public and private institutions to develop curricula that ensure employment after graduation (Lesesne, 2013). Their curricula often include internships or some industrial practice, which allow students to develop the necessary skills to be successful in the field (Lucore, 2012). Additionally, community colleges often hire industry experts as instructors, providing students with a realistic view of the expectations and demands of the job (Lesesne, 2013).

In addition to technical STEM programs, community colleges often serve as the starting field for students interested in a four-year degree. Approximately 80% of the students who start their post-secondary education at a community college are interested in transferring to a four-year institution (Sansing-Helton et al., 2021). Of the students interested in transferring, 75% expressed interest in obtaining a STEM-related degree (Sansing-Helton et al., 2021). However,
even though most students attending community colleges are interested in obtaining at least a bachelor’s degree, only 26% of community college students successfully transfer to a four-year institution (Sansing-Helton et al., 2021). After transferring, their success rates at the four-year institution are often lower than those who started at the four-year institution. For community college transfers, their completion rates at a four-year institution are approximately 45%, compared to 70% for students who began their education at the transfer institution (Handel & Williams, 2012). However, it has been reported that roughly 50% of the students who acquired STEM credentials at a university have taken at least one course at a community college (Snyder & Cudney, 2017).

Studies have associated the low transfer and completion rates of community college students with several factors (Baylor, 2016; Handel & Williams, 2012). A report from the College Board Advocacy and Policy Center identified six factors as the major issues keeping community college students from being successful through and after transferring (Handel & Williams, 2012). Handel identified the complexity of the transfer process, inadequate guidance, non-inclusive institutional policies and practices, rising tuition and fees, inadequate financial guidance, and that transfer students are often the last group to be accepted by four-year institutions as the major issues affecting these students (Handel & Williams, 2012). To be able to diversify the workforce and to increase the number of diverse graduates with certificate, associate, and bachelor’s degrees in STEM, community colleges are tasked with finding ways to address the factors negatively affecting transfer and completion rates of students in STEM.

Current Initiatives in STEM Programs. The lack of representation of Black, Hispanic, and Native American individuals in STEM has been attributed to many factors. Some of the major
barriers are often classified as cultural (social integration), structural (discriminatory acceptance, lack of support, lack of college readiness), and institutional (non-inclusive institutional policies and procedures) (Tsui, 2007). Many local, state, and federal programs have been providing funding and helping implement initiatives in the United States to address some of these barriers. In the K-12 system, many initiatives have been put in place to address college readiness. One of the major obstacles for minority students to enter STEM programs is their math level (Adelman, 2006; Tsui, 2007). This has pushed many K-12 districts to redesign their math courses and create a more rigorous math curriculum. (Tsui, 2007). Other initiatives, such as summer bridge programs, access to dual credit courses, and access to remedial courses, have also been put in place (Hodara, 2013). However, the effects of these initiatives have been minimal in terms of increasing recruitment, retention, and completion rates of diverse students in STEM.

At the college level, faculty mentoring and increased student-faculty interactions have been shown to positively influence recruitment, retention, and completion rates of diverse students in STEM courses. A study completed at the City University of New York (CUNY) showed that intrusive and consistent advising from faculty and staff could positively influence academic performance for community college students (Kolenovic et al., 2013). Similarly, several studies that focused on the effects of structured mentoring on underrepresented minorities in STEM showed that students receiving professional and peer mentoring displayed substantial academic and social improvements (Markle et al., 2022). The article published by Markle et al. on the effects of mentoring on underrepresented minorities highlighted the importance of developing communities and high-quality relationships, increasing the appeal of scientific
careers, and providing trusted support as the key features of effective mentoring and student-faculty interactions (Markle et al., 2022).

Peer mentoring is another activity that has been shown to increase the retention and completion rates of student mentors and mentees in STEM programs. A study presented by Holland et al. (2012) showed that peer mentoring in STEM fields is effective at increasing the retention of students, especially for underrepresented students. Another peer mentoring mechanism that has shown promise in helping students succeed in STEM is “near-to-peer” mentoring (Tenenbaum et al., 2014). “Near-to-peer” mentoring refers to a mentor-mentee relationship where the mentor is close to the social, professional, or age level of the mentee. “Near-to-peer” mentoring in this study was shown to provide students with social support and semi-constructed peer mentoring, which was identified by the participants as very beneficial in their educational path in STEM (Lancaster & Xu, 2017).

The feeling of community and belonging can play a critical part in keeping students, especially diverse students, in STEM (Myers et al., 2015). One of the most common activities for fostering community and a sense of belonging in students at the community college level is involvement in cocurricular activities (Myers et al., 2015). Sithole et al. (2017) discuss how the social interactions between peers in co-curricular and extracurricular activities can positively influence the participant’s perceptions of the field and their relationship to the field, thus increasing persistence in educational programs. These observations are supported by research done by Derby (2006), who observed a strong connection between high academic performance and participation in clubs and organizations among community college students. Another mechanism employed to create cohorts and develop a sense of community and belonging is
cohort courses. Research at the University of Hawaii provided evidence that having STEM students grouped as a cohort helps students create a group identity that positively influences the retention and completion rates of students (National Research Council, 2012).

Hands-on activities and undergraduate research have been shown to increase the retention and completion rates of students in STEM (Jordan et al., 2014; Sun et al., 2020). One of the new trends in undergraduate research experiences is Course-Based Undergraduate Research Experiences, also known as CUREs. CUREs are research-based activities incorporated into the course curriculum as a way to expose all students, regardless of their professional interests, to immersive undergraduate research experiences (Sun et al., 2020). CUREs, as well as any other form of undergraduate research, have been shown to engage participants in thinking like a scientist, develop an interest in science and scientific research, and increase interest in pursuing a science-related career (Corwin Auchincloss, 2014). Undergraduate research experiences have been shown to be very beneficial in increasing diversity in science-related programs. In addition to providing diverse students with an immersive science experience, these programs also provide participants with mentors in the field and cultivate an environment of teamwork and cohort building (Corwin Auchincloss, 2014).

Many initiatives have been implemented at the college level to increase the interest, recruitment, retention, and completion rates of diverse students in STEM. However, even though a large amount of money and time has been dedicated to addressing the lack of diversity in STEM, the overall outcomes of these initiatives have been minimal (Li et al., 2020; Tsui, 2007). Often, initiatives aimed at increasing recruitment and retention are only evaluated based on changes in recruitment and retention rates (Hinton et al., 2020; Martin et al., 2020; van der Hunk
This approach provides limited information about how these initiatives can be modified to better serve underrepresented students. A more holistic approach to evaluating the effectiveness of this type of initiative is by evaluating how these experiences are being perceived by the students (Tsui, 2007). This approach can provide more information about the intended and unintended consequences of each initiative, thus providing a better understanding of the effects of the experiences on the participants. Consequently, it would be beneficial to take a deeper dive into these initiatives to evaluate how they influence the student’s perception of science. This data can be used to implement fundamental changes in current STEM-focused initiatives to improve and broaden the impact of these approaches.

**Developing a Science Identity.** Identity is an “internal positional designation” (Carter et al., 2013, p. 204) created by the way an individual defines themselves and their role in relation to their surroundings and as a member of a group (Carter et al., 2014). Individuals are often motivated to look for environments that match their identities. Based on their interactions with that environment, identities get strengthened or weakened (Carter et al., 2014). Due to the dynamic nature of identities, individuals can modify or even change their identities throughout their lives as a result of their interactions with their surroundings (Amiot et al., 2015).

Faculty mentoring, peer mentoring, cohort building, extra- and co-curricular activities, and social activities have been shown to have the potential to positively influence the science identity of students (Corwin Auchincloss, 2014; Derby, 2006; Holland et al., 2012; Kolenovic et al., 2013). Many studies suggest that these types of experiences improve success in STEM by positively influencing the way students view and interact with science and the scientific community (Carlone, 2004; Carlone & Johnson, 2007; Le et al., 2019; Puente et al., 2021). Due
to the significance of science identity in the recruitment and retention of students in STEM, especially underrepresented students, current research on equity and inclusion in STEM has taken a deeper understanding of the science identity development of students (McDonald, 2019; Puente et al., 2021).

Puente et al. (2021) studied the development of the science identity of high school students. In the study, Puente et al. found that students viewed by their peers as science people display higher science identity scores than those not considered a science person by others. In this study, Puente et al. also found that Latinx and Black students have lower science identities than Asian and white students. Additionally, within each ethnic group, females display lower science identity scores than males. Puente et al. also identified first-generation status as a predictor of the students’ science identity level. First-generation students exhibit lower science identity scores than any other group (Puente et al., 2021). Puente et al. associated the lower science identity of first-generation students with experiencing lower recognition by others as science people.

Hazari et al. (2013; 2010) have also studied the relationship between ethnicity, gender, and science identity. Hazari et al. (2010) found that students with a stronger physics identity display a higher likelihood of choosing a career in a physics-related program. In this study, Hazari et al. also found that extra and cocurricular activities, such as laboratory experiences that aligned with the student’s beliefs, student engagement with the course material and their peers, and the frequency of support and encouragement by others to pursue a career in science, positively influenced the physics identity the participants. Lastly, this study found evidence to support other studies that indicate that females, on average, exhibit lower physics, or more
general, science identity than males. However, Hazari et al. showed evidence that suggests that incorporating activities in the classroom that challenge stereotypes of science can positively influence the science identity of females while causing no significant change in the science identity of males. This observation supports the idea that science identity is a fluid characteristic that can be modified by environmental factors and experiences.

In another study focused on college students, Hazari et al. (2013) studied the relationship between science identity and race, ethnicity, and gender. In the study, Hazari et al. found that, on average, college students have low science identity scores. The study identified that females in some specific disciplines of science display lower science identity scores than males. However, Hazari et al. could not show that science identity differences were prevalent in all STEM fields. Hazari et al. found that in many STEM fields, it was difficult to disaggregate ethnic and gender differences in science identity as they were all interconnected (Hazari et al., 2013). However, in terms of ethnicity, Hazari et al. found that Hispanic females exhibited the lowest science identity.

Carlone & Johnson (2007) studied the science identity development of 15 women of color through their undergraduate and graduate education and after entering the STEM workforce. In this study, Carlone & Johnson found a strong connection between recognition and the science identity level of the participants. Carlone & Johnson observed that the external recognition received by the participants directly influences their own recognition of themselves as a science person. This external feedback was used by some of the participants as a way to determine what type of science person they were (Carlone & Johnson, 2007). Similarly, Carlone & Johnson reported that competence, or the capability to be successful in the field, was strongly linked to the scientific identity of the participants. Participants who felt successful in their
courses or when completing science-related tasks felt a stronger sense of belonging to the science field, resulting in a stronger science view of themselves as scientists.

Many other authors have shown strong connections between participation in science-related events and changes in science identity. However, most of these studies have been done on either K-12 systems or at four-year institutions. This has resulted in little information about how participation in science-related events influences the science identity of students attending community colleges. Community college students experience the academic world differently from K-12 students and students attending four-year institutions. Due to the discrepancy in needs and the way community college students interact with education, it will be important to understand how participating in science-related activities influences the science identity of community college students.

Theoretical Framework

Science identity development will serve as the theoretical framework for this study. As defined by Kim & Sinatra (2018), a science identity is the general sense an individual has with regard to science. In other words, science identity represents how an individual feels about whether they belong in the scientific world. In general, it is believed that the science identity of an individual is a result of experiences in science educational settings, including experiences with peers, teachers, professors, mentors, and materials in the science setting, and how those experiences have influenced the individual’s perception of self with regards to science (Kim & Sinatra, 2018). To better understand how all these experiences influence the science identity of an individual, Carlone and Johnson (2007) described science identity as a field composed of three main domains: competence, performance, and recognition. Competence represents the
knowledge and motivation each individual needs to succeed in a field; performance represents the capability of an individual to demonstrate knowledge to self and others; and recognition represents the effects of positive reinforcement or acknowledgment received by themselves or others about one’s scientific competency (Carlone & Johnson, 2007).

In Carlone and Johnson’s (2007) framework, having a strong science identity implies that the individual has demonstrated a deep understanding of scientific content, possesses the necessary skills to validate scientific knowledge to themselves and others, and has experienced recognition of their science capabilities by themselves and others. One of the limitations of Carlone and Johnson’s framework is that the framework assumes that individuals have a natural interest in science. In Carlone and Johnson’s study, all participants were professionals in a STEM-related job; thus, all have already demonstrated a natural interest in science (Carlone & Johnson, 2007; Chen & Wei, 2020). However, not all individuals, even the ones enrolled in STEM-related programs, might share the same interest in science (Hazari et al., 2010).

Vincent-Ruz & Schunn (2018) expands beyond Carlone and Johnson’s three constructs and identifies three main events that drive the science identity development of an individual. Vincent-Ruz & Schunn identified (1) a sense of community and affiliation; (2) built by consistent extrinsic and intrinsic attitudinal factors; and (3) a match between school science and real science as the three main drivers of science identity development (Vincent-Ruz & Schunn, 2018). In the paradigm, a sense of community and affiliation refers to the perception of the student regarding their belonging to the science field. This domain reflects the individual’s perception of science, cultural norms, interactions with members of the scientific community, and how influential others (family, friends, teachers) perceive the scientific world in relationship
to the individual (Vincent-Ruz & Schunn, 2018). The second domain—built by consistent extrinsic and intrinsic attitudinal factors—represents the interest and motivation of the individual to learn and engage in science-based activities. This domain is mostly driven by the motivation of the individual to take part in science activities. Engaging in these activities would lead individuals to make more science-related choices, thus allowing the immersion of the individual in the scientific world (Vincent-Ruz & Schunn, 2018).

The third domain is the match between school science and real science. This domain focuses on the capability of the student to compare and contrast the type of science that they are exposed to in the classroom to what a real scientist does in the real world. This domain is often a reflection of the exposure the student had to the real scientific community. Many underrepresented students have minimal to no exposure to members of the scientific community; thus, their views of the scientific world can be inaccurate. These inaccuracies can play a role at the time of choosing to pursue a STEM career (Vincent-Ruz & Schunn, 2018).

Hazari et al. (2010) found that interest in a field plays a crucial role in the professional identity development of individuals, especially those who have not yet made a final decision about their major. Many first- and second-year college students have not solidified their career path. Instead, many are still trying to identify their interests. Since not all students, especially first- and second-year students, have a similar level of interest in science, a fourth domain regarding interest should also be considered when evaluating the science identity development of individuals (Chen & Wei, 2020; Hazari et al., 2010).

This study will use the construct developed by Hazari et al. (2013) of science identity development. A science identity development framework has been effectively used to identify
how views and attitudes toward science can be used to predict involvement in science-related activities (Kim & Sinatra, 2018; Vincent-Ruz & Schunn, 2018). Additionally, a science identity development framework will allow this student to evaluate how the student’s experiences throughout the program influence different aspects of the student’s social and academic engagement. As described by Kim & Sinatra (2018), the science identity development framework works under the following assumptions: (1) that all individuals have the potential to develop a science identity; (2) that science identity is a process that develops over time; and (3) that the interactions between an individual and their surroundings influence their science identity development (Kim & Sinatra, 2018).

Hazari et al.’s science identity framework is based on Carlone and Johnson’s (2007) work on science identity development which identifies performance, competence, and recognition as the main three domains influencing the science identity development of students. Figure 1 illustrates how each of the four domains contributes to the science identity development of individuals.

This study will explore students’ science identity development using the modified version of Carlone and Johnson’s interactionist approach to science identity development used by Hazari et al. (2010) and Chen & Wei (2020). In this study, science identity will comprise four domains: competence, performance, recognition, and interest.
Description of the Case

The data for this study will be collected from a public community college located in a rural district in the Midwest. The community college enrolls approximately 11,000 students a year. Like most community colleges, the institution serves mostly local students. Approximately 80% of the student population is considered “in-district,” and only about 2% is considered international. The college’s student body is approximately 57% female and 43% male. Approximately 60% of students are part-time, and approximately 44% of students are between the ages of 17 to 20 years of age. Most of the students enrolled at the college are Caucasian. Non-Caucasian students comprise approximately 45% of the students on campus. Within the non-Caucasian population, approximately 16% are African American, 9.5% Hispanic or Latino, 6.8% Asian, and 3.7% Nonresident Alien students. The college also serves students with an array
of different needs. Approximately 6% of students are veterans, 22% are first generation, 4% with identified disability accommodations, 21% are not college-level ready, 11% are low socioeconomic status, and 2% are English limited.

Students enrolled at the institution have a variety of educational goals. Since the college is located close to a four-year institution, the college serves many students as a pathway for transfer. Approximately 46% of the students currently enrolled at the college are planning on transferring to a four-year institution, while 20% are enrolled in training and technical programs. Of the transfer students, 47% are STEM majors. In STEM, 43% of the students are minorities, and 84% come from low-income households.

**STEM Community Program**

In 2021 the college received a five-year National Science Foundation (NSF) award to fund an in-house program to increase the recruitment, retention, and completion rates of low-income and diverse students in STEM programs. The initiative was aimed at addressing the equity gaps in retention, completion, and transfer rates of low-income students in STEM programs by providing participants with financial assistance, academic support, and social engagement. The program was officially funded by the NSF in the Spring of 2021 and was instituted at the college in the Fall of 2021. The program has a principal investigator (PI) and two co-PIs, all of them faculty members at the institution. The program is expected to serve a total of four cohorts of 10 students each through their two years at their college. This program is expected to impact a total of forty students in a five-year time span.

The program builds on existing institutional initiatives and other strategies taken by other institutions that have been shown to be successful at increasing recruitment, retention, and
completion or transfer rates of low-income and diverse students in STEM programs. One of the major factors affecting these students is financial uncertainty. Throughout their two years in the program, participants will receive $2,450 dollars in financial assistance each semester. As a result, each participant can earn $9,800 of financial assistance thought their two academic years in the program. The financial assistance earned through this initiative is supplemental to any state and federal financial aid each participant may receive.

In addition to receiving financial support, each program participant is expected to engage in five co-curricular activities. These activities include faculty and graduate student mentoring, a STEM introductory course, financial assistance, undergraduate research experiences, and social events. Three science faculty members at the institution will serve as faculty mentors to the participants. Each student will be assigned to a faculty mentor, and they will be expected to meet a minimum of eight times each semester. They will also have a minimum of two meetings over the summer. The meetings are expected to focus on coursework, navigating the institution, utilizing institutional resources, and planning for the future. However, mentor meetings are not expected to be limited to those topics but instead are expected to help students help participants succeed in higher education. Similarly, each participant is paired with a graduate student mentor in a field similar to the participant’ field of study. Graduate student mentor meetings are variable depending on the mentor and mentee availability. The goal of their meetings is to help participants gain a better understanding of graduate school, and allow them to see themselves as potential graduate students.

Starting the second year of the starting of the program, participants will engage in peer mentoring. First-year students will participate as mentees and second years students will serve as
mentors. This in-program mentoring system will be supplemented with external mentoring from other local STEM-focused student chapters. This will ensure that both first- and second-year students have access to peer mentors. Mentoring in this program is not expected to happen in isolation. The program will host mentoring events, which will include different types of social events such as lunches, discussions, research observations, and field trips.

During the summer, participants are encouraged to participate in a paid undergraduate research experience. With the help of faculty mentors, each student will apply to participate in a STEM-related summer research internship. The research experiences will cover a variety of STEM-related fields, such as engineering, biology, geology, physics, chemistry, and math. The experiences will also include different experimental modalities such as computational, benchtop, and field-based research. To ensure that all participants will have access to summer research internships, each summer there will be research opportunities through partnerships with local institutions.

To provide cohort students with a support system outside the program, participants will be expected to join and participate in at least one college-wide student organization. The college-wide organization will provide participants with talks about relevant topics in the field, social activities, additional opportunities to integrate into the college community, and an additional layer of mentoring. The college’s STEM-related clubs, ethnic clubs, and other academic-related clubs are expected to be some of the clubs students will be engaging with.

The last initiative of the program is the participation in a STEM introductory course. This course will be taught by the program coordinators and will focus on teaching participants about research methods, facilitating peer mentoring, connecting participants to institutional resources,
field trips, professional development seminars, and preparation for summer research opportunities. Additionally, this course will include seminars focused on preparing participants for transferring to research-focused institutions and will utilize alumni panels as a way to help participants navigate STEM education.

Program participants are selected through a collaboration between the Admissions office and the program coordinators. Participants must meet the following minimum requirements to qualify for the program: (1) demonstrate financial need by being Pell-eligible; (2) have a minimum of 2.5 high school GPA and score at least a 21 on their ACT; and (3) complete the program application form which includes questions about their personal and professional goals. The pool of potential participants will be evaluated by the program coordinators, and the project team will make their final selections based on academics, financial needs, and majors. To continue in the program, participants must remain in good standing at the college. The program defines good standing as maintaining a GPA of 2.5 or above and keeping their full-time status. In addition, participants must comply with the attendance requirements for mentoring appointments and other events and activities coordinated through the project.

Research Design

The goal of this case study is to explore how co-curricular initiatives influence the science identity development of underrepresented students in STEM. Specifically, this study aims at understanding how the science identity development of underrepresented community college students in STEM is influenced by their experiences during their first two years of college. As defined by Rahman et al. (2021) and Kuan et al. (2019), co-curricular activities are opportunities provided to students with the goal of supporting, complementing, or enhancing
student learning. In addition to complementing the academic curriculum, co-curricular activities are aimed at helping students develop their personalities and improve the classroom experience (Rahman et al., 2021). In this study, co-curricular activities include those involving interactions between the students and the college and those required as part of any course they are taking. Co-curricular activities in this project include academic advising, mentoring, internships, participation in student organizations or college events, financial assistance, research experiences, peer interaction, student-faculty interactions, and any other activity associated with a class.

This study will operate under a constructivist framework. A constructivist approach is based on the idea that knowledge is constructed by individuals as a result of their interactions with their environment (Crotty, 1998; Dawadi et al., 2021; Yilmaz, 2008). In this framework, there is no absolute truth; instead, individuals create their own truth based on how experiences and events are perceived and internalized by the observer. Since there is no absolute truth, the main goal of a constructivist is to gather as much information as possible about how the participants experience a phenomenon to be able to rely on as much information as possible about the participant’s experiences (Creswell & Creswell, 2018; Dawadi et al., 2021). To obtain a broad and rich understanding of how individuals experience events, constructivists rely on open-ended questions and multiple methods of qualitative data collection to be able to interpret the subjective meanings the participants created through their experiences (Creswell & Creswell, 2018).

Individuals from low-income and diverse backgrounds are often underrepresented in the STEM field (Zilberman, 2021). Due to their lack of representation in STEM, there is a growing
interest in obtaining more in-depth information about their experiences through STEM education at the college level. There is also a need for information about these student groups’ experiences in STEM at community colleges. To better understand the journeys of low-income and underrepresented students in STEM at the community college level, this study will provide a platform for low-income and diverse students to share their unique experiences through STEM. These experiences will be used to gain a better understanding of how STEM initiatives at community colleges influence the identity development of low-income and diverse students in STEM.

Methodology

This study will use an instrumental case study design (Merriam & Tisdell, 2016). A case study is a qualitative research model in which “the researcher develops an in-depth analysis of a case, often a program, event, activity, or process” (Creswell & Creswell, 2018, p. 14). An instrumental case study approach allows a researcher to gain a better understanding of a particular issue that is directly related to the primary overarching issue (Hancock & Algozzine, 2017; Jones et al., 2014). In this study, an instrumental approach will allow the researcher to better understand how participation in cocurricular activities influences the science identity development of low-income and underrepresented students in STEM at a community college. Studying how co-curricular activities influence the identity development of students will help understand how student experiences during their first two years in college influence their decision to complete STEM-related courses and programs.

The case in this study is a STEM Community program offered at the community college. This program provides participants with financial, social, and academic assistance. The STEM
Community program is a two-year program and targets low-income and underrepresented minorities in STEM. The program consists of two cohorts of 10 students, one first-year and a second-year cohort. To participate in the program, each student must show financial need and must be a member of an underrepresented group, which includes first generation and ethnically underrepresented in STEM. Program participants receive financial assistance and are strongly encouraged to participate in activities focused on increasing their social and cultural capital through their two years in the cohort. The program expects that participation in the program activities will increase the social and cultural capital of the students, thus positively influencing their science identity development. Science identity development has been shown to be instrumental in the retention of students in STEM (Sithole et al., 2017; Windsor et al., 2015). Understanding how these initiatives are influencing the science identity development of the participants can provide valuable information about how science identity is shaped in community college students. The evidence collected through this case study can be used by higher education institutions to identify novel ways to address the low recruitment and retention rates of low-income and underrepresented students in STEM programs at community colleges.

**Selection of Participants**

This study will use a purposeful sampling strategy as described by Jones et al. (2014). Purposeful sampling is a participant selection process in which the researcher selects individuals based on shared knowledge or experiences related to the phenomenon of interest (Jones et al., 2014; Palinkas, 2016). This study focused on how participation in the STEM Community program co-curricular activities influences a student’s science identity development. To gain a robust understanding of the phenomenon, all program participants will be invited to participate in
this case study. The program serves twenty students each year; 10 first-year students and 10 second-year students who have already completed one year in the program.

**Data Collection**

Multiple methods of collecting qualitative data will be implemented to ensure the accuracy of the findings (Creswell & Creswell, 2018). Acquiring data through multiple methods will allow me to triangulate or use different data sources to provide a comprehensive understanding of the observations (Carter et al., 2014). Qualitative data will be collected through three main methods: document analysis, semi-structured interviews of participants, and semi-structured interviews of program coordinators and mentors. Demographic data of all program participants will be provided by the institution.

**Demographic Data**

All participants’ demographic data will be collected from the institution through their Office of Internal Accountability and Research and Financial Aid Office. Demographic data includes biological sex, race, financial needs, academic standing, and ethnicity. Program coordinators will collect and provide data on student engagement (attendance) in each of the program activities.

**Document Analysis**

The first method of data collection in this study will be document analysis. Document analysis is an approach for gathering evidence based on evaluating printed and electronic documents with the purpose of eliciting meaning, gaining knowledge, and creating empirical knowledge (Bowen, 2009). These documents must be created without the researcher’s intervention and should be directly related to the research question (Bowen, 2009). The
document analysis will be focused on a pre-selected set of program and course documents. Program documents to be evaluated in this section will include recruitment materials, informational materials, and promotional materials about program activities created by the program coordinators. The goal of evaluating program documents is to gain a better understanding of how the program is trying to address their needs/develop a scientific identity.

In addition to program materials, this study will evaluate course materials associated with a course all program participants are required to take. As part of the program, participants are required to take an Introduction to Science course each semester. This study will use the course syllabus and materials related to some of their most recent activities to gain a better understanding of the participant’s experiences through the course and program. The information obtained from these documents will be supplemented with faculty observations on the level of engagement each participant has with the course activities, peers, and the instructor.

**Student Interviews**

The second method for qualitative data collection will be semi-structured student interviews. First and second-year participants will be interviewed once at the end of the fall semester to gather evidence on their experiences and science identity development. The interview protocol will consist of a card-sorting activity and approximately twenty open-ended questions. The card sorting activity will be focused on gaining a better understanding of the student’s perceived identity, and the open-ended questions will focus on exploring the four domains related to the science identity development described by Hazari et al. (2013) and Chen & Wei (2020). The interviews are expected to be 45 minutes long. The end-of-the-semester interviews will provide valuable information about the early changes first-year participants might
be experiencing as a result of being part of the program. Additionally, late in the fall semester, interviews will give an opportunity to collect rich data from second-year students on how participating in the program for over a year has influenced science identity development.

**Interviews of Program Mentors and Coordinator**

The third method of qualitative data collection is semi-structured interviews with the program coordinator and mentors. Each mentor and coordinator will be interviewed once at the end of the fall semester. The interviews are expected to last approximately one hour. The interview protocol will contain approximately twenty open-ended questions to provide a platform for coordinators and mentors to describe their goals of the program, the intent behind the activities included as part of the program, and an overview of their involvement and interactions with the students. These interviews will provide background and context to the program design and activities and provide a deeper understanding of the program as a whole. These interviews will also provide information about participant engagement and progress through the program that might not be observed during the participant’s interviews.

**Data Analysis**

This study will analyze qualitative data collected using a thematic approach (Jones et al., 2014; Saldaña, 2021). Findings obtained by each data collection method will be subjected to review by the source. In the case of document analysis, the program coordinators will be involved in verifying the finding associated with evaluating the document analysis findings. Findings related to the interview will be shared with the interviewees to ensure the findings reflect their unique views. Finally, all data collected through all three approaches will be compared as a way to ensure the trustworthiness of the finding of the study using triangulation.
Document Analysis

Document analysis will be performed using the approach described by Bowen (2009). Bowen describes that documents are often evaluated by a superficial examination, followed by thorough reading or examination of the documents, and finally, an interpretation of the document. The interpretation process often involves a thematic analysis of the content. A thematic analysis is the study of data by identifying patterns in the data. Initially, documents are evaluated by the presence of important topics or codes. Recurring codes, or patterns, are grouped into themes that represent the overarching findings of the document analysis. This process often requires multiple evaluations of the evidence to ensure all codes and themes are identified. For this process to be effective, the researcher must evaluate the documents objectively and with sensitivity, making sure that all codes, including subtle ones, are identified. Findings from the document analysis section will be shared with program coordinators to make sure the findings accurately reflect the content of the document.

Interviews

Interviews will be video recorded and transcribed. Recordings will be deleted after data is transcribed. Interview transcripts will be evaluated using a thematic approach, as described by Maguire & Delahunt (2017). A thematic analysis is a process of evaluating qualitative data, such as transcripts, by identifying patterns or themes (Maguire & Delahunt, 2017). In this thematic approach, the data will be evaluated using a six-step process. The first step will be to get familiarized with the data. Becoming familiar with the date will be done by reading the transcripts multiple times and writing notes and impressions of the transcripts. The second step will be to generate initial codes. In this study, since the goal is to identify how the participants’
experiences influence their science identity development, the researcher will use a theoretical
thematic approach. As defined by Braun & Clarke (2006), a theoretical thematic analysis is
driven by specific research questions, which in this study are the domains identified in the
theoretical framework. In step three, the researcher will search for codes that align with the
science identity development domains. In the fourth step, the researcher will focus on
aggregating codes into larger themes. Step five will be the review of themes. This will include
the review of themes by the researcher, the interviewees, and at least one additional source to
ensure that the themes identified are logical and accurately represent the perspectives of the
participants. The sixth and final step in the process will be defining themes. In this step, each
theme will be defined as a way to explicitly describe what the theme represents.

Limitations and Delimitations

The goal of this study is to determine how co-curricular activities influence the science
identity development of low-income and diverse STEM majors. Specifically, this study
investigates if there is a relationship between the science identity development of students and
their retention and completion rates in STEM courses and programs. It is not the intent of this
study to explore other student populations outside low-income, diverse, and community college
students in the rural area of the Midwest who had declared a major in a STEM-related field and
are participants of the selected program. This study limits the types of co-curricular activities to
those identified under methods, and no other activity was included in the study. This study does
not intend to evaluate how factors external to the program, such as personal or work-related
events, might have affected the students’ outcomes. Additionally, this study collected limited
data on how each participant interacted with the institution outside of the program.
Data about the relationship of the participants with their instructors, classmates, student services professionals, and other college personnel was limited to those shared by the participants during the interview, so important data about how these interactions affected the participants’ experiences might have been missed. Interview data will only be collected from a small sample of participants. Samples only represent a small fraction of the population of interest; thus, the data obtained through this study might not reflect all outcomes experienced by the participants. However, it is not the intent of the study to identify all possible outcomes of each initiative but to bring to light how a sector of low-income and diverse students internalized the program experiences and to investigate how those influence their science identity development.

**Trustworthiness**

Trustworthiness for the qualitative data analyzed in this study will be established by using a triangulated data collection analysis (Saldaña, 2021). Initially, interviews will be recorded and transcribed using a recording device. As suggested by Saldaña (2021), the initial codes will be identified during the transcription process. In addition to transcripts, other non-verbal observations will be collected during the interview as a source of data for the triangulated analysis. Non-verbal cues and other interview observations will be recorded in a reflective journal. Transcripts will be analyzed using a theoretical thematic approach, and emerging codes will be discussed with participants and program coordinators. To ensure that the final themes accurately represent the perspectives and experiences of the participants, final themes will be defined and shared with program participants for a final review. The constant communication with program participants will help ensure that the final themes accurately reflect their voices.
and experiences as part of the program. By combining transcript evaluation with observational data, peer review evaluation of emerging themes, and a final review of the interview outcomes by the participants, this study aims at ensuring that the data is accurate and reproducible.

Data Management Plan

Data regarding enrollment, retention, and graduation will be tracked through the institution’s Office of Institutional Accountability and Research (IAR). The Dean of Institutional Effectiveness will be responsible for ensuring that data is accurately collected and maintained. IAR will keep electronic copies of all data collected from the program. Data will be stored for a minimum of 10 years on secure institutional servers; paper copies will also be retained in locked filing cabinets in the IAR office until the project ends. The Dean of Institutional Effectiveness will also ensure all project records, data, reports, and communications are stored securely digitally (and as hardcopy when necessary) throughout the project period. All electronic data/server storage costs will be covered by the college. Data formats to be stored include the following: text documents (e.g., .docx), spreadsheets (e.g., .xlsx), desktop publisher documents (e.g., .pub), and PDF.

Positionality Statement

As a low-income, Hispanic, and ESL professional in the STEM field, I have faced many barriers in my academic, personal, and professional life because of my background. As an undergraduate student, I participated in undergraduate research and was a member of the American Chemical Society student chapter, and those experiences played a very important role in my personal and academic development. As a STEM educator, I approached this study with the goal of gaining a better understanding of the experiences community college students in
STEM acquire through participation in extra- and co-curricular activities and how these initiatives impact students’ view of themselves as scientists. As an employee of the institutions where the participants attend, I believe it is important to understand how our interactions with students are perceived and internalized by them.

I also work with the coordinators of the program. While I am not part of the program, I understand the extra and co-curricular activities students participate in and their intent. This knowledge helps me better understand the students’ experiences but could cause me to impose on the study an unconscious preconceived notion of their experiences. I expect that the combination of qualitative data collection methods will help minimize the effects of my program knowledge on the outcomes of the study. I believe that allowing participants to share their experiences through their own perspectives will provide new information about the participants’ own journeys and will help me better understand how faculty, staff, and administrators can better serve the needs of students pursuing credentials in STEM programs. While conducting this research, it was very important for me to ensure that my personal experiences and views did not influence the interactions with the participants and were not reflected in how the data this study obtained and analyzed.

Significance

This study aims at understating how some of the most prevalent initiatives targeting low-income and diverse students in STEM programs influence their science identity development. The findings of this study could better inform higher education institutions on best practices to address the barriers low-income and diverse students face when attempting to gain credentials in any STEM-related field. Little is known about how the science identity develops during the first
two years of post-secondary education, and the lack of data in this field is even more prevalent when focusing on low-income and diverse students in STEM. Evidence is especially lacking on how extra and cocurricular activities influence the science identity development of participants and whether the science identity development of each participant can be used as a predictor of retention and completion of STEM courses and programs.

This study will provide valuable information about how STEM students develop their science identity through their first years of college education. Understanding how their identity develops will inform higher education institutions on how to increase retention and completion rates of low-income and diverse students in STEM. This knowledge can help higher education institutions decrease the inequity gap in retention and completion of STEM credentials, which can have significant social and financial implications. Increasing the number of low-income and diverse graduates in STEM will provide members of these communities with credentials that will increase their competitiveness in the job market and their average annual income, job security, and financial mobility. Additionally, increasing the diversity in the STEM field will allow the field to diversify its ideas, approaches, and goals: items extremely important for the field to remain relevant in the global markets. Creating a diversified STEM workforce will not only help the low-income and diverse community benefit from the increasing demand for STEM professionals and higher salaries but also help the nation remain competitive in the increasingly technologically dependent world. This is significant as the financial stability of most advanced nations depends on their capability to meet the needs of a world that is rapidly becoming more diverse.
CHAPTER 2

“IT SOLIDIFIED MY POSITION THAT I SHOULD BE IN SCIENCE.”: A CASE STUDY ON HOW PARTICIPATING IN A STEM INTERVENTION PROGRAM INFLUENCES THE SCIENCE IDENTITY DEVELOPMENT OF LOW-INCOME STUDENTS IN STEM AT A COMMUNITY COLLEGE.

Introduction

Science, Technology, Engineering, and Math (STEM) professions are among the most rapidly growing sectors of the United States workforce (Kennedy et al., 2021; Ouimet, 2015). The increased demand for STEM professionals has resulted in STEM graduates experiencing higher job security, job mobility, and incomes (Fry et al., 2021; Kennedy et al., 2021; McDonald, 2019; Ouimet, 2015). However, STEM is among the workforce's least diverse fields (Fry et al., 2021; Kennedy et al., 2021; Li, 2022). Blacks/African Americans, Hispanics/Latinx, and women are considered some of the major historically marginalized groups in STEM (National Science Foundation [NSF], 2023). Only 9% of the STEM professionals in the United States are Black and 8% identify as Hispanic, compared to 67% as White (Fry et al., 2021; Kennedy et al., 2021). Women represent over 50% of the STEM workforce, but their representation is disproportionate across different STEM fields. Women represent 85% of all health-related bachelor’s degrees but only 22% of engineering and 19% of computer science degrees (Fry et al., 2021). Historically marginalized groups' lack of representation in the STEM field, including individuals from low-income backgrounds, exemplifies how the benefits associated with STEM careers cluster in a small sector of the U.S. population.
The lack of representation in STEM fields is noticeable in STEM programs at the college level. Underrepresented students have lower enrollment and completion rates in STEM programs (Kennedy et al., 2021; Snyder & Cudney, 2017). Blacks and Hispanics constitute approximately 31% of the U.S. population but only between 7% and 12% of all college STEM graduates (Tichenor, 2021). Several factors have been suggested to play a role in the lack of student diversity in STEM programs. These factors include a lack of access to equitable K-12 education, STEM mentors and role models, and academic and career advising (Lichtenberger & George-Jackson, 2012; Milgrom-Elcott, 2020). This lack of support often results in underrepresented individuals not considering STEM as a possible career path.

To address these inequities, STEM intervention programs (SIPs) have been developed to help underrepresented students navigate STEM education to pursue STEM careers. The most common practices within SIPs are supplemental learning, mentorships, skill-building opportunities, financial assistance, socialization opportunities, and bridge programs (Palid, 2023). These intervention approaches have been shown to positively affect the experiences of historically marginalized students in STEM programs. However, despite the prevalence of SIPs at higher education institutions, the representation of historically marginalized individuals in STEM remains low. The slow increase of representation in STEM suggests that to scale SIPs programs effectively, colleges need to better understand how historically marginalized students experience SIPs.
Purpose Statement and Research Questions

This case study aims to better understand how participation in a STEM Intervention program (SIP) influence the science identity development of low-income students in STEM at a community college. This study is guided by the following questions:

1) How do low-income students develop an interest in careers in STEM?
2) How do low-income and underrepresented students at a community college develop and sustain their science identity?
3) How does participating in the program influence students' science identity development over time?

Findings from this study will help higher education professionals understand community college students’ experiences in STEM education as well as how to expand SIPS offerings to increase recruitment, retention, and completion rates of underrepresented students in STEM programs.

STEM Education at Community Colleges

Community colleges have historically played a major role in diversifying the workforce (Burris et al., 2022; Chen, 2022; Hoffman et al., 2010; Lesesne, 2013; Schwartz, 2020). Their open access policies, lower tuition rates, specialized training, lower student-faculty ratio, and flexible schedules provide individuals with increased opportunities and flexibility to pursue post-secondary education (Chen, 2022; Hoffman et al., 2010; Lesesne, 2013). Low-income and non-traditional students and students of color disproportionally enroll in community colleges compared to 4-year colleges and universities (Chen, 2022; Lucore, 2012). Approximately 40% of community college students are low-income (Fountain, 2019). Similarly, about 44% of community college students are 25 or older, compared to only 20% of public four-year
institutions (Ma & Baum, 2016). Hispanics represent 22% of the community college student population, compared to 13% of public four-year institutions (Ma & Baum, 2016). Blacks represent 14% of community college students, compared to 11% of the students enrolled at four-year colleges (Ma & Baum, 2016). The higher number of historically marginalized group members enrolled at community colleges allows these institutions to increase the representation of these individuals in the workforce.

Community colleges diversify the workforce by providing students with flexible paths to earn credentials. Students can complete certificates, which are often short, affordable, and provide real hands-on experience in the field (Jepsen et al., 2023). The most common certificates are obtained through Career and Technical Educational (CTE) programs. CTE programs are often created in response to local and national job demands, providing students with direct access to jobs (Starobin, 2010). In addition to certificates, community colleges offer associate degrees and transfer programs. Associate degrees give students access to higher-paying jobs and often provide the foundation for a four-year degree (Jepsen et al., 2023). Transfer programs allow students to start their bachelor’s degree at a community college, giving them access to low tuition, low student-faculty ratio, and flexible schedules (Josuweit, 2017). Many community colleges support their transfer effectiveness with articulation agreements with neighboring four-year institutions. These agreements ensure that students transfer successfully to the four-year institution and that their credits are accepted by the institution (Lavinson, 2021; Sansing-Helton et al., 2021; Starobin, 2010).

One major role of community colleges is to help students transition to a four-year institution. Approximately 80% of the students who start their post-secondary education at a
community college express interest in transferring (Sansing-Helton et al., 2021). Within this group, about 75% express interest in obtaining a STEM-related degree (Sansing-Helton et al., 2021). However, only 26% of community college students successfully transfer to a four-year institution, and their success rates at the four-year institution are often low. Only 45% of community college students who successfully transferred were able to complete their degree at a four-year institution (Handel & Williams, 2012). Studies have associated the low transfer and completion rates of community college students with the complexity of the transfer process, inadequate guidance, non-inclusive institutional policies and practices, higher tuition and fees, inadequate financial guidance, and late admissions by four-year institutions (Baylor, 2016; Handel & Williams, 2012). These factors disproportionally affect low-income and diverse students, contributing to their low representation in STEM.

**STEM Intervention Programs**

Colleges and universities have been working on finding ways to increase interest, recruitment, retention, and completion rates of low-income and diverse students in STEM programs (Cessna et al., 2018; Corwin Auchincloss et al., 2014; Derby, 2006; Holland et al., 2012; Lichtenberger & Geroge-Jackson, 2012). These programs have included faculty mentoring programs, peer mentoring programs, and participation in STEM student organizations. Faculty mentoring programs have positively influenced recruitment, retention, and completion rates of historically minoritized students in STEM courses. For instance, Kolenovic et al. (2013) found that intrusive and consistent advising from faculty and staff can positively influence academic performance for community college students. Similarly, peer mentoring has been shown to increase retention and completion rates of student mentors and mentees in STEM programs,
especially for underrepresented students (Holland et al., 2012). Social interactions between peers in co-curricular and extracurricular activities positively influenced the participant’s perceptions and relationship to the field, resulting in higher persistence rates (Sithole et al., 2017). Community college student participation in STEM clubs and organizations was connected with high academic performance (Derby, 2006).

Undergraduate research experiences (UREs) have been shown to increase the retention and completion rates of students in STEM (Bangura, 2014; Jordan et al., 2014; Lopatto, 2017; Sun et al., 2020). Undergraduate research experiences are teaching-oriented activities that employ the scientific method or an engineering design process to investigate a problem with an unknown solution to the student and faculty (Patton & Hause, 2020). The most common way undergraduate students access undergraduate research opportunities is by enrolling in a research course, summer research program, or Course-Based Undergraduate Research Experiences (CUREs) (Patton & Hause, 2020). While undergraduate research experiences were originally limited to research-focused institutions, in recent years non-research institutions have increased their access to UREs for their students (Patton & Hause, 2020). Community colleges are increasingly adding CUREs to foster students’ interest and performance in STEM programs (Bangera & Brownell, 2014; Corwin Auchincloss et al., 2014; Lo & Le, 2021; Smith et al., 2021). This expansion has been catalyzed by the increase in collaborations between community colleges, local research-focused institutions, and private industry (Patton & Hause, 2020). The expansion of URE offerings at community colleges has the potential to positively impact representation in STEM programs. Undergraduates who participate in this type of research-immersive experience report positive outcomes, such as learning to think like a scientist, finding
research exciting, feeling part of the scientific community, and intending to pursue graduate education or careers in science (Bangera & Brownell, 2014; Corwin Auchincloss et al., 2014; Kardash, 2000; Laursen et al., 2010; Lopatto, 2010; Patton & Hause, 2020).

Faculty mentoring, peer mentoring, cohort building, extra- and co-curricular activities, and social activities have been shown to have the potential to positively influence the identity development of students (Corwin Auchincloss et al., 2014; Derby, 2006; Holland et al., 2012; Kolenovic et al., 2013). Many studies suggest that these types of experiences can improve success in STEM by positively influencing the way students view and interact with science and the scientific community (Carlone, 2004; Carlone & Johnson, 2007; Le et al., 2019; Puente et al., 2021). Due to the significance of science identity in the success of students in STEM, especially underrepresented students, current research on equity and inclusion in STEM has taken a deeper look into understanding the science identity development of students (McDonald, 2019; Puente et al., 2021).

Conceptual Framework

The conceptual framework guiding this study is science identity development (Kim & Sinatra, 2018). Science identity is shaped by how an individual experiences science education, including interactions with peers, teachers, professors, mentors, and materials in the science setting (Kim & Sinatra, 2018). A science identity comprises three domains: competence, performance, and recognition (Carlone & Johnson, 2007). Competence represents the knowledge and motivation each individual needs to succeed in a field. Performance represents the capability of an individual to demonstrate knowledge to self and others. Recognition represents the effects of positive reinforcement or acknowledgment received by themselves and others about one’s
scientific competency (Carlone & Johnson, 2007). Three main factors drive the science identity development of an individual: (1) a sense of community and affiliation; (2) built by consistent extrinsic and intrinsic attitudinal factors; and (3) a match between school science and real science as the three main drivers of science identity development (Vincent-Ruz & Schunn, 2018).

Sense of community and affiliation refers to how the student perceives they belong in the science field. This domain reflects the individual’s perception of science, cultural norms, interactions with members of the scientific community, and how influential others (family, friends, or teachers) perceive the scientific world in relationship to the individual (Vincent-Ruz & Schunn, 2018). The built by consistent extrinsic and intrinsic attitudinal factors—represents the interest and motivation of the individual to learn and engage in science-based activities. This domain is mostly driven by the individual’s motivation to participate in science activities. Engaging in these activities could lead individuals to make more science-related choices, thus allowing the immersion of the individual in the scientific world (Vincent-Ruz & Schunn, 2018).

The third factor is the match between school science and real science. This focuses on the capability of the student to compare the type of science that they are exposed to in the classroom to what a real scientist does in the real world. This domain often reflects the student’s exposure to the real scientific community (Vincent-Ruz & Schunn, 2018).

The student’s interest level in pursuing a STEM field is crucial in their professional identity development, especially those who have not yet decided on their major (Hazari et al., 2010). Many first- and second-year college students have not solidified their career path. Instead, many are still trying to define their interests. Since not all students, especially first- and second-year students, have a similar level of interest in science, a fourth domain regarding interest
should be considered when evaluating the science identity development of individuals (Chen & Wei, 2020; Hazari et al., 2010). Figure 2 illustrates the intersectionality of each domain contributing to the individuals' science identity development.

This study will use the construct developed by Hazari et al. (2013) of science identity development. Hazari et al.’s science identity framework is based on Carlone and Johnson’s (2007) work on science identity development which identifies performance, competence, and recognition as the main three domains influencing the science identity development of students. However, as Hazari et al. described, a fourth domain focused on interest will be included in this study. First- and second-year STEM students often display different levels of interest in sciences; thus, the fourth domain will allow for understanding the role of attitudinal aspects in their identity development.

Figure 2: Science identity intersectionality between all four domains: competence, performance, recognition, and interest.
Description of Case

The data was collected from a public community college in a rural district in the Midwest. The college enrollment is approximately 11,000 students a year. The college’s student body is approximately 57% women and 43% men. Approximately 60% of students are part-time, and approximately 44% of students are between the ages of 17 and 20 years of age. The racial and ethnic demographics were 55% Caucasian, 16% African American, 9.5% Hispanic/Latinx, 6.8% Asian, and 3.7% Nonresident Alien students.

The college serves students with an array of different needs. Some of the most prominent groups are 22% first generation, 21% academically not college ready, 11% low socioeconomic status, 6% veterans, 4% with at least one disability accommodation, and 2% English limited. The institution also serves students with a variety of educational goals. Due to the proximity of the college to a four-year institution, the college serves many students interested in transferring. Approximately 46% of the students currently enrolled at the college are planning on transferring to a four-year institution. Of the transfer students, 47% are STEM majors. In STEM, 43% of the students are minorities, and 84% come from low-income households.

The SIP program that this case study focused on is the STEM Community program. The STEM Community program is a five-year National Science Foundation (NSF) funded program offered at the community college focused on increasing representation in STEM. The program provides participants with financial, social support, and academic assistance. The program consists of two cohorts of 10 students, one first-year and one second-year cohort. To participate in the program, each student must be majoring in science or engineering and demonstrate financial need. Programs under health professions are excluded from participating in the
program. Participants can be enrolled in a two-year program at the college, including certificate, associate in science, or transfer program. Members of an underrepresented group including first generation and ethnically underrepresented in STEM are prioritized in the selection process.

Program participants receive financial assistance, must enroll in an introduction to science course, are paired with a faculty mentor, a graduate mentor, and a peer mentor, and are required to participate in activities focused on increasing their social and cultural capital. The goal of the course is to expose participants to the science field, help them connect with professional in their field of interest, help them identify experience opportunities in their fields, and help them craft professional materials such as cover letter, and personal statements. Three STEM faculty members at the institution, including the program coordinator, served as faculty mentors to the participants. Students were assigned to a faculty mentor based on their field of interest. Mentors met with their mentees a minimum of eight times each semester. Table 1 includes faculty mentors and their respective fields of study. Pseudonyms were assigned to improve confidentiality (Heaton, 2022). The meetings mainly focused on academic and career advising, and social and emotional counseling.

Table 1

<table>
<thead>
<tr>
<th>Name</th>
<th>Field of Study</th>
<th>Teaching Subject</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice</td>
<td>Biochemistry</td>
<td>Chemistry</td>
<td>Faculty mentor</td>
</tr>
<tr>
<td>Carl</td>
<td>Physics</td>
<td>Physics</td>
<td>Faculty mentor</td>
</tr>
<tr>
<td>Bree</td>
<td>Microbiology</td>
<td>Microbiology</td>
<td>Faculty mentor</td>
</tr>
</tbody>
</table>

Participants were paired with a graduate student mentor in a field similar to the participant’ field of study. Graduate student mentor served as a venue for participants to be
introduced to research and graduate studies. First year participants were assigned a second-year program mentor. The goal of the second-year mentor was to increase connections between the first- and second-year cohorts, and to provide first-years with extra resources at the college. Finally, the program offered participants the opportunity to engage in many social and scientific events, including picnics, scientific conferences, outreach opportunities, research fairs, and scientific talks.

Methodology and Methods

The goal of this case study (Merriam & Tisdell, 2016) is to understand how engagement in co-curricular STEM programs influences the science identity development of community college students. A case study is a qualitative research model in which “the researcher develops an in-depth analysis of a case, often a program, event, activity, or process” (Creswell & Creswell, 2018, p. 14). This case study will utilize several data collection mechanisms, including participant interviews, faculty interviews, and document analysis. This study is framed by constructivism, which views knowledge as created by individuals as a result of their interactions with their environment and others (Crotty, 1998; Dawadi et al., 2021; Yilmaz, 2008).

Participants

This study will use a purposeful sampling strategy (Jones et al., 2014). Purposeful sampling is a process in which the researcher selects individuals based on shared knowledge or experiences related to the phenomenon of interest (Palinkas, 2016; Jones et al., 2014). All participants of the STEM Community program were invited to participate in the study. Twenty students were initially invited to participate in the study (10 in the first-year cohort; 10 in the second-year cohort). A total of 17 students, eight first-year students and nine second-year
students, agreed to participate in this study. The remaining three had left the program and did not respond or declined to participate in the study. Table 2 includes the demographic information of the 17 participants. Pseudonyms were assigned to enhance confidentiality (Heaton, 2022).

Data Collection

Data were collected through multiple methods—semi-structured interviews of participants, mentors, and the program coordinator and document analysis—which aligns with case study research (Creswell & Creswell, 2018; Merrian & Tisdell, 2016). All 17 participants participated in a semi-structured interview (see Appendix A) that lasted between 45 and 70 minutes. During the interview, participants engaged in an identity card-sorting activity (Le et al., 2019). In this activity, participants reflected upon their identities and made connections on how these identities influence their perceptions, interest, and engagement with the STEM field. Three sets of questions followed the card-sorting activity. The first set focused on their experiences with the STEM field. The second section focused on understanding their perceptions of science and themselves as scientists. The last set focused on their experiences in the STEM Community program.

Document analysis was performed to supplement the interview data gathered (Saldaña, 2021). Program course syllabi were used to map the participants’ experiences throughout the program. Additionally, at the end of each semester, participants submitted an essay reflecting upon their experiences through the program and their perceptions of themselves as scientists. These documents supplemented the data collected through the participant’s semi-structured interviews.
Table 2
Participants’ demographic data from the Office of Internal Accountability and Research.

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Age</th>
<th>Gender</th>
<th>Low-Income</th>
<th>1st Gen</th>
<th>Race/Ethnicity</th>
<th>Major</th>
</tr>
</thead>
<tbody>
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<td>White</td>
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</tr>
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<tr>
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<td>Woman</td>
<td>Y</td>
<td>Y</td>
<td>White</td>
<td>Biology</td>
</tr>
</tbody>
</table>

Program mentors (2) and the program coordinator also participated in semi-structured interviews (see Appendix B) lasting between 50 and 75 minutes. Interviews began with a card-sorting activity. During the card-sorting activity, participants were asked to identify identities that describe themselves, followed by the ones describing “a scientist,” and ending with the ones they believed described the program participants. The program coordinator and mentors reflected on what identities empowered them as scientists and connected the identities they identified as prominent in scientists and the program participants. The card-sorting activity was followed by three sets of questions. The first set of questions focused on their journeys as scientists, followed by questions on their views and understanding of science and the scientific community. The
interview portion concluded with questions about the program activities, goals, and expected outcomes.

Data Analysis

The data analysis and findings of this study were driven by the data collected through the first- and second-year participant interviews. I transcribed each interview and read them multiple times (Saldaña, 2021). I completed multiple rounds of In Vivo coding during and after the transcription process to ensure the voices and views of the participants guided the data analysis (Saldaña, 2021). After completing various rounds of In Vivo coding, I engaged in axial coding. This allowed me to compare codes between interviews, remove redundant codes, and group codes into broader categories (Saldaña, 2021). After codes were grouped into categories, a round of focused coding was employed to identify the most frequent codes or categories per cohort (Saldaña, 2021). Categories identified through axial coding were compared with the four science identity development domains (Chen & Wei, 2020; Hazari et al., 2010). A researcher journal containing analytic memos, quotes, and other reflections was collected during each coding round and was used to support the final codes.

Program activities and intent were evaluated through document analysis (Saldaña, 2021). Syllabi for each program course were collected. Each syllabus contained a weekly schedule including all activities program participants were expected to attend, any assignment or reflection they were expected to complete, and a list of expected outcomes for each initiative. Course syllabi helped map the participants’ experiences through the program. Participants’ interview data and syllabi content were supplemented with data from the program coordinator and mentor interviews. I transcribed the program coordinator and mentor interviews and coded
them using a similar approach as described for the participant interviews. Data obtained through these interviews were used to gain a deeper understanding of (1) the intended outcomes of the program activities; (2) the strengths and weaknesses of the program; (3) the level of engagement of each participant with the program; and (4) the program coordinator and mentor’s perception of how participants are changing as a result of being part of the program.

End-of-the-semester reflections written by the participants were used to triangulate the participant’s experiences through the program (Carter et al., 2014; Saldaña, 2021). Each student’s reflection provided supporting data to better understand their unique experiences as part of the program and a deeper view of the participant’s emotional journey. Each reflection was analyzed using focused coding (Saldaña, 2021). Focused coding allowed me to use the codes identified during the coding of the interviews. Data obtained through the coding of the reflections were used to triangulate the data shared by each participant and to understand better how their views of science and the scientific community have changed as part of the program.

Trustworthiness

The trustworthiness of this study was ensured by combining multiple sources of data with constant communication with program participants and staff (Carter et al., 2014; Jones et al., 2014; Saldaña, 2021). The use of multiple data sources, combined with collaboration with program participants and staff during the data analysis, was used to ensure the credibility, dependability, transferability, and confirmability of the study (Jones et al., 2014). The credibility of the findings was ensured by having a prolonged engagement of the participants with the outcomes of the study, also referred to as member-checking (Jones et al., 2014). Throughout the data analysis process, participants had the opportunity to review their transcripts, the codes, and
the overarching themes and provide feedback to the researcher about the study results. Participants’ end-of-the-semester reflections were used as secondary data sources to support the codes obtained through the interviews (Jones et al., 2014). End-of-the-semester reflection analysis and the data collected through the mentor interviews were used to tie the findings and increase the confirmability of the study (Jones et al., 2014).

To increase the trustworthiness of the study, I used a triangulated data analysis approach (Carter et al., 2014; Saldaña, 2021). Triangulation is using multiple data sources to develop a comprehensive understanding of a phenomenon (Carter et al., 2014). Data collected through interviews, document analysis, and observational data were compared to verify all findings (Jones et al., 2014; Saldaña, 2021). Preliminary results were shared with all program participants through a one-hour session with both cohorts, the program coordinator, and mentors. During the session, I showed participants the main outcomes of the student. I allowed them to elaborate on their experiences and comment on any outcome of the study. After each session, preliminary results were re-evaluated to ensure that the outcomes presented directly represented the individual and collective experiences of the program participants. By supplementing the thematic analysis of transcripts with document analysis, engaging participants in reviewing the data and outcomes, and creating a platform for participants to evaluate the results of this study, this study ensured that the data presented accurately represents the participants’ voices (Jones et al., 2014; Saldaña, 2021).

Positionality

As a low-income, Puerto Rican, and ESL professional in the STEM field, I have faced many barriers in my academic, personal, and professional life. As an undergraduate student, I
participated in several co-curricular activities, which played an important role in my personal and professional development in pursuing a B.A. and M.A. in chemistry. I have experienced many obstacles low-income, diverse students experience in STEM education firsthand. I have also experienced how co-curricular activities can influence how individuals experience STEM education. I believe that my experiences provide me with an understanding of how different historically marginalized individuals experience STEM education.

As a STEM educator, my goal is to understand how community college students experience STEM education and how these experiences influence their science identity development. As an employee of the institution where the participants attend college, it is important for me to understand how our interactions with students are perceived and internalized by them. As a colleague of the program coordinator, I did have a basic understanding of the intent of the program activities. Before starting this study, this knowledge provided me with familiarity with the program design and its intended outcomes. I minimized my preconceived notions about the program's potential success by employing multiple methods in data collection to allow for different perspectives and support conclusions.

Findings

This study sought to understand how low-income students, many that also held other minoritized identities, involvement in a community college STEM program influences their science identity development. Participants indicated that early exposure to science and scientists sparked their initial interest in STEM. Participants shared that the program provided helped them see themselves more like a scientist through exposure to the STEM community, a broader view of career paths within STEM, hands-on research experience, connections with professionals in
their field of interest, personal and academic advising, and mentoring. Second-year students discussed being more confident in their potential to become a scientist and a more realistic understanding of what it means to be a scientist. The following outlines these findings in more detail.

**Becoming a Scientist: Early Motivations & Continued Support**

Participants identified curiosity as a main motivator in pursuing a STEM degree. Many participants identified their need to understand their surroundings as driving their interest in science. Commonly, participants identified needing to know the “why” of things as the reason they decided to pursue a career in STEM. Jasper stated:

> I’m constantly, just always looking up things, trying to learn the next thing. All the time. I'm constantly thinking, you know, looking at things. How does that work? Why does it work? So personally, I just feel like learning science and being a science learner. It's sort of a huge part of how I function.

Similarly, Robin explained:

> I'm eager to learn like I want to, really badly. So, it's like I want to understand things, and I want to know how things work. So, I think being open to learning is going to be the most helpful thing.

Participants shared this tendency toward wanting to understand their surroundings. The inclination to learn more about how the world works fueled their interest in science.

Participants discussed wanting to understand how things work as a reason to pursue a career in science. Leo and Daisy discussed how intellectual curiosity drove their interest in science. Leo discussed having “science in [his] head,” meaning he was constantly trying to understand why things are. He explained, “So, I'm just in my head just like thinking about, ‘Oh, I wonder how this plant like does this.’ and makes like all of these plants stuff compared to this one based off like what color it is.” Similarly, Daisy stated:
I'm a very big thinker. Like I'm constantly thinking and stuff or asking questions about things in the world and how they work. And I'm just very driven to understand the world that way. And I think I am so curious about things that I am really going into the science field just felt right for me because, well, I want a career that has a purpose, and then I feel like science always has a purpose.

Participants identified intellectual curiosity as the spark that motivated them to consider science a viable professional path. Their tendency to want to find out how things work provided them with the motivation to explore a career in STEM.

First- and second-year participants identified early exposure to science as one of the main drivers of their intellectual curiosity. Participants identified participation in science events and engagement with online science videos and apps as major experiences sparking their scientific curiosity. Muriel discussed how her high school science teacher pushed her to participate in science fairs. She shared, “I had a [high school] teacher… she was involved in our life, and I loved it.” Initially, Muriel shared that she wasn’t as engaged, but her teacher forced her to participate in these events, “we enjoyed her classes and science fairs… actually, she forced me to go because, when you're in high school, you just want to have fun with your friends”. She then added that the more she participated, the more she enjoyed them, stating, “She really was the one that made me really like, become curious. I should say, like become really curious about science.” Muriel also talked about how her science teacher was very compassionate, and she felt like the teacher truly cared about her. These early positive experiences with science played a role when she was choosing a major.

Similarly, Leo and Jasper shared how science demonstrations in school made them curious about science. Jasper shared:

I think the most enjoyable, maybe for everyone, were these science demonstrations, the classic ones. Like, oh, we made this thing turn from blue to orange. Or hey, here's what
happens when you put it like hexafluoride, something like that, inhale it, and now you have a deep voice. Helium. Now he has a very high voice and then hydrogen in a balloon, and he hits it with fire, the thing explodes, that stuff too. Little kid me was just enamored that, you know, how can I be in a position where I can do stuff like that? Sure. Glorified. Still really cool.

Some demonstrations participants identified were in class, while others were at school events. Regardless of the nature of the scientific demonstrations, participants identified being exposed to science early in their educational path and being able to relate science to their everyday life as one of the main events that sparked their interest in science.

However, not all participants discovered their interest in prior entering college. Luna, a 33-year-old non-traditional student, discovered her interest in STEM through a “happy accident”; she shared. When Luna enrolled at the college, she was interested in entering the horticulture program which to her “was not science” since the program is under the division Career and Technical Education (CTE). As with most CTE programs, the courses are non-transferable to four-year degrees. Luna shared: “When I first came back, I knew I would want to transfer eventually”. Her academic advisor “instead of putting me in the plant and horticulture program, which is only an associate degree program. They put me in the Ag transfer program.” The Ag transfer program requires students to take a major’s chemistry course. Luna was not prepared to take a college level chemistry course at that point in time, so she did not perform as well as she wanted. She added: “It was just like my first real chemistry class since, ever really… It was hard.” However, even though she was not ready to take the course, she developed an interest in STEM, specifically chemistry. Luna continued: “I was taking a soils class and the soils-based chemistry lab at the same time. And I was kind of striking to see how those fit together.” This experience made her discover her interest in science. Luna shared: “I didn't start coming to
school for science”, but she said that taking the course “took me down a whole new path that I had not ever before considered. So that was really cool.” Luna decided to retake the course, “I'm doing it again right now actually and passing it now.” Luna described the whole experience as a “happy accident” she said. She explained: “I'm going to call it that honestly, because had I not done that, then I wouldn't be sitting right here.” Luna’s experience shows that interest in science can be sparked at any point in the student’s academic path, and it can be unexpected. Adult-leaners, similar to younger students, often lack exposure and understanding of the STEM field, which keeps them from developing an interest in a career in STEM.

Participants talked about how online applications such as YouTube, Instagram, Twitter, and Google were and continue to be a driver of their interest in science. Bruno shared:

I follow a couple of different accounts on Instagram and Twitter of like EMS [Emergency Medical Services] things and like Combat Medicine and those kinds of things…that kind of stuff like that stuff is super interesting to me because it's helpful for the job that I was doing, but it's also like I want to continue doing that in the future.

Similarly, Samuel discussed that he would watch YouTube when he was younger. By watching online videos, he learned about projectile motion. He shared, “I thought it was cool. How they can figure out; they could predict the future with the present… I wanted to know why it worked.” He indicated that he “wasn't so much about the theoretical models. It was also like the practical applications I saw, like robots and motors. And I wanted to make that myself.” Participants indicated that access to science and scientific discoveries through social media help foster their interest in science.

In addition to intellectual curiosity or knowing how things work, participants discussed making meaningful contributions and reaching financial security as motivators to pursue science as a career. Many participants referred to these goals as “dreams.” Regarding the significance of
these dreams, Gary said, “The only thing that influences me or drives me to like to keep on going towards science is just my dream.” Similarly, Samuel shared that “dreams” keep him motivated. He shared, “I like to dream big. That's because whenever I'm not like motivated, I just look back at the dream I have, and it makes me want to achieve it more”. Dreams, for many of the participants, were what motivated them to study science and what kept them interested in the field.

Participants often connected “dreams” to more tangible outcomes. These outcomes included making a difference in the world and helping others. Robin and Daisy believed that having STEM credentials would allow them to make a positive impact in their communities. Robin stated, “my goal is to make the world more accessible for people with disabilities because the world is not accessible for everyone. And I think that that's kinda bogus. So, I'd like to do something about it.” Similarly, Daisy shared that she wanted to “create something that has a lasting impact on our civilization” and was “determined that going into the science field would give me a good purpose in life or at least make me feel like I had a good purpose.” For many participants, being able to make meaningful contributions meant having the power to make changes. They saw credentials in STEM as a way to improve their communities and to do something they considered significant.

Many participants discussed how their “dream” involved reaching financial stability. They saw careers in science as a path to financial and social mobility. Gary and Mike, both first-year participants, talked about how credentials in STEM can give them a path to higher earning incomes, thus, financial security. Gary shared, “Well, honestly, it's all because of the money.” He explained,
Yeah. I mean, like, obviously STEM majors, like engineering or like nursing or being a doctor, it brings you a lot of money. So, like, I think it's like really be worth it to at least invest my time into science and at least make it part of who I am, to at least have a better major in the future.

Mike also shared a desire to be financially stable. He said,

I knew I wanted to do more than just work my high-school jobs that I always had. But I wanted to, like, I wanted to finally be able to support myself, but I wanted to make this… sort of my compromise to myself. It's like something I cared about. But I could hopefully make enough to where like I'm not working paycheck to paycheck anymore.

Daisy indicated that returning to school was a way for her to earn a higher salary. She shared,

I wouldn't be honest if I said, like, money wasn't a factor. I mean, that's one reason why I did go back to school because I was like, “Wow, the job that I had really good at paid really well,” but I got in there like I snuck my way in there somehow, but they really wanted people who have a bachelor's degree. So, I was like, “Well, if this is the kind of job that I like and this is something I want to do.”

Daisy realized that for her to advance in that area and make a higher wage, she needed to get a degree.

Talia discussed the need to earn college credentials in a more general manner. Talia talked about how earning college credentials would help her be financially stable. To her, pursuing a science career would “give me more stability in my life.” She stated,

It's like there's a lot I can do without a degree in this society at this point. That's part of it. And I just want to make a career getting something that I actually enjoy. A lot of the jobs now that pay well now require a bachelor's, master’s.

Talia believed that earning STEM credentials was the only way for them to access intellectually stimulating careers and a good wage.

Participants shared many reasons for their interest in science. Overall, all participants shared an innate intellectual curiosity and a desire to understand their surroundings. Some participants indicated that their interest in science was motivated by early exposure to science.
The early exposure for some was a result of participating in science events, such as science demonstrations at their schools, or through teachers who pushed them to participate in science events. For others, the exposure and engagement with science happened virtually through online social platforms such as YouTube, Instagram, and Google. Regardless, all participants shared that early exposure played a role when deciding to attend college and picking a major.

A second major motivator of their interest in science was “dreams” of making a positive impact on the world and financial freedom. Participants shared that STEM credentials were for them a way to reach careers that are intellectually stimulating and with the potential to have a positive influence on society. This included helping others, creating useful items, and having a long-lasting impact on the world. Participants also saw STEM credentials as a path to financial stability. Many participants believed that to earn a good wage, they needed to have college credentials.

**Hands-On Experience Increased Confidence**

Participants identified “doing” science as a primary contributor to their perceived confidence in becoming a scientist. Many first-year participants had limited to no access to hands-on science experiences. This limited access to science resulted in first-year participants displaying varied levels of confidence in becoming a scientist. In contrast, all second-year students participated in some form of Undergraduate Research Experience (URE) over the summer. Seven second year participants participated in an eight-week Research Experience for Undergraduates (REU) program over the summer, Nina completed an undergraduate research experience part-time, and Abe completed an industry-sponsored internship. In all cases, all nine second-year students worked as scientists for eight weeks. Additionally, they participated in
many scientific events, including talks, fairs, and symposiums, and met many professors, researchers, and graduate students in their fields of interest. Through those interactions, students had the opportunity to experience science firsthand, which increased their confidence in becoming a scientist.

First-year students often expressed that due to their lack of experience in science, they are not confident they can become a scientist. For instance, Muriel shared that she was initially very excited about being part of the STEM Community program and becoming a scientist. However, after starting the program and seeing the academic and time demands of being a STEM major, she considered switching majors. Muriel said:

I don't even know if I'm gonna be a scientist anymore. But am I going to continue to be a science learner? I feel like I got the potential. But I don't know. Like I just I feel like when I think about everything else this time, I believe I have the potential, but I might have to make some sacrifices.

Similarly, Robin shared that their confidence in becoming a scientist was not very high. She indicated that her lower confidence level was partially a result of low exposure to the STEM field at a younger age. Regarding their potential to become a scientist, Robin shared:

I'm not super confident. I feel like I can probably be a PE teacher pretty well… But like, as far as science, like working in the lab and doing research, I really struggle seeing myself doing that kind of thing. That’s just because it's never been within my reach before, I never thought about it, and for a long time, I felt like I didn't wanna do it or that I had no interest in doing it just because I felt like I couldn't.

The lack of exposure to STEM has resulted in the participants struggling to see themselves be able to become part of the scientific community.

The role of early exposure and representation in the field was a common theme among first-year program participants regarding their perceived potential to become a scientist. This resulted in many participants believing that STEM careers were out of their reach. Cheryl shared:
It's not like there is a lot of encouragement for them [students of color] to seek education, especially in science. So sometimes I feel like I don't belong. Or sometimes I feel like maybe I should choose something else just because it's not encouraged.

This lack of exposure, combined with a lack of encouragement at the schools experienced by low-income and students of color to pursue careers in STEM fields, seemed to play a role in keeping many participants from envisioning themselves as scientists.

Many participants identified a lack of knowledge in STEM, mentoring, role models, and guidance as the foundations for struggles to feel like they belong in the field. The lack of belonging played a role in their perception of their potential to be successful as STEM professionals. Ray, a first-year participant, shared:

I feel like it's always been hard for me to, like, interact in science or have a different opinion about science, especially because I guess I was an immigrant and back home, like you don't have a lot of education. Like you're only like… you're open to seeing what your education lets you see, basically.

Ray also added:

I feel like society has set norms where they put up minorities in this group. So, I feel like that's how we tend to think that we're not capable of doing more than what society says we can do. So, I feel like that's why we also don't see a lot of minorities in the stem field. Because we tend to believe like all of those are for smart people, though, I'm not capable of doing what they do.

The lack or limited access to opportunities to experience science firsthand and limited access to STEM professionals resulted in many first-year participants struggling to see themselves as a scientist. This caused many participants to doubt their potential to become a scientist, limiting their interest in pursuing a career in STEM.

The lack of mentoring in STEM at their high schools and the lack of representation in STEM played a similar role in their interest in science. Some participants shared how they felt STEM education was not presented to them as a viable option. Initially, when Muriel was
exploring career options, she said she wanted to see someone who looked like her in the field. Seeing someone who shared some of her experiences would have helped her see potential in pursuing a career in that field. Muriel shared, “When I was looking up people, I was going for more people that looked like me… I needed to see myself… like a black woman. Somebody that has gone over everything and is doing what they love.” Similarly, most participants believed that being from a low-income family makes it harder for them to succeed in STEM. Robin shared, “You can still be interested regardless of your background.” But interest was insufficient to succeed in STEM if you did not have the financial recourses or support. Robin added, “But it makes it more complicated to get into it [science] if you don't have money or if you are from a different area where you are not as exposed [to STEM].” These participants’ experiences highlight how interest in STEM is influenced by their intellectual curiosity and perceived access to the field.

Second-year participants indicated higher levels of confidence regarding their competence in STEM. Participants attributed their increased competence with their participation in a summer Research Experience for Undergraduates (REU). Having the opportunity to work in the field and interact with current scientists helped them see potential in themselves to be successful in the field. Daisy and Talia shared that being able to do research over the summer and work in a research laboratory gave them the confidence to say they are part of the scientific community. Daisy shared,

The REU thing is also really beneficial because I feel like getting us all to do research over the summer, I think, helps solidify a lot of people's goals in wanting to do research. And then also my kinda took the scare out of that. So, the next time I go into a lab is not going to be my first time, so I'm not going to feel completely stupid. So that was a really good thing too. I'm glad that we were pushed to do the research experience over this
summer because I don't think I would have progressed so far this semester if I wouldn't have that over to the summer.

Initially, many participants were skeptical about participating in the REU program. Luna shared that she was nervous when she started her REU. She stated, “I was so scared.” However, after participating in the REU, her confidence in becoming a scientist improved. Luna added, “But I think once I got there and started doing it, it was it again; it solidified my position that I should be in science.” Luna continued, “I don't think I would've really considered research or academia as before.” Talia had a similar experience. Talia shared that her “ability to do what I'm doing has improved because of the (REU) program. Like now, like if I feel like I want something, I've just got to do it.” The increased sense of belonging REU provided students was due to the increased positive interactions participants had with scientists in the lab and with science. Jasper felt that the REU allowed him to be part of the scientific community and be a scientist. Jasper shared, “In that period of time, I really got to be a scientist. I got to every question that I had… answer from, you know, whoever else was nearby, or I figured it out myself through the testing and creation phase of the project.” The opportunity to be a scientist and be immersed in the scientific field allowed second-year students to feel part of the scientific community, increasing their perceived potential to become a scientist.

The participant’s change in attitude towards science after the summer research experience became evident to all three faculty mentors. Alice, faculty mentors and program coordinator described the impact of participating in REUs as “hugely transformative” for all second-year participants. Faculty mentor, Bree, also saw the impact of REUs on program participants. Bree shared that during the first year, “we tell them we're setting you up for this research experience and they have no idea what that looks like. They have no idea what that means. They don't really
even know what research is like.” Bree continued, “But after having done the research experience, that's when I saw the biggest difference.” Bree got to see second-year participants working in their labs and heard them share their experiences with their peers and first-year program participants. Bree continued, “their confidence was very high, [they] had a better idea of what the future could look like”, which made participants “excited about their future”. All three program mentors believed that being able to work as a scientist for a summer allowed participants to create a more realistic view of what is like to be a scientist, which allowed them to fully commit to their science education.

In addition to engaging in science and with the scientific community, second-year participants presented their research and results at several scientific events. Presenting their scientific results positively impacted their perceived recognition as scientists. Nina shared how significant it was for her to feel like the owner of her scientific discoveries and have other members of the scientific community give her that recognition. She shared,

My groundbreaking spot was doing research, but not when doing the research. At the point when I was writing my abstract. I was putting my name on the abstract and my poster. I was putting my name on the poster. I went to DC and talked about my experiences, and it was me. It wasn't anybody else they wanted to know about me and what my team had done. But when I said like my team, it sounded as if I'm not; I'm not a student anymore.

Daisy shared a similar experience. Daisy talked about the importance of receiving positive feedback from her summer research advisor after one of her presentations.

Especially when presenting my research over and over again. Because I've done that, I think, like five times now. And the last time I did it, I was like so confident that I didn't even, I wasn't scared, and my mentor even came that do the project with me. So, I thought this should have been nerve-racking because I hadn't presented it in front of her before. But she was like really impressed that I remembered everything from the summer, and it had spent several months. But I just felt great about it. I didn't have a lot of umm or
a lot of stuttering. It was really cool that I finally got to a place where I’m feeling more comfortable being a public speaker.

Presenting their work at scientific conferences provided second-year participants a platform to truly be immersed in the scientific world. They were surrounded by scientists, which allowed them to experience recognition by themselves and others about their potential as a scientist. Being able to own and receive credit for their work from other scientists increased their identity as scientists.

REU experiences provided second-year participants with the opportunity to experience firsthand a scientific career. Many first-year participants did not have a clear understanding of what a career in science entails or whether they have the capabilities to be successful in the lab. This caused doubts about their potential to become a scientist. Second-year students had the opportunity to be a scientist during their REU experience. Through the REU, participants were able to be scientists and be recognized as scientists. This provided them with an opportunity to validate themselves and receive recognition from others about their potential to become a scientist.

**Expanded Understanding of the Nature and Process of Science**

Part of the program’s goal was to challenge the students’ perception of science and the scientific community. Because of the lack of access to STEM professionals, most participants had a narrow understanding of science and who were scientists. The program challenged those perceptions by increasing access to scientists and providing students with a science faculty mentor, a graduate student mentor, and a peer mentor. Participants were constantly exposed to scientific research, STEM professionals, and the scientific world. Through these opportunities, students had the opportunity to interact with researchers and graduate students and ask about
their experiences through their education and research. These interactions with scientists played an important role in their definition of science and scientists. The increased interactions with STEM professionals allowed students to break down some misconceptions about science and scientists, thus allowing them to broaden those definitions. The broadening effect was very evident in second-year students who had more time interacting with the scientific community and more time to reflect upon those interactions. Redefining science had an impact on the participants’ confidence in becoming a scientist. The new view of science became more diverse and inclusive, making it easier for each participant to see themselves as potential scientists.

First-year participants were in the early stages of redefining science and who could be a scientist. Many first-year participants initially felt that science was only for smart people. Robin and Ray shared how prior to entering the program, they thought that science was only for smart people. Ray shared, “I feel like at the beginning, I was like, oh, it's more for smart people, like people who wanted to be doctors, specifically scientists.” But because of their increased interactions with scientists and the scientific community, those misconceptions started to change. As a result of being part of the program, Ray added, “I’ve always thought that science was just for biology majors, for doctors, for scientists. But I didn't include engineers in that thing because drawing out that's all that is.” Ray shared that his misconceptions about scientists are partially due to a lack of exposure to other fields of science at a younger age. Ray added, “You don't really see teachers teaching about engineering and (others) sciences.” Similarly, Leo shared how his perception of scientists had changed as a result of being part of the program. Leo said,

I always just had like an image of what scientists would be or what I wanted to be as a scientist, not like a real-life example of what scientists looked like, of what it actually means to be a scientist. They would just be like, Oh, I want to go into STEM and stuff
like that. And so they just gave me lots of examples like REU and all this stuff. I just got to see what it actually means to be a scientist rather than just the fraud word.

Gary shared a definition of a scientist that highlights how the definition of a scientist has been broadened by first-year participants through the program. Instead of smart people, Gary described scientists as “someone who just study and try to understand the concept of light, the concept of physics, the whole universe, and stuff.” Participants started to define science around interests rather than cognitive capabilities. Broadening the definition of a scientist made it easier for each first-year participant to see themselves as scientists.

Second-year participants shared a more expansive definition of science and scientists and who belongs in the science field. Their definitions were focused on focus on interests and soft skills rather than predetermined factors such as cognitive level or social status. Rosa shared that after over a year in the program, her perceptions of a scientist have changed in the last year. Now she sees scientists as “pretty much human. Yeah. I think I can get there too.” Other second-year participants shared similar definitions of a scientist as a result of being part of the program. Dale felt that a scientist is someone who is interested, hard-working, and passionate about the field. Dale shared, “You need to sacrifice and be hardworking… you need to be a little bit passionate too. You need to have this kind of passion because sometimes you, people like, run away from science because they don't have the passion.” Dale highlighted that it wasn’t the cognitive level that allows an individual to become a scientist but their commitment and perseverance in the field. This broader and more inclusive definition of a scientist was well described by Luna.

When asked whom science is made for, Luna answered,

Ideally, everybody, because it really encompasses literally every fiber of your being. And I don't think people will consider that enough. I mean, literally, everything is science. So yeah, I think it's for everyone. I didn't always feel that way. Because I didn't think it was
for me previously. But again, now I've actually gotten involved. That perception has changed, and I feel like I just have to know more. I need to; I got to keep up.

Throughout their one-and-a-half years in the program, participants were able to challenge their perceptions of science and scientists. This allowed them to redefine it based on their firsthand interaction with the field. As Samuel described, scientists were not “white guys with lab coats”; instead, anyone who has an interest in science can become a scientist.

Failure was another concept that first- and second-year participants seemed to be redefining. Second-year participants displayed a broader and most positive definition of failure. Individuals often define failure as the opposite of success. In this bimodal definition, success is associated with a positive outcome, while failure is the lack of positive outcomes. Using this definition of success, success was perceived as positive reinforcement while failure was associated with a negative outcome, which often draws individuals away from that field. Some first-year students expressed success-failure definitions following a bimodal framework. For instance, Muriel shared,

Science is about failure, but it's like, I'm not ready to fail, right? Yeah. I know that you say sciences fail and whatever. I don't want to run out. Once I get to that point, and if I fail, then I fail, but for now, if I’m going to fail, I'm going to leave the course altogether. I don't want to fail.

The bimodal definition of failure often pushed students away from STEM. Students associated failure with a lack of potential to become a scientist. If they failed a class or sometimes an assignment, they felt science was not for them.

However, most participants were developing a different perception of failure. Many expressed that their view of failure changed from negative to another way of learning. They started to see success and failure as a gradient rather than a bimodal function. Mike indicated that
his mentor played a role in redefining failure. Mike said, “Seeing like failure is an option... like (my mentor) is always saying like, you know, they love seeing failure because failure means you've learned from it.” Knowing that failure is an option and not an indicator of his potential as a scientist was important for Mike. He added, “It always just sounds like something nice to say, but like getting to see it as, like, okay. Yeah, cool. It it's real.” Participants started to understand that failure is not just an option but an important part of being a scientist. Bruno talked about how to innovate, you have to take risks, and with risks, there will be failure. Bruno explained the importance of failure in science,

    With research, you have to take risks and like, “Hey, this might not work, but I'm gonna do it anyway, and I'm okay with like failing if that's a thing.” I think that just kinda like makes it easier for me to kind of fit in with science and like in not being easy and you might fail a lot to get to what-like, fail 20 times. But one thing works in that's like, So you're working towards that one thing.

Opening the door to failure allowed students to explore science without the expectation of needing to be successful right away. It opened a window to fail. In other words, it normalized failing by making it a part of becoming a scientist.

    First-year students started integrating this new view of failure into their perception of success. Second-year participants seemed to have this new definition of failure already integrated into their perception of success. Luna, a second-year student, talked about her failures through school and how failure was an opportunity to learn and become a better student. Luna described “Failing as a part of the process.” Luna believed that “You have to learn how to be okay with that (failing) and how to move on, and so even though I come up short, sometimes I have learned, like, okay, well, that didn't work.” Luna added that failure is part of learning, and when she fails, she says, “Let me try something else...” Seeing failure as an option was very important
for Luna, who had to retake a chemistry class. Luna shared, “I actually ended up failing the chemistry classes. It was just like my first real chemistry class since, ever, really. But it was hard.” But Luna didn’t give up on chemistry after her first attempt. Luna continued, “I’m doing it again right now, actually, and passing it now.” Luna added that seeing failure as an option is important for every aspect of her life, not only science. Luna shared that as a mother, “I want to show my children what it’s like to be a human being, that you make mistakes and that you still keep going and you learn, and no matter what, you get back up and keep going.” To her, this is what she wants to teach others: “You try an experiment and fail. And you don’t just stop.” To Luna, science, as in life, is not about failure but will and perseverance. Luna finalized her definition of failure, as failure is “just one more way of not doing that.”

The view of failure as part of the development as a scientist was very prominent among all second-year students. Jasper and Dale, both second-year students, share very similar views of failure. Jasper found peace in knowing that failure was allowed in science. Jasper indicated that knowing that failure was an option made science “sort of calming in a way.” It made failure not as “hard-hitting” but “necessary.” Jasper further indicated that “Failure has to happen for you to understand.” Similarly, Dale shared,

So, the failure is not something bad. For me, I know it’s part of learning. So since, you know, in your lab, you fail a lot, we need to start learning. Failure is something that you can learn things from.

The understanding that failure was part of the process helped participants move forward in their scientific journey as second-year participants were more confident in their potential to become a scientist.
Most first-year participants had limited access to STEM professionals and the scientific community. The lack of access often resulted in misconceptions about the scientific community and who can become a scientist. The STEM Community program increased access to STEM professionals and the scientific community. This increased access allowed participants to engage with scientists and challenge their perceptions of the scientific community. Through these interactions, participants were able to broaden their perceptions of who can become a scientist and the meaning of failure in science. The broadening of these ideas resulted in participants feeling an increased sense of belonging to the scientific community and perceived potential of becoming a scientist.

**Importance of Mentoring, Guidance, and Positive Reinforcement**

First- and second-year participants expressed that early exposure to the STEM fields, mentoring and guidance, and positive reinforcement received by family, teachers, and professionals in the field increased their competence in science. Bruno, a first-year participant, had firsthand exposure to his field of study prior to entering the STEM Community program. Bruno talked about the impact of being able to experience the field prior to enrolling in college. Bruno shared, “I got to see kind of the behind-the-scenes end result of ‘Hey, I really want to pursue this’ … this is kind of what day-to-day life looks like.” Early exposure helped him stay focused on his track. He shared that during this experience prior to the program, “I got to kind of reinforce the, ‘Hey, this is what I enjoy.’ I really am passionate about this as opposed to, like, I didn't have the traits and experiences.” Bruno’s experience shows how access to firsthand experiences in science can positively influence the recruitment and retention of students in STEM.
Both first and second-year cohorts identified mentoring as important regarding their perception of their capability to learn science knowledge. Many participants shared that one major issue they faced earlier in their education was the lack of guidance and exposure to the STEM field. Regarding the role mentoring played in their STEM education, Rosa said that “Before his program, I don't think like I'm a scientist.” But due to her experiences through the program, her feelings have changed. Rosa added,

But like now. In the program, I feel like potentially like I will be a scientist. Because now I figured everything out. I also made a website a professional one, and I made a connection with a professor from the U of I. And got a connection with the mentor at the U of I, and I know they do a lot of research, and I read those papers. And if I don't know. Yeah, they are happy to respond. And when I talk to them, it is like, yeah, they are human.

Through the program, participants received mentoring and guidance on how to create a resume and a professional website, how to share their accomplishments, and how to reach out to STEM professionals. Participants were able to increase their scientific network by connecting with professionals in STEM through their professional website. These activities allowed students to create their own scientific community, increasing their perceived sense of belonging to the scientific community.

Mentors played an important role in providing positive reinforcement to the participants, helping them overcome their low sense of belonging. Often participants felt like they did not belong in academia or STEM fields, which resulted in many of them struggling with imposter syndrome. Faculty and peer mentor feedback and encouragement helped alleviate the imposter syndrome in many of the participants. Robin talked about how her faculty mentor helped her believe they have the potential to succeed in science. Robin said their mentor was “really helpful in helping me realize that I am capable of doing things (in science) because I just didn't think that
I was.” Nina found the recognition received by her first-year mentee key to feeling recognized as a scientist. She shared, “My first-year mentor, I think respects me as a scientist because I had the confidence to tell them what I did.” Nina described the recognition she received as very motivating. She wanted to ensure others experienced that feeling, so she tried to do the same for others. Nina shared that, “That’s something I always try to end my sentences with: You can do that too. And you too.”

Faculty mentor, Bree, talked about how she helps her mentees fight the low sense of belonging, or imposter syndrome. Bree often asks mentees “Is that the impostor syndrome popping up again?”, when she sees them starting to express feelings associated with the imposter syndrome. She feels that “they need to recognize when they are struggling with it (imposer syndrome) to be able to fight it”. Bree found that these negative feelings peak when they are asked to apply to scholarships, internships, and research opportunities. She said that her mentees often say, “I'm in this program and I got in, but I'm not gonna get an REU or I'm not gonna get into my college or I'm not gonna get into grad school.” To help her mentees build confidence, Bree helps them “put together a competitive portfolio and actually apply.” Bree noticed that “once they've done that first application. It gets a lot easier.” As Bree, all three faculty mentors talked about imposter syndrome, and the approaches they use to help program participants cope with the feelings associated with a low sense of belonging in science.

Participants did not limit the power of encouragement to only to mentors in the program. Recognition received from other individuals outside the STEM Community program had a similar effect on the participants. Many participants identified positive reinforcement from teachers, family and friends, and other faculty as important in helping them feel like they belong.
Gary found inspiration in knowing that some of his faculty and high school teachers believe in his potential to become a scientist. Gary said, “I do have some people do believe in me, like some of the teachers I met in my high school or even here (at the college) who believe in me. And I think that is really inspiring.”

Other participants found recognition outside of school from their family and friends. Dale, Mike, and Samuel talked about how the recognition they received from their friends and family helped them feel like a scientist. Dale’s friends believe he will be a scientist. Dale shared, “My friends like they see me as a scientist. So sometimes when they want some help in scientific subjects or anything related to science, they ask me to help them.” Mike said that every day he receives recognition from his roommate. Mike shared, “My roommate, me every time I go out the door, every time he knows I’m leaving for class. He's like, ‘Go be a science scholar.’”

Similarly, Samuel received recognition from his family and friends. Samuel shared:

My mom doesn't really have much of an understanding of a scientist, but she thinks I'll succeed. In the same with my grandmother. Also, my friends. They think I'm like really smart, so I think I will pass the class as easily, so yeah.

The support received from friends and family provided participants with the recognition needed to feel confident in their potential to succeed in STEM.

Leo and Mike found support from knowing their teachers and faculty cared for them. The interest shown in them by their faculty made them feel “seen.” Feeling seen motivated them to continue and do better in science. Leo shared that he “remember(s) one biology class; in my senior year with biology.” He didn’t think his teacher noticed his progress, but he “got a B on like a test or a quiz,” and the teacher recognized his improvement. He said, “My teacher is like, ‘Oh, you did a good job. You did better than the last one.’” Leo shared that being recognized by
the teacher made him feel “seen,” which made him more engaged in the class. Similarly, Mike shared a similar experience regarding feeling seen by faculty after struggling with a college course:

Went to talk to my math professor about him being brutally honest about whether or not I should drop or not. And I thought I was just going to be very short. And we sat there for almost an hour, and I thought I was going to cry. Not because he was being mean, but because he was being very, very nice and saying stuff like I see you care. I know you show up for every class even though I know I've missed a couple with I slept over, were caught COVID, or all those things that happened this year, but like that, like that was probably the most important one to me, was like feeling seen. That felt really good and really, really made me want to perform the way, made me want to perform the way people see that I perform like, I want it to like not to be like imposter syndrome.

Faculty mentor and program coordinator, Alice, shared a similar experience regarding feeling seen in by a faculty member. Alice shared, when she was in college taking chemistry for the first time, “I asked her [her professor] a question like the second week of class, and she knew my name”. Alice felt seen, which motivated her to perform well in the course. Alice added, “that was completely transformative”, she continued, “I wasn't just a number.” All program mentors and the program coordinator understood the importance of being seen. They all made sure they know as much as they can about their mentees academically, and outside school. They wanted to make sure all program participants know they are important to them and to the program.

Participants identified that feeling recognized and seen by STEM professionals gave them the confidence to continue their STEM education. This recognition was constantly received by the STEM Community faculty mentors and peers. However, friends, college faculty, teachers, and family also played a role in providing recognition and support. Often constant recognition by others was key in keeping participants engaged in their science education and the program.

**Relationship Between Representation and Confidence in Becoming a Scientist**
First- and second-year students talked about how the lack of representation in STEM fields decreased their confidence in becoming a scientist because it often made participants feel like they did not belong. The lack of representation was often experienced by individuals at the earliest stages of their education. This pushed them away from considering a career in STEM before entering college. Related to the lack of representation in sciences, Cheryl, a Black student, talked about how she felt isolated and unheard of when taking advanced STEM-related classes in high school. She shared,

Growing up, I always used to be in the higher advanced classes. But as time went on, like the less diversity in the classrooms. It would be like, I would probably be the only black girl and like all my upper-level classes, and like I’ve noticed when people were asking for help, and I would ask and tell them the answers, people wouldn't listen to me like I felt unheard of. And then if they ask someone asked the same question and they give them the same exact answer that I gave, then they are praised for having that opinion, but I just told you that 2 min ago. That kind of feels belittled. I don't want to, yeah.

Ray, a Latino student, also shared a similar experience to Cheryl when taking advanced courses in high school. Ray shared,

I would take like advanced classes, and I wouldn't see a lot of people like me. So that's why I felt like, what if I'm like just because I'm the only person like me in this class, I'm not going to be able to do it because there's a reason why there's no one else like me in the class.

Participants from ethnically diverse backgrounds shared that many of them entered the STEM Community program with the belief that science was not inclusive. They experienced feeling isolated in science throughout their K-12 education and did not know if their college experience in science would be better. The lack of inclusive and supportive environments in science classrooms kept them from fully engaging with science.

The lack of diversity in the classes, supported by the lack of diverse professionals in STEM, made many of the participants feel that STEM was not a possible career path for them.
Muriel and Cheryl talked about how racial minorities often feel a STEM career is possible for them. Muriel, who identifies as African American, shared:

When it comes to science, I feel like the automatic, automatic rights go to the white people. But yeah, I can't even deny that I know a lot of people are having conversations about the whole race situation. But I felt like, no matter where you go, you know, what type of job you want, it’s going to be the white people, then maybe whoever's next. Cuz, I feel like they go about like skin tones, I don't know, the lightest skin, and you go all the way to get in the dark, is just at the bottom. We might have a chance, you know, because I know they're like, oh, we all have the same type of chance, and we all have the same type of test, so go and do it; it’s right there. Yeah, but it’s not, though.

Cheryl, who identifies as Black, shared a similar perception regarding the potential of diverse women in STEM.

Some of the things are a black woman. It is kinda hard because, in science, you don't see a lot of people like me. And I feel like being a woman is already like harder, but then throw black on top of it because you expect black people to be like actors and football players. But you never see it like that. I want to be a scientist. Or even when there are scientists, it is frowned upon.

The lack of representation observed by many diverse students in science classes made them doubt their potential to become a scientist. This feeling is reinforced by the lack of representation in the workforce. Diverse students perceived the lack of support and representation as an indicator that STEM careers are not accessible to them.

Low-income status played a similar role to ethnic background in some of the program participants. While low-income backgrounds are not as easy to identify as ethnicity, many participants shared that they felt isolated due to their financial constraints. Bree, a faculty mentor talked about her experience talking about financial insecurity with one of her first-year mentees.

Bree said the mentee was struggling with “paying bills month to month”, “she lives paycheck to paycheck”, Bree added. Bree shared with the participant “I remember doing that, but I don't do that now.” Bree talked to the participant about how earning a STEM credential helped her reach
financial stability. Bree told the participant, “I don't do that now” and she added “she seemed kind of shocked about that”. Bree continued:

yeah, girl. Like, I don't really worry about money anymore. I don't really think about it the way I used to do. I don't have to check my bank account to see if I can go grocery shopping. I just go grocery shopping. That's what these jobs (STEM) do for you.

Bree used her personal experiences to make sure her participant understood that “there is stability at the end of the road” and “this isn't just because you like science. There is a sustainable career out of this, and you can support yourself and your family.”

The low sense of belonging in STEM identified by first-year participants due to lack of representation was also experienced by some second-year participants. However, their confidence in becoming a STEM professional was not as heavily dependent on the lack of representation in STEM. Instead, second-year students based their confidence level on their experiences through the summer research opportunity. The summer research opportunity exposed second-year participants to the current scientific field. Those experiences changed some of their perceptions of science, resulting in changes in their perceived potential to become a scientist. For instance, Daisy shared,

So, I thought I was just like a bunch of dudes in the lab. But now I'm like, oh, like science is really diverse. There are women; there are, there's an equal amount of men and women. There are people my age; there are people younger people; there are people older. Different ethnicities. Like it, kind of like going into the undergraduate symposium was really eye-opening because I met like a lady who was older than me, and she was presenting research.

The REU experience provided participants with the opportunity to experience firsthand being a scientist. This experience allowed them to validate their interest and perceived confidence in becoming a scientist.
The STEM Community program increased the participants’ exposure to different professionals in the STEM field. This helped participants meet and interact with STEM professionals from different social, ecumenic, and ethnic backgrounds. These interactions played a role in showing participants that anyone can become a scientist, regardless of their background. Overall, the increased exposure to STEM professionals helped participants broaden their views of who can become a scientist.

Role of Personal Identities in Science Identity Development

Participants shared that participating in the STEM Community program provided them opportunities and privileges in developing identities and confidence in becoming a scientist. However, participants shared how being first generation, low income, and having other minoritized identities mediated their experience. Many participants discussed how finances directly affect their perception of themselves as scientists. Muriel, a first-year participant, talked about how, due to financial constraints, she was not able to get all the materials needed for her science classes, resulting in an incomplete class experience. Muriel shared, “If I’m not working, something’s gonna have to be sacrificed.” Similarly, Robin, a first-year participant, talked about how the effects of not being able to afford high-end equipment negatively influences the way they engage in science and their perceived potential to become a scientist. She shared, “[being] low income makes things complicated because, like, I can't afford the fancy lab kit. I can't afford to just drop everything and go and study science or work in a lab for free or do an internship.”

Program mentor Carl, a community college graduate, did not realize the important role finances play in many community college students. Carl never experienced not having “the money to sign up for this class” or not been able to “take this class because I have to work at that
same time to pay this bill or, you know, or rent or anything like that.” For him, getting to know the financial struggles and “how little support some of them [program participants] have from outside the program” was “an eye-opening experience”, Carl said. Carl added, “they are not getting any support from family or parents or anything like that.” Carl had one mentee that couldn’t sign up for their classes because “they took one [class] over the summer and for one reason or another, financial aid didn't cover it” and now they have an outstanding bill they cannot pay, so they “have to find a way to pay the class before they enroll in classes for the upcoming semester”. All three mentors shared that they did not foresee their mentor role to revolve so heavily around social, financial, and emotional support. However, while often they felt unprepared to address those issues, they learned to work closely with different offices within and outside the college to make sure their mentees received the help they needed.

Another factor associated with financial constraints was the ability to be a full-time student without having to work outside of school. First- and second-year participants identified balancing their job and school workloads as a factor affecting their engagement with science. To be successful in most STEM courses, students needed to spend a lot of time practicing and working through problems to grasp a good understanding of the concepts and mathematical calculations involved in each class. Ray shared,

I'm taking calculus and chemistry. I feel like it's gonna be more of a challenge for me because I would have to drop hours at work just to spend more time studying. But then also, I need the money too, so it's going to be hard to manage my time between work in school.

Additionally, most STEM courses include a laboratory component which adds laboratory preparation and reporting to an already daunting course. Daisy shared: “It's really hard to do super well in your classes if you're working full-time or working two jobs. Because you really
need that extra time to work and study and like nail the topics for your classes and work on the lab reports.” Daisy added that work also takes away being able to work with others and even have a normal college experience. She continued, “Where there's other students like, I'm gonna go to the movies tonight, I have to work until midnight, then get up at six or seven and hopefully not being so fricking tired.” Many participants linked their struggles with performing well in STEM courses due to their need to work to stay financially stable. Trying to balance the academic rigor and time demands of STEM courses with an outside work schedule directly impacted how participants engaged with science.

Mike, a first-year student, was a returning student who had attended college multiple times while having to work full-time. However, with the help of the scholarship provided by the STEM Community program, Mike was able to fully commit to college without having to worry about working outside of school. Mike discussed his experiences attempting college, and how those are different from this one since now, he’s able to attend school full-time. Mike shared that the main reason he was not successful in his previous attempts to college was due to finances: “Low-income. Again, just because like that, it’s been like a big part of like the coming back and stopping and starting and going again over half a decade or so school. Despite really wanting to…. This time he is receiving financial support from the program. This made him feel more confident about his potential to succeed this time: “One of my biggest short-term goals was just like being able to set myself up financially to not have to work or work as much while attending classes. And so that I can fully focus on that (school) for once.” Mike was able to see the results of being able to fully immerse himself in school. He added, “I just finished a chem course here
with a B and, which is better than my last time, probably six years ago now, where I finished out with a D. And, like, I’ve improved; I know I can do it.”

Financial constraints and not being able to meet the time demands of STEM education negatively influenced the science identity development of the participants. Additionally, many participants identified struggles navigating higher education programs and offerings as another factor influencing their development as scientists. This factor seemed to play a very crucial role in the science identity development of first-generation students. Many program participants were first-generation students, and they talked about how the lack of understanding of how to apply for programs, get help, and find resources was a struggle for them. Mike talked about how he felt “like learning everything, I’m teaching myself all that.” To him, that made college difficult because, “you know, not having anyone there to like figure out loans and stuff with me and all that sort of stuff.” This added an extra layer of stress to his college experience. Samuel and Talia shared how they had to learn how to navigate college on their own. Samuel shared how being first generation impacted his college experience even prior to entering college. He shared, “Like the SAT route. If you're a, if you're middle-class, then your parents might teach you at a young age all of this stuff. I mean, I don't really. I didn't really know any of that. I didn't know you had to have good grades to go to college. So I had to learn on my own.” Samuel felt that his first generation status made his experience in college “tougher.”

Participants in their first-year identified that their performance in college was a result of other factors outside their capability of learning science. Some first-year participants said that they were still figuring out how to navigate college, develop study habits, and balance school and personal life to succeed in college. Gary shared that he struggled to adjust to a college education.
He said, “It’s just that studying the first semester in college has been like; I just feel like I was just not very ready to start college.” He said that his performance had been affected by his lack of readiness. Gary added, “My performance during my first semester was just really, really bad.” Gary’s poor performance made him doubt about his potential in science. However, his faculty mentor helped him understand that performing poorly did not mean he was not meant to be a scientist. With the mentor’s guidance, Gary felt that taking some time and readjusting might help him get back on track and improve his GPA. Gary concluded, “I'm just like maybe actually slow down a little bit. Take a few classes, at least for one semester and then give time to myself to reset.” In this case, Gary identified the lack of understanding of college expectations and academic demands as the main contributor to his poor performance during his first year in college, but the guidance received by his mentor has helped him see these experiences as part of his learning process.

Many participants shared how their paths were very different from other students, making them feel alone. Nina, when talking about her path to college, she shared,

I'm a first-generation college student, but I am the only one that the motivation to do college actually did everything on my own. I applied for colleges late, so I didn't know about deadlines. Nobody ever talked to me about that. My parents never pushed me to go. If you want it, it's there. I obviously didn't have the financial freedom to do whatever I wanted. So, my first year… was actually out of pocket. Actually, I got donations for college.

Often participants shared that the lack of understanding of higher education they experienced made them feel isolated. They felt others wouldn’t understand their journeys, so they were alone.

Talia shared that being a first-generation student makes her college experience “a little bit difficult.” She added, “I feel like I don't want to get emotional; it can feel like polarizing. Especially when talking to students who are not, like, don't come from that background.”
belief that others couldn’t relate to their experiences made participants often seclude themselves from fully immersing themselves in science. The feeling of being alone, combined with imposter syndrome, caused students to feel that they did not belong in science.

Additionally, many participants indicated that setbacks associated with being first generation go beyond lack of understanding. A few participants shared that the limited exposure to STEM professionals plays a role when trying to apply for different schools, financial assistance, and other services. The participants felt that their limited exposure to the STEM field put them at a disadvantage. They attributed the lack of exposure to lack of experience, lack of connections with professionals in the field to write letters of recommendation or serve as a reference, and lack of support and guidance through these processes. Robin, a first-year participant, shared how they perceive being a first-generation student has influenced their experience in STEM education. They felt “like new and fresh out the gate.” But being new meant, “It’s really hard for me to think that people would want me in their lab because I, you know, I don’t have any experience at all....” Robin felt that being new put them at a disadvantage because they did not have the experience or support to take advantage of many opportunities. Robin added, “They (partner) worked in three labs. Two of them they did it for free because they didn’t have to worry about paying for school because their parents paid for their school.” Robin said that not having access to these opportunities made their science journey harder. Robin added,

My partner's dad went to school. He is a Dr. and lawyer... And then he has friends from other colleges. And one of them is in sciences.... And he writes all of my partner’s letters of recommendation because he has status, and experienced people are really suade (persuaded) to listen to him. I don't know anybody in academia or anything like that.
The lack of access to voluntary opportunities and professionals in the field who can advocate for them made participants feel their path in science was harder.

Most first- and second-year participants felt that their course performance was a result of external factors outside academics. First-generation students identified the lack of guidance and understanding of higher education as a major factor keeping them from excelling in college. They felt responsible for understanding how to navigate college and complete all related tasks, which are often done by relatives. Overall, they felt they were alone in their educational journey. Participants also identified the need to work and lack of connections with STEM professionals as other factors interfering with their scientific journey. Participants felt that they did not have the financial stability to be able to dedicate enough time to their courses and to take advantage of extracurricular activities, such as research opportunities. The combination of these external factors played a major role in their development as scientists.

Discussion

The goal of this study was to better understand how participation in a STEM support program assisted low-income students, many that held other minoritized identities, in their science identity development. To understand the science identity development of participants, this study used the science identity development framework used by Hazari et al. (2013), which consists of four domains: interest, competence, performance, and recognition. The following will discuss the findings by each domain.

Interest in Science

First- and second-year participants identified intellectual curiosity as the main source of their interest in a career in STEM. Throughout all the interviews, there was a common theme of
wanting to know more about their surroundings. Participants discussed having a natural inclination towards learning and getting to know “why” things happen. Participants discussed how being engaged in science-related clubs and organizations, attending science demonstrations and events, and engaging in science through online platforms while in high school helped cultivate their interest in science. These experiences played a role in promoting their intellectual curiosity by exposing them to the field and promoting a mentality of discovery. These observations align with DeJarnette’s (2012) and Martin et al.’s (2020) findings, whose studies found that early exposure to science and involvement in extracurricular activities played a role in high school students choosing to study science.

Personal and professional goals played a role in both first- and second-year participants’ interest in science. Most participants referred to these goals as “dreams.” These dreams involved achieving something meaningful for themselves and others and financial stability. This observation suggests that for many individuals, individual social and financial mobility is not enough for them to engage in STEM education. This finding aligns with Fuesting et al.’s (2017) findings suggesting that to increase interest in STEM careers, institutions must take a comprehensive approach. The approach must provide academic motivation and opportunities for the students to align STEM education with their communal goals (Fuesting et al., 2017).

In terms of personal benefits, students talked about how STEM jobs are “high-paying” jobs and earning a STEM degree can help them be more financially stable. Participants talked about how getting a better-paying job was one of the factors they considered when deciding their majors. They saw STEM jobs as a way to earn enough money to not have to “live paycheck to paycheck,” to be able to “support their families,” to be able “travel,” and even to “start their own
company.” These observations align with Lichtenberger & George-Jackson’s (2013) findings which suggested that students with “lofty” goals are more likely to develop an early interest in STEM. However, this study found that “lofty” goals or “dreams” played a role in their retention in the program. Participants indicated that they often felt lost in their academic work and lost sight of their goals. But they talked about the importance of remembering their “dreams” to remind focused and interested in completing the STEM degree.

**Perceived Competence and Performance in Science**

First- and second-year participants expressed different levels of perceived competence and performance in science. In general, first-year participants did not have a clear way to evaluate their competence and performance in science, which resulted in overall lower perceived competence and performance levels compared to members of the second-year cohort. First-year participants linked their low competence levels to their lack of exposure, experience, and connections with the field. Participants who had firsthand experiences in the field through professional experiences or clubs and organizations expressed higher levels of competence and performance compared to participants who had limited to no firsthand experiences in their field. Similarly, participants who had more interactions with professionals in the field and had received positive reinforcement from mentors, peers, family, or teachers expressed higher levels of competence and performance in science. These observations align with the finding reported by Markle et al. (2022) and Thompson & Jense-Ryan (2018). Markle et al. that found that professional and peer mentoring often results in substantial academic and social improvements in students in STEM. Thompson & Jense-Ryan found that recognition by faculty and others reinforces students’ self-recognition, increasing their competence in the subject. That data
supports the observations that suggest the student’s competence and performance in STEM are dependent on the student’s social capital (Carlone & Johnson, 2007; Hazari et al., 2013).

Second-year participants heavily relied on their summer research experience to evaluate their competence and performance in science. The REU experiences provided participants with the opportunity to engage in science, interact with scientists, and own a research project. Throughout their experience, participants had the opportunity to challenge their perceptions about science and the scientific community, including who is a scientist. The experience changed their perception of scientists and themselves as scientists. The idea of becoming a scientist became achievable. After the REU, some participants even felt like they were already scientists. Similar findings were presented by Hunter et al. (2006). In the study, Hunter et al. found that Undergraduate Research (UR) increases “thinking like a scientist” and “becoming a scientist” attitudes (Hunter et al., 2006, p.71). These observations support the belief that undergraduate research experiences can increase competence and performance in STEM, including low-income and diverse students in STEM at a community college (Bangura, 2014; Jordan et al., 2014; Lopatto, 2017; Sun et al., 2020).

Perceived Recognition by Self and Others in Science

First- and second-year participants mentioned that growing up, they believed a STEM career was out of reach. Some participants indicated that this belief came from the lack of representation in the field, the lack of encouragement for them to become STEM professionals, and the lack of access to STEM professionals to guide them through a STEM career. This limited access to knowledge, encouragement, and exposure to STEM fields has been linked to students
struggling to see themselves as scientists (Dökme et al., 2022; Holland et al., 2012; Rainey et al., 2018).

Mentors played an essential role in helping participants overcome feelings associated with imposter syndrome. Most participants identified the help received by their faculty mentors in guiding them through STEM education, helping them apply for student academic and financial assistance, teaching them how to navigate education and college resources, and encouraging them to apply for summer undergraduate research opportunities as some of the most significant contributions by their mentors. These findings support the observations presented by Kolenovic et al. (2013), who identified that advising and mentoring from faculty can positively influence the academic performance of community college students. Many participants talked about how they were unaware of the opportunities available to them, and the only reason they were able to find them was through their mentors.

Imposter syndrome played a crucial role in self-recognition in both first- and second-year participants. Many participants expressed doubts about their capability of becoming a scientist due to their unique life circumstances. Faculty mentors played a role in helping participants overcome feelings associated with imposter syndrome. In addition to providing participants with constant positive reinforcement and recognition, mentors addressed these feelings by sharing their personal and professional paths with their mentees. Mentors often shared with the participants their life struggles and showed them how no one’s path is ideal. Some faculty mentors talked about their experiences through STEM education as low-income students and community college students. The sharing of these experiences played a positive role by helping students feel more connected to science and decreasing the feeling of isolation.
Some participants experience the same positive reinforcement through attending scientific conferences focused on low-income students. Participants shared that they felt a sense of relief and an increased sense of belonging when they attended conferences where the main speaker was from a low socioeconomic background and shared their struggles through STEM education. Similar observations were reported by Kricorian et al. (2020). In the study, Kricorian et al. observed that a sense of belonging in historically marginalized groups is strengthened by exposure to STEM professionals who share similar backgrounds. This study highlights the importance of representation and being mentored by individuals with whom the individual can identify to help increase recognition in STEM (Kricorian et al., 2020; Rainey et al., 2018).

Firsthand experiences in the field played a key role in recognition. Second-year participants expressed that their biggest gain in confidence and recognition as scientists occurred during and after their summer research opportunity. During the REU experience, second-year participants were treated as scientists by graduate students, postdocs, and professors in the lab. Students felt heard by all those power figures, making them feel recognized as scientists by people they considered professionals in STEM. Some participants had the opportunity to present their results at scientific events, be part of scientific publications, and see their results being used by others. Some participants expressed their biggest change in self-recognition as scientists when writing their names as authors of their work. The feeling of ownership over scientific work catalyzed their increased sense of belonging in science.

Access and Opportunities

In this study, each domain played a role in the science identity development of each participant. However, there were many other significant experiences that did not seem to fit in
this framework and were influencing the way students engage with science and the program, directly affecting their science identity development. Through the data analysis, it became evident that the participants’ science identity development was influenced by how they engaged with the college, the program, and with the scientific world. Many external factors such as income, housing, understanding of college expectations, knowledge of college resources and how to access them, work-study balance, academic readiness, and social support played a major role in the science identity development of many of the participants of this study. To ensure that this study considered all relevant experiences regarding the science identity development of the subjects of this study, an overarching category focused on access and opportunity is being added to the discussion. The purpose of this category is to highlight how students’ background and socioeconomic status affect how they engage with science, thus influencing their science identity development. Figure 3 illustrates the proposed theoretical framework with a new domain on access and opportunity. The figure shows how this new fifth domain directly influence the domains of competence, performance, recognition, and interest.

The results of this study also suggest that the science identity development of low-income community college students is directly influenced by their socioeconomic status. We proposed that to better understand how low-income and diverse students at community colleges experience STEM education and how those experiences influence their identity development, a fifth domain focused on access and opportunity should be added and evaluated. The four-domain framework used by Hizari (2013) can be used, but an additional domain overarching all domains must be evaluated to fully understand how these experiences are influencing the science identity development of the students.
Figure 3: Proposed five-domain framework of science identity development for members of historically marginalized groups in STEM at a community college.

**Finances.** Financial stability played a major role in the participants’ engagement with science and the program. Many participants talked about how having to work outside of school was keeping them from fully immersing themselves in science and the program. Participants shared that having to work outside limited their time available for studying and forced them to work on their schoolwork while being tired. This often made them have to work on their schoolwork late and close to when the assignments were due, keeping them from truly learning the material. The lack of time also influenced the way they experienced the courses. Many participants talked about how having to work kept them from taking advantage of school resources such as faculty office hours and tutoring and from engaging socially with their peers.
Some participants talked about not having money to buy all course materials, especially those that were recommended but not required, and only having access to lower-quality materials due to their financial limitations. As a result, many participants felt like they were getting a lower quality of education, affecting their sense of belonging and competence in the field.

Financial stability also played a role in access to STEM resources. Participants attributed their low-income status to limited access to opportunities for growth in STEM. A participant shared that their lack of financial support from their relatives keeps them away from being able to volunteer in research labs, participate in student organizations, and engage in extracurricular activities. This lack of access to cocurricular activities hinders the students’ engagement with science. This directly influences their sense of competence and limits their opportunities to receive positive reinforcement or recognition from others (Carlone & Johnson, 2007, Rodriguez et al., 2019, Sithole et al., 2017).

Guidance and Role Models. Many first-generation students identified a lack of understanding of higher education, the lack of diversity, the lack of guidance, and the limited access to STEM professionals as factors that negatively affected their path to becoming a scientist. Many participants shared that they didn’t know how to apply for financial aid, scholarships, or any other student resource available at the institution. A participant talked about having to pay their first-year tuition out of pocket because they didn’t know about the financial aid deadlines. A few students talked about how they didn’t know the consequences of not doing well on the placement exams. One participant did not prepare for their math placement exam, which added over two years of math courses to their program. This lack of understanding of
higher education often puts students on unique paths, keeping them from fully integrating with their classmates and the college.

Some students felt like their lack of connections with STEM professionals also played a role in their access to opportunities in STEM. Participants talked about how their lack of access to STEM professionals limits their opportunities in science. As an example, a participant talked about how their friend knew a science professor and that professor wrote all their recommendation letters. That student felt that their lack of access to STEM professionals who can advocate and write recommendation letters for them hindered their potential to benefit from those opportunities. In both cases, the limited guidance and mentorship experienced by historically marginalized groups in STEM keep these students from fully integrating into the field, resulting in limited access to opportunities to increase their competence, performance, and recognition. However, this STEM community program does an outstanding job of ensuring that its participants remain active in the STEM community and take advantage of all the opportunities available for students in STEM.

Recommendations

Curiosity played a major role in the interest level of the participants. Many K-12 schools serving low-income and diverse students have limited resources, which often results in less exposure to technology, hands-on activities, and exposure to the field than schools with more resources. Without access to these opportunities, the intellectual curiosity levels of these students are limited, thus decreasing their interest in STEM careers. To increase curiosity in STEM, colleges and universities need to continue increasing their outreach events to K-12, especially for schools serving mostly low-income and diverse students. Often these schools do not get a lot of
attention due to their lower performance and lack of access to advanced courses. However, colleges and universities need to start promoting their science programs as career opportunities for low-income and ethnically diverse students. Ideally, these outreach opportunities will target middle schoolers and the earlier stages of high school, to allow students to prepare for the academic demands of STEM education. The colleges must supplement these outreach events with academic counseling and advising, networking events, and access to STEM professionals and mentors. Additionally, the college needs to provide middle and high school science teachers with resources to help students interested in science prepare for college and take advantage of all available resources and opportunities.

Community colleges present a unique path to increase diversity in the STEM workforce. They also provide an opportunity for low-income and diverse students to attain STEM credentials. However, to ensure that low-income and diverse individuals take advantage of these opportunities, community college administrators need to be intentional in the way they provide support for high school students and adult learners interested in STEM education. Participants indicated that one of the major obstacles when attempting college was the lack of guidance on how to navigate college education. Participants dealt with delayed graduation rates, paying college out-of-pocket, and taking the wrong courses due to the lack of mentoring and understanding of higher education. Program participants stayed in their program mostly due to their experiences and the support received through the STEM Community program. However, it is very likely that without the program’s mentoring and support, these students would not have stayed in STEM or even in college. To address these issues, community colleges need to be intentional about the way they provide support to incoming students. This type of course should
be mandatory for all students, as it promotes cohort building. The course should contain a module where students create an academic portfolio containing a personal statement, and an update resume, and use those documents to apply for scholarships, internships, and other relevant opportunities. Ensuring that students create the documents and apply for these opportunities will ensure that students will continue to take advantage of what the college has to offer. Community Colleges can also create a similar course for juniors or seniors in high school interested in college education. The course can focus on how to apply for college and get financial aid, the importance of placement exams, and how to adjust to college life. The course can be supplemented with access to academic advisers, and the course tuition could be waived for low-income students. The creation of a course focused on high school students can alleviate the lack of college knowledge many low-income and first-generation students experience when considering attempting college.

STEM education is often very time-consuming and mentally draining. To succeed in most STEM courses, students need to spend many hours doing homework and practicing. This is often a big barrier for low-income students who often must work while in college. The financial support low-income students receive from federal, state, and local support is often not enough to allow them to fully immerse themselves in education. This puts low-income students at a disadvantage when attempting STEM education. Community colleges can help low-income students in STEM balance their academic and work life by expanding work-study opportunities and creating additional scholarships opportunities through external funding. Many community colleges are not aware of the different funding opportunities available to them. Most do not have the personnel to apply for these opportunities nor a mechanism to support faculty and staff when
applying for these grants. As a result, only a limited number of community colleges have access to external funding. With enrollment dropping at almost every community college, community college administrators need to allocate money into training and supporting personnel interested in applying for external funding. This type of funding can make a difference in who has access to STEM education, and how they engage with their education.

Many community college students are at a disadvantage in STEM due to the lack of research opportunities at their institutions. Community colleges can address this issue by creating partnerships with local research-focused institutions and private industry through which STEM students have access to research opportunities, networking with researchers, and exposure to scientists. Another way community colleges can help students gain access to research opportunities is by increasing partnerships and promoting Research Experiences for Undergraduates (REUs). Most low-income and diverse students are unaware of these types of opportunities and the benefits associated with participating in them. There are even some summer research opportunities for community college students only. By increasing the awareness of these types of experiences, community colleges can increase student engagement in science, increase the students’ social capital in the field, expose them to the scientific community, and increase their interest and sense of competence, performance, and recognition in the field—thus improving their science identity.

Most low-income and diverse students struggle with imposter syndrome. Many students expressed that they see STEM professionals as individuals who do not have the same financial and social struggles as they do. However, the mentoring and engaging with the scientific community showed them that others with similar struggles have been successful in STEM. To
create a more diverse and inclusive image of STEM fields, it is important for STEM professionals to share their successes and failures with students, especially low-income and diverse students. This can be done by highlighting their unique paths in their professional websites and highlight how their individuality propelled them as STEM professionals. To ensure students with unique backgrounds are successful in STEM, institutions must provide students with faculty mentors, accessible counseling to support them through the ups and downs of education, and normalizing failure as a way of learning. Many low-income and diverse students choose career and technical programs as their entry point to higher education. These students are often not exposed to science education or the benefits of a career in STEM. Community College leaders must work with state boards and legislators to find ways to ensure that CTE credentials function as a path to a transfer program. Allowing students to use CTE programs as entry points to baccalaureate degrees will increase access of low-income and underrepresented students to STEM programs.

Conclusion

The study highlighted the importance of mentoring, social and financial support, and firsthand experiences in the science identity development of low-income students in STEM at a community college. Most students identified the guidance given by their mentors on how to navigate college education, access academic and financial resources, and take advantage of field-related opportunities, such as the REUs, as the most beneficial aspects of participating in the program. Some participants were willing to be part of the program even if they lost their financial support due to their academic standing because they valued these components of the program.
CHAPTER 3

SCHOLARLY REFLECTION

Throughout my professional career, I have developed a strong commitment to helping underrepresented students access and succeed in higher education. Entering this EDD program, my goal was to gain a better understanding of why underrepresented students, specifically Latinx students, struggle in STEM. Growing up in Puerto Rico, I never knew of the lack of interest, persistence, or completion of underrepresented students in STEM observed nationwide. Since I was a Puerto Rican attending school in Puerto Rico, I never experienced the negative consequences of being a minority. After moving to the United States to complete my graduate education in STEM, I learned what it meant to be a member of an ethnic minority group in STEM. My experiences through graduate school changed my perception of science, the scientific community, and what it means to be a scientist in a negative way. I wonder if this is how many minority students feel after transitioning from a Minority Serving Institution (MSI) to a larger university.

After graduating and working in a research lab for a few years, I joined academia as a chemistry instructor. Throughout my tenure as an associate professor of chemistry at a community college, I saw many underrepresented students struggle through STEM education. I learned that most students from underrepresented communities struggle with STEM education as I did when attending graduate school. I saw how students from historically marginalized groups, including Latinx, Black or African American, Puerto Rican, women, and low-income students shared some of my struggles through STEM. As a professional in the STEM field and a member
of a historically marginalized group, I knew I could not become a bystander. I started to get involved in several college-wide initiatives aimed at helping underrepresented students.

However, resources at a community college are limited. This motivated me to look for external venues to access support and funding for some of my initiatives. As I continued to grow outside the classroom, I reached the point where I felt that to have a bigger impact on our underrepresented community, I needed to go back to school and complete a doctoral degree. A doctoral degree would allow me to focus more time studying underrepresented students in STEM, help me move up in higher education to a position with more power to make changes and increase my credentials to be more competitive when applying for grants and other external funding.

At the beginning of my doctoral education, I was convinced that my dissertation would be a quantitative study focused on evaluating how current higher education initiatives affect the recruitment, retention, and completion rates of historically marginalized groups. As someone trained as a physical scientist, I found comfort in numbers and did not fully understand the power of qualitative research. However, after taking a few courses with Dr. Nyunt on qualitative research, I started to learn the value of qualitative approaches. I learned that to truly understand the reasons behind the low retention and completion rates of underrepresented students, I need to listen rather than quantify something. I needed to hear underrepresented student voices without any preconceived notions. Initially, I explored conducting a mixed-method case study. Mixed methods would allow me to listen to the students’ experiences and use quantitative data to evaluate the results. However, when I presented my initial proposal to my dissertation chair, Dr. Kortegast, she presented me with a question about my use of a mixed-methods approach. She
wanted to know whether I wanted to use quantitative data to validate the student's answers or if I needed quantifiable values to create a full picture of the study. She also wanted to know if I would weigh both values similarly or if I would weigh the quantitative part heavier due to my comfort with numbers. Although I was not confident in my skills in conducting and evaluating qualitative research, the guidance I received from Dr. Kortegast made me dig deep into what I wanted to get out of my dissertation. I wanted to understand the experiences of underrepresented students in STEM. At first, I didn’t care about the reproducibility of my results, nor if they could be used to generalize underrepresented students’ experiences; I truly wanted to learn about their experiences through STEM and know what I could do to help them succeed. After identifying my true goal, I knew I needed to conduct a qualitative case study.

The next step in the process was identifying the case. Sadly, I did not have many underrepresented students in my courses, largely because there were few underrepresented students in STEM at my community college. That is why this study is important. But it is hard to learn about their experiences if there are not many students that meet the criteria. Luckily, the college received an NSF grant aimed at increasing low-income and diverse students in STEM. The program recruits and supports students from historically marginalized groups to enter the STEM field. During their second year, they needed to add an educational researcher to the program. The role of the educational researcher was to “generate knowledge” by evaluating the students’ experiences through the program. The researcher role would give me access to historically marginalized students in STEM, so I took the role. As the researcher, I had the opportunity to learn about low-income and diverse student experiences in STEM through
interviews, reflections, surveys, and class observations. Joining this program gave me access to the case I needed to conduct my study.

Designing a qualitative case study took a lot of work. I struggled to understand the differences between theoretical frameworks, conceptual frameworks, epistemology, positionality statements, and all those other concepts absent in research in the natural sciences. Additionally, it was often difficult to get feedback from my colleagues and program staff about these concepts, as these concepts were also foreign to them. I relied heavily on what I had learned in my classes, the feedback from my dissertation chair and Dr. Jaekel, notes from the courses I took with Dr. Nyunt, and the support from my classmates Tricia, Darrell, and Vasu. After a lot of research and some guessing, I finalized a dissertation proposal. By the time I submitted my final draft to my dissertation committee, I had gained a good understanding of all qualitative research components that, at some point, were foreign to me. I felt confident that my design would allow me to learn more about how students from historically marginalized groups experience STEM education.

Getting students to participate in the study was relatively easy. The program staff did a good job of ensuring that students participated in the interviews. Most students seemed excited to talk to me about their experiences. They wanted to share their views about STEM education and the program. They also wanted to meet me and connect with a STEM professional with a similar background and experience. I completed seventeen participant interviews and three program staff interviews in three weeks. One of the hardest parts of my study was transcribing the interviews. It took me over a month, working during the day and often overnight, to transcribe interviews. I did all transcriptions manually, which was very time-consuming, but it allowed me to know each interview in depth from start to end. I created initial codes during each transcription, and that
knowledge helped me complete the coding rounds. If I were to do the transcription process again, I would still do manual transcriptions. I do not think I would be as knowledgeable about each story if I hadn’t listened to each one of them over and over.

I enjoyed the last rounds of coding and themes. I appreciated the feeling of success and accomplishment when I started to map the themes identified through analysis of the participant interviews, staff interviews, and analysis of student reflections. My feeling was similar to the joy a person feels when they complete a puzzle. I was understanding their experiences and identifying how they relate to each other. However, aligning my results with the theoretical framework was the hardest part of this process. When aligning my results, I had to decide what was relevant and what was not. What made that part difficult was deciding what data was relevant and what wasn’t. I felt uncomfortable excluding codes and themes from the study. I felt that each participant poured their heart out to me, and I did not want to be the one who silenced their voice. I got very invested in their stories, and I wanted to make sure none of their voices were silenced. After working on the data for weeks, I felt like I found a way to ensure that the most important outcomes were presented in my study. I also found comfort in the idea that I could always complete a second publication with any important outcomes not presented in this dissertation.

I am very proud of my progress as a graduate student at Northern Illinois University. When I started the program, I didn’t believe my English language skills were good enough to be an administrator, write academic papers, or be successful in graduate school. My partner, Jeremy Dassow, and his friend, Stephanie Kinney, pushed me to take this path. They always believe in me, and not taking on this adventure would mean that I would let them down. Throughout the
program, I met amazing faculty and great classmates who supported me and recognized my work. I slowly felt more confident about my English skills and knowledge of education, community colleges, and administration. The program changed the way I see education and myself as a professional in the field. The program also changed the way I perceive reality. I used to have a strong positivistic approach to truth, and now I want to believe I have a more constructivist approach to reality. The truth is what you make it to be, and your reactions to your surroundings are just a result of how you see the world. This change in mentality helped me select a qualitative study over a mixed methods approach. I didn’t want to know if the student got an A or a B in the class. I wanted to know what the grade they earned meant regardless of the value society imposed on them. For some, a C is a sign of failure; for others, a C is a sign of success. I did not want to be the person who decides what grades mean for anyone. I wanted participants to tell me how they see the world. I wanted to be able to see the world through their eyes.

My journey through graduate school was the right path for me. There were ups and downs. I did not enjoy the Strategic Enrollment Management Class. I almost dropped the program because I felt unsuccessful and not capable of completing the program. I only stayed in the program because of the support I received from my classmates. However, regardless of the hardships that course could have caused, I am glad I was able to push through. I am now completing my dissertation as a better person. The program, as a whole, prepared me to be a good educational researcher and a good community college administrator. It is crazy to think that I started this program as an Associate Professor of Chemistry and am ending it as a Dean of Math, Sciences, and Health Professions. This shows how much I have grown since I started the
program. Now, I plan to use all the knowledge I gained through this program to support the faculty and staff in my division and to continue to find ways to help underrepresented students in higher education, especially in STEM programs.

My goal as a dean is to use the knowledge I acquired through this dissertation to help individuals succeed in higher education. This research has given me a deeper understanding of the struggles many students face when entering higher education, especially those from low-income and underserved communities. Listening to these students allowed me to immerse myself in their world and see the barriers they faced when attempting higher education. It also showed me how influential we are as higher education professionals in their professional development. One of the major takeaways from my study was that low-income and first-generation students struggle with navigating higher education and seeing themselves as part of their academic field. I hope to stir my division toward creating outreach initiatives focused on providing students with mentoring and networking opportunities. I want prospective students to feel “seen” by us and know their success matters. I want them to know that their unique experiences are what make them special, and only by embracing them they will be able to reach their potential. My dissertation showed me that when students believe in their potential and feel supported by others, success will come naturally.

Through my dissertation, I also learned about the impact of hands-on and field experiences on students. Working in the field provides students with the opportunity to challenge many of their misconceptions about the field. This often results in students developing a deeper sense of belonging to the field and a stronger commitment to their education. As community college professionals, we have limited resources. However, I want to make sure we, as a
division, use these resources wisely to maximize the opportunities our students have to have firsthand experiences in the field. I hope to accomplish that by creating partnerships with other units at the college, local industries, and neighboring four-year institutions.

Upon reflecting on my past three years in the program, I don’t think I would have been able to predict how this experience would have influenced my life. I expected this program to help me earn the credentials I needed to advance my career. But I did not consider all the other effects the program would have on me as a professional and a person. I had the opportunity to learn from experts in the field, which helped me develop the confidence needed to be a leader. I was able to work with many community college administrators around the nation, which helped me see myself as part of the leadership community. Lastly, the program gave me the opportunity to work directly with students outside the classroom, which gave me a chance to truly see the world from their point of view. All of that together helped me see myself as an administrator. As someone with the potential to become an outstanding community college leader. I truly thank the program for this opportunity.
REFERENCES


APPENDIX A

INTERVIEW PROTOCOL FOR PARTICIPANTS
Interview Protocol – Program Participants

Welcome

Interviewer:

Thank you for taking the time to participate in our research today. The goal of this interview is to get a deeper understanding of your experiences as a science student and as part of the Science Scholars program. I hope that this conversation can help me better understand how your experiences prior to joining the program, as well as in the program, have shaped your views of yourself as a scientist and the scientific community. I hope to use the information gathered through this interview to help us design programs that better address the needs of all students in science.

First, I would like to know if you will allow me to record this interview. The recording will be confidential and will be destroyed after the interview is transcribed. If you approve, please sign the release form that states what I just described. Additionally, I will need you to please sign this research consent form. This document states that: (1) all information will be held confidential, (2) your participation is voluntary, and you may stop at any time if you feel uncomfortable, and (3) I do not intend to inflict any harm.

Thank you for agreeing to participate!

Introduction

I have planned this interview to take between 45-60 minutes. During that time, I have a set of questions I would like to ask you but feel free to share as much as you want in your answers, as it is not required that we answer all questions I have planned for this interview. This
The interview is focused on your experiences, so my questions are only designed to guide our conversation.

The interview will be divided into two parts. Part 1 will be an ice-breaking activity involving the sorting of cards. Part 2 will be the interview section. Please let me know if you have any questions.

Part 1: Icebreaker

Interviewer:

The first part is the card sorting activity. I will give you a set of index cards with various identities listed in them. Your goal is to look through them, select the ones you identify with, and rank the selected cards from most important identity to least important identity. Know that you do not need to use all the cards, and you can discard any card you feel is not important or relevant to your experiences. Also, there are a few additional blank cards in case you want to add any other identity that is not listed on the cards provided. With your consent, I would like to take a picture of your rankings when you are finished.

Cards: mother, student, Black, low-income, introvert, father, science learner, White, middle class, extrovert, son, scientist, Hispanic, wealthy, funny, daughter, first generation, Latinx, provider, curious, women, smart, Asian, self-supporting, dreamer, men, low achieving, multiracial, healthy, angry, firstborn, high achieving, foreigner, unhealthy, and sad.

Follow-up questions regarding card sorting:

Interviewer questions (Modified from Le, 2019):

1. I noticed that your top-ranking identity is __________. Why did you decide to put this first?
2. Could you describe your process for sorting the identities? What were you thinking when you sorted them this way?

3. Do they bring up science learner in the card sort?
   a. Yes - Ask them why they placed it in the position that they did. Why did you rank science learner where you did?
   b. No - Ask them why they chose not to place science learner in their collection. After, ask them to place it. I noticed that you did not include science learner in your rankings - why is that? *After they respond* Can you take the science learner card and rank it?

Interviewer:

Thank you for sharing your ranking with me. I will now take a photo of your ranking.

(Take a photo, but leave the card on the table)

Now we will transition to the interview portion. In this part, I will ask you a few questions about your experiences within and outside the program. As I mentioned before, these questions are just to guide our conversation, so you have free range on what you are willing to share with me. Also, remember your answers are fully confidential, so no one besides me will have access to this interview.

Part 2 Interview

General Science Questions (Adapted from Le, 2019)

4. Tell me a little bit about yourself.
   a. Why did you decide to study science?
   b. What are your goals (short and long term)?
c. Why are these goals important to you?

5. What were some previous experiences you had in science that stand out (elementary, middle, high school, outside of school), and how do you think they impacted you?

6. What are your perceptions of science in general?
   d. How do you think society generally perceives science? Who is it made for, and what does being a scientist mean?

7. How do you think your identities influence how you participate in/experience science and science courses?
   e. How do they help or hinder your experiences?

8. How do you feel people with similar identities to yours are represented in science?
   f. How do you think society influences who gets represented in science? How does this affect you?

9. What traits related to your identities empower you as a scientist? Why? (e.g., What aspects of your identities do you believe will make you a strong scientist/science learner? How do your identities help or hinder your success as a scientist?)

Interviewer:

Now I will ask you a few questions about your feeling toward science and the scientific community. As before, feel free to share anything that you think would help us better understand your experiences. These questions are only to guide our conversation.

10. How do you feel about your potential to become a scientist? Can you share an example of this?
11. How do you feel about your capability of learning and applying the knowledge you have acquired in courses and everyday life? Can you share an example of this?

12. How do you think what you are learning shows in your courses? Do you think you are able to show what you have learned to the instructors, mentors, and peers? Can you share an example of this?

13. How do you think others see you as a scientist? Do you feel like people see promise in you as a scientist? Can you share an example of this?

14. How do you feel in a science setting? How do you feel when you are surrounded by scientists?

15. How do you feel when working on science-related tasks? How does that feel compared to when you are working on non-science-related tasks?

16. How do you describe your likelihood of engaging in science-related activities? How often do you engage in science activities? Can you share an example of this?

Interviewer:

We will now transition into the last section of the interview, which focuses on learning more about your experience in the program.

17. How do you describe your experiences in this program thus far?

18. Do you think participating in the program has changed your perception of science? If so, how?

19. How do you think participating in the program has (or will for first year participants) changed your perception of yourself as a scientist?
20. How do you think participating in the program has (or will for first year participants) prepared you to become a scientist?

21. How do you think participating in the program has (or will for first year participants) changed the way others see you as a scientist?

22. How do you think participating in the program has (or will for first year participants) changed your engagement in science-related activities?

23. Is there anything that can be offered to you to better help you in your scientific journey?

Interviewer:

Thank you for participating in this interview. I truly appreciate your time and help!
APPENDIX B

INTERVIEW PROTOCOL FOR PROGRAM COORDINATOR AND MENTORS
Interview Protocol – Program Coordinators and Mentors

Welcome

Interviewer:

Thank you for taking the time to participate in our research today. The goal of this interview is to get a deeper understanding of the program and your perception of the participant’s experiences through the program. I hope that this conversation can help me better understand the intent of the initiatives part of the program and their effectiveness and give me a sense of how you see the progress of the program participants. I hope to use the information gathered through this interview to help us better understand the impact of co-curricular activities on low-income and diverse students in STEM at a community college.

First, I would like to know if you will allow me to record this interview. The recording will only be used to simplify my notetaking during the interview. The recording will be confidential and will be destroyed after the interview is transcribed. If you approve, please sign the release form that states what I just described. Additionally, I will need you to please sign this research consent form. This document states that: (1) all information will be held confidential, (2) your participation is voluntary, and you may stop at any time if you feel uncomfortable, and (3) I do not intend to inflict any harm.

Thank you for agreeing to participate!

Introduction

I had planned this interview to take between 45 to 60 minutes. During that time, I have a card-sorting activity and a set of questions I would like to ask you. Feel free to share as much as you want in your answers, as it is not required that we answer all the questions I have planned for
this interview. This interview is focused on your experiences, so my questions are only designed
to guide our conversation.

Please let me know if you have any questions.

Part I- Card-Sorting Activity

Cards: mother, student, Black, low-income, introvert, father, science learner, White,
middle class, extrovert, son, scientist, Hispanic, wealthy, funny, daughter, first generation,
Latinx, provider, curious, women, smart, Asian, self-supporting, dreamer, men, low achieving,
multiracial, healthy, angry, firstborn, high achieving, foreigner, unhealthy, and sad.

Interviewer:

The first part is the card sorting activity. I will give you a set of index cards with various
identities listed in them. Your goal is to look through them and select the ones you feel are the
most prevalent identities in scientists. Also, there are a few additional blank cards in case you
want to add any other identity that is not listed on the cards provided. And with your consent, I
would like to take a picture of your rankings when you are finished.

Could you describe your process for sorting the identities? What were you thinking when
you sorted them this way?

We will repeat the same process, but this time I want you to select the cards that you feel
best identify you. As before, there are a few additional blank cards in case you want to add any
other identity that is not listed on the cards provided. And with your consent, I would like to take
a picture of your rankings when you are finished.
Could you describe your process for sorting the identities? What were you thinking when you sorted them this way? How do you think your identities relate to the ones you identified for scientists?

We will repeat the same process, but this time I want you to select the cards that you feel best identify the program participants. As before, there are a few additional blank cards in case you want to add any other identity that is not listed on the cards provided. And with your consent, I would like to take a picture of your rankings when you are finished.

Could you describe your process for sorting the identities? What were you thinking when you sorted them this way? How do you think your identities relate to the ones you identified for scientists? For yourself?

Interview

Interviewer:

Thank you for participating in this interview. I will ask you a few questions about your experiences as part of the program. These questions are just to guide our conversation, so you have free range on what you are willing to share with me. Also, remember your answers are fully confidential, so no one besides me will have access to this interview.

Professional background

Let’s start with your professional background information:

1. What is your title at this institution?

2. How long have you been doing this work?

3. Can you describe the events and experiences that contributed to you being in your current role?
Let’s focus on your role in this program:

4. Can you describe what your role in the program entails?

5. How did you decide to be part of this program?

6. What are your goals within this program (short and long-term)?

7. Why are these goals important to you?

8. How do you think this program fits on a larger scale?

Let’s talk about the goals and purpose of the program:

9. What are the main program goals?

10. How do you think the program is achieving those goals?

11. How do you feel about the services provided?

12. What do you think are the program’s strengths in achieving those goals?

13. What do you think are the areas of improvement or gaps towards achieving those goals?

Let’s talk about the participants:

14. How do you think the students are changing from their experiences through this program?

15. How do you think the initiatives or program activities are affecting or influencing those changes?

16. How do you think the needs of the students are being met by the program? Are all student needs been addressed by the program? To what extent? What are the gaps in the program in terms of meeting all student’s needs?

Wrap up
17. Is there anything else you would like to add to this interview regarding your experience in the program?

Thank you for participating in this interview. I truly appreciate your time and help!