Peer Mentorship In Interdisciplinary STEM Education: The Underrepresented Groups

Experience

A dissertation submitted to the faculty of
San Francisco State University
in partial fulfillment of
the requirements for
the Degree

Doctor of Education

In

Educational Leadership

by

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San Francisco, California

May 2022
Certification of Approval

I certify that I have read Mentorship In Interdisciplinary STEM Education: The Underrepresented Groups Experience by Hossein R. Saray, and that in my opinion this work meets the criteria for approving a dissertation submitted in partial fulfillment of the requirement for the degree Doctor of Education in Educational Leadership at San Francisco State University.

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Abstract

This study explored how peer mentoring affects the self-perception, sense of belonging, and persistence of underrepresented groups (URGs) in interdisciplinary science, technology, engineering, and math (I-STEM) courses, and how such peer mentorship shapes the leadership skills of URG mentors. San Francisco State University’s College of Science and Engineering approaches I-STEM education through the Promoting Inclusivity in Computing (PINC) program, which uses instructional and curricular methods to increase the number of URG students in computing. This case study examined how peer mentor collaborative learning in I-STEM courses affects enrolled URG students’ self-perception to persist in interdisciplinary studies at a 4-year university. This qualitative study explored the mentee experience in the PINC program and its reciprocal effect on URG peer mentors’ leadership skills development and how it affected their educational trajectory. The findings highlight how peer mentoring impacts the URG mentees in a collaborative learning in I-STEM courses, and affects their self-perception and academic achievement. Peer mentorship in I-STEM program builds leadership skills in the URG peer mentors through giving them perspective on how to teach I-STEM concepts to the URG mentees and as a result the URG mentors improve their academic rigor, professional experience, and persist in the I-STEM program.
Acknowledgements

I would like to thank all my family for their dedication and support, and the honor of this study goes to them. I am here because of special people in my life, my ancestors, my grandfather, and my grandmother whom I never met personally, but I grew up with their legacy as I carried their name, and each time when I traveled to the Saray village, I saw their touch. My father (Hassan Roushani Saray) taught me the importance of family, my mother (Sariah Hashemzadeh Gargari), taught me kindness, my sister (Safieh) raised me into who I am, and my brother (Mohammad Reza) has changed my life with his support from my early elementary school through high school and even graduate studies. My brothers (Boyook, Mohammad Hossein, Gholam Reza) to whom I owe my integrity, and my nieces, Zohreh and Sahar, have given affection to fuel my passion.

My beautiful wife (Melody Amirehsani), and children (Ashley, Hannah, and Ryan) have supported me and helped me through this journey. As a first-generation student, I looked at them each time that I lost strength and the roads were rocky. They have given me love and affection to help me energize, and I am forever grateful for their love and dedication. My second parents (Daryoush and Farideh Amirehsani), have treated me as their son, and Lela who has been my second sister.

I would like to acknowledge my committee chair, Dr. Sheldon Gen, and committee members, Dr. Brian Beatty, and Dr. Shasta Ihorn who have unconditionally supported me throughout this study. I would also like to thank Dr. Ilmi Yoon for her key role in helping me understand the student experience in interdisciplinary science technology engineering and math.
(STEM), and the Promoting Inclusivity in Computing (PINC) group for their support throughout the study. I am grateful to the faculty of the School of Education who helped me throughout this journey, and special thanks to Dr. Andrea Goldfein who was my mentor.

I never thought that I would enter the world of higher education if I had not met Michael Rouan in March 2005 at Stanford University. He encouraged me to pursue a career in higher education and has been a beacon each time that I have lost my way. I shall remember him for his profound impact on my life.
# Table of Contents

Certification of Approval ............................................................................................................. ii

Abstract ......................................................................................................................................... iii

Acknowledgements ....................................................................................................................... v

Table of Contents ........................................................................................................................ vii

List of Tables ................................................................................................................................ ix

List of Figures ................................................................................................................................ x

List of Appendices ........................................................................................................................ xi

Chapter 1: Introduction and Problem Statement ...................................................................... 1

  Problem Statement ....................................................................................................................... 2

  Purpose of the Study ................................................................................................................... 7

  Research Questions ................................................................................................................... 8

  Significance of the Study ........................................................................................................... 8

Chapter 2: Literature Review .................................................................................................... 10

  Peer Mentoring, Self-Perception, and Persistence ................................................................. 11

  Peer Mentor Integration in Critical Curriculum Design ...................................................... 14

  Effective Peer Mentoring Collaborations in a STEM Learning Environment .................... 18

  Faculty Professional Development to Support Peer Mentors ............................................ 21

  Peer Mentor Leadership Skills Development ..................................................................... 22

Chapter 3: Methods .................................................................................................................... 26

  Research Design ....................................................................................................................... 27

  Description of Setting .............................................................................................................. 27

  Target Population ................................................................................................................... 29

  Data Collection, Management, and Analysis ........................................................................ 32

  Data Analysis .......................................................................................................................... 38

  Data Management .................................................................................................................. 39

  Internal and External Validity, Reliability, and Transferability .......................................... 40

Chapter 4: Findings .................................................................................................................... 41

  Analysis ...................................................................................................................................... 43

    Sense of Belonging ................................................................................................................. 47

    Peer Mentor Leadership Skills Development ................................................................ 53

    Faculty Perspectives ............................................................................................................. 55
Culture of Inclusivity ......................................................................................................................................... 56
Mentee–Mentor Relationships................................................................................................................ 57

Chapter 5: Implications................................................................. 60
Study Limitations .................................................................................. 61
Educational Equity ............................................................................... 61
Educational Leadership ........................................................................ 62
Educational Policy ............................................................................... 63
Wider Application of Study ................................................................... 64
Further Directions ................................................................................ 64

References .......................................................................................... 66
Appendices .......................................................................................... 81
## List of Tables

Table 1 STEM 2-Year Retention Rates in CSU for First-Time First-Year Students (2007 and 2015 Cohorts) .............................................................................................................................. 3

Table 2 STEM 6-Year Graduation Rates in CSU for First-Time First-Year Students (2007 and 2011 Cohorts) .............................................................................................................................. 4

Table 3 PINC Program Pathways for I-STEM students in Computer Science Minor (Pathway for Biology/Chemistry Majors) ...................................................................................................... 28

Table 4 PINC Program Pathways for Computer Science Major Students (Pathway for Nonbiology/Chemistry Majors) ........................................................................................................ 29

Table 5 Guiding Framework for Interview Protocols’ Sense of Belonging Construct ................................................................................................................. 34

Table 6 Conceptual Variables and Operational Measures ................................................................................................................................. 36

Table 7 Emerging Themes From First Cycle Coding ............................................................................................................................................... 44

Table 8 Emerging Themes From Second Cycle Coding ............................................................................................................................................... 45
List of Figures

Figure 1 The Persistence Framework .......................................................... 11
Figure 2 Ten Years of Institutional Data on Student Drop Rate in STEM and Non-STEM from Fall 2005 to Fall 2014 .......................................................... 13
Figure 3 SFSU Student Demographics ....................................................... 30
List of Appendices

Appendix A: PINC Program Mentee Interview Protocol ................................................................. 81
Appendix B: PINC Program Mentor Interview Protocol ............................................................... 83
Appendix C: PINC Program Faculty Interview Protocol ............................................................. 86
Chapter 1: Introduction and Problem Statement

Growing consensus has shown professionals are needed who can integrate knowledge across science, technology, engineering, and mathematics (STEM) fields to address global challenges and meet the demands of increasingly complex issues. Interdisciplinary STEM (I-STEM) education seeks to integrate the knowledge, skills, and tools from multiple STEM fields to increase learning, understanding, and ability to apply this knowledge to solve complex problems. Many of today’s greatest challenges such as eradicating COVID-19, global warming, and addressing world hunger have relied on interdisciplinary approaches to develop creative, effective, and sustainable solutions. These issues require individuals tackling these problems have disciplinary expertise, for instance in virology, chemical engineering, or crop sciences. However, achieving expertise to solve complex issues requires infusion of knowledge from other disciplines, such as data science, to analyze the impact of the virus during a pandemic for virologists, solar battery data interpretation for a chemical engineer, or crop resistance due to global warming.

Because diversity drives innovation, finding solutions for these issues with a diverse group of professionals would be more innovative and sustainable (Jones et al., 2020). Training diverse professionals with such unique skillsets requires including individuals from diverse backgrounds who are equipped with knowledge and experience from multiple STEM disciplines who are also interested in tackling these issues because of the implications in their community. Therefore, developing solutions draws on training in two or more STEM disciplines with students from diverse backgrounds. If the persistence of students in a STEM discipline has hindered higher education since its inception, the persistence of students in I-STEM is a
challenge with a higher magnitude. Because the persistence of underrepresented groups (URGs) in STEM is a major concern, the persistence of URG students in I-STEM is alarming and causes inequity. Such inequities in interdisciplinary education impact underrepresented communities harder; therefore, it is necessary to find solutions for the URGs persistence in I-STEM.

**Problem Statement**

URG students have been significantly underrepresented in I-STEM courses due to low enrollment and disproportionately low degree attainment. The California State University Office of the Chancellor (see Table 1) reported 52.8% student retention for Latinx students in a STEM discipline, whereas the total system-wide retention rate was 72.5% in 2015, which followed the alarming graduation rate of 27.2% for Latinx students with STEM degrees compared to a 53.6% system-wide graduation rate for its 2011 cohort (California Education Learning Lab, 2019). This trend was even more alarming for African American students in California State Universities (see Table 2), where only 15.4% graduated with STEM degrees when the system-wide graduation rate for the 2011 cohort was 43.3% (California Education Learning Lab, 2019). Despite the noticeable improvement in the student retention and graduation rate in STEM, both the 15.4% graduation rate in STEM for African Americans versus 43.3% system-wide graduation rate, and 27.2% Latinx graduation rate in STEM versus 53.6% system-wide graduation rate are disproportionate (see Table 2). This trend is more critical as only 35.7% of female students graduate from STEM majors as opposed to the 62.1% system-wide female graduation rate (see Table 2). As a result of this underrepresentation, students are not afforded the opportunities and experiences of equitable STEM education, resulting in educational inequity.
Table 1

*STEM 2-Year Retention Rates in CSU for First-Time First-Year Students (2007 and 2015 Cohorts)*

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<td>Total</td>
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<tr>
<td><strong>Total System-wide</strong></td>
<td>75</td>
<td>74.9</td>
<td>75.4</td>
<td>75.9</td>
<td>64.1</td>
<td>66.7</td>
<td>72.5</td>
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<tr>
<td><strong>% of STEM entry students remaining in a STEM discipline</strong></td>
<td>55.3</td>
<td>61.2</td>
<td>52.2</td>
<td>57.1</td>
<td>39.4</td>
<td>51.8</td>
<td>47.6</td>
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*Note. Adapted from California State University Graduation and Continuation Rates by California State University, Institutional Research and Analyses, n.d. (http://asd.calstate.edu/csrde/index.shtml#stemi)*
Table 2

*STEM 6-Year Graduation Rates in CSU for First-Time First-Year Students (2007 and 2011 Cohorts)*

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<tr>
<td>Total system-wide graduation rate (%)</td>
<td>51.8</td>
<td>59.2</td>
<td>54.9</td>
<td>62.1</td>
<td>35.9</td>
<td>43.3</td>
<td>44.9</td>
<td>53.6</td>
</tr>
<tr>
<td>Graduation rate for STEM entry students graduating with STEM degree (%)</td>
<td>32.5</td>
<td>39.1</td>
<td>30.6</td>
<td>35.7</td>
<td>11.2</td>
<td>15.4</td>
<td>19.5</td>
<td>27.2</td>
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Note. From California State University Graduation and Continuation Rates by California State University Office of the Chancellor, Institutional Research and Analyses, n.d. (http://asd.calstate.edu/csrde/index.shtml#stemi)

The STEM workforce has traditionally lacked diversity. Research has demonstrated this trend is caused by educational institutions’ inability to sufficiently recruit and support URG students in STEM, which has decreased their presence in I-STEM tremendously (Blackburn, 2017; McGee, 2020; Perez-Felkner, 2018). Specifically, research has suggested the conditions of STEM education tend to push URG students out of STEM programs due to poor teaching, lack of relevance in the curriculum, and psychosocial factors such as the experience of stereotype threat (Meador, 2018; Shapiro & Williams, 2012). Therefore, URG students’ success in I-STEM
education would benefit from programs that integrate peer mentorship into the curriculum development, encourage students to recognize the value of their presence in I-STEM, use mentorship to help students to navigate through the challenges that they face in I-STEM education, and provide mentor skills training.

Failure to increase the inclusion of underrepresented groups in STEM, especially I-STEM education, and consequently the STEM workforce, has social and economic implications. I-STEM education tends to prepare workers not only for STEM careers, but also to build skills highly prized in a variety of jobs. STEM jobs, especially highly technical careers, tend to pay higher wages, and increasing access to those higher-paying jobs is important for decreasing the highly skewed income disparities and the consequent social disparities (Strah et al., 2022). Other researchers have argued that the need to diversify the STEM workforce goes beyond economics and has benefits to society in creativity and productivity (Brewer & Clayton, 2020). Therefore, educational institutions need to ensure the inclusivity of URG students in STEM, especially I-STEM education.

The traditional approach for interdisciplinary education requires students to be immersed in discipline-based courses and compete with students in that major rather than providing a guided path and modifying the curriculum to meet the needs of students from other majors. For instance, a biology major who is interested in the data science minor offered through the computer science (CS) department needs to enroll in courses that are necessary for the CS major students’ graduation, and compete with the CS major student to remain in the course and receive a minor. The discipline-based curriculum design typically builds on its prerequisite courses and assumes students have developed all skills necessary to receive their diploma based on this
curriculum. This type of curriculum focuses on knowledge transfer, and validation of student knowledge, which poses a challenge to interdisciplinary education and especially URG students in interdisciplinary education. Research on learning has demonstrated that traditional, teacher-centered methods of teaching such as lectures and decontextualized knowledge typical of rote learning, skill-and-drill pedagogies, are not only less interesting, but also less likely to lead to a deep understanding of the material and the ability to apply it to real-world problems or uses (Brown et al., 2019; Springer et al., 1999). I-STEM students need to work diligently to rise above the crowd to continue, which for URG interdisciplinary students poses the imposter syndrome effect when their limited knowledge of one discipline is compared with students who are committed to pursuing a career in that discipline (Akin et al., 2022; Buckley et al., 2017; Cooksey, 2012).

Conversely, researchers trying to understand what supports success of URG students in higher education have found that peer mentor relations increase social-emotional factors such as a sense of belonging (Rainey et al., 2018), validation (Linares, 2011), and self-efficacy (Beier et al., 2016) and have a positive impact on retention and persistence. For example, being part of a community of learners can increase a student’s sense of belonging (Chickering et al., 2015). Students receiving validation by having their ideas accepted and valued by peers and teachers demonstrates important contributions (McConnell, 2020; Salomone, 2017); as such, opportunities to problem solve and succeed increase a student’s self-efficacy in education and in that field and increase their motivation to persist (Mistele et al., 2019; Zavala & Hand, 2019).

Broadly speaking, peer-mentored collaborative learning is one student-centered pedagogical practice that mitigates many of the factors leading to student attrition in STEM.
First, studies in collaborative learning have suggested that it impacts how students see themselves as scientists (Graham et al., 2013; Lamont & Pierson, 2019). Second, studies have shown that collaborative peer-mentored learning in STEM education increases the sophistication of students’ scientific thinking to solve complex problems (McGunagle & Zizka, 2020). Finally, peer mentor relations during collaborative learning create a community of learning that increases student efficacy (Beier et al., 2016). Overall, there has been growing evidence that STEM students learn best in peer mentor collaborative learning environments (Brown et al., 2019; Laal et al., 2017; Springer et al., 1999). Mistele et al. (2019) found education centered on meaningful interaction with faculty and careful design and implementation to have a positive impact on student success, including degree attainment. Research about the particular value of social-emotional factors for URG students including a sense of belonging, validation, and self-efficacy has further suggested that such collaborative pedagogies would have an especially powerful effect in supporting persistence and success in STEM. In line with this argument, this dissertation looked at equitable practices in I-STEM education to explore what affects the self-perception and persistence of URG students in I-STEM education.

**Purpose of the Study**

This study examined how peer mentor collaborative learning in I-STEM courses affects enrolled URG students’ self-perception to persist in interdisciplinary studies at a 4-year university. San Francisco State University’s College of Science and Engineering approaches I-STEM education through the Promoting Inclusivity in Computing (PINC) program, which uses instructional and curricular methods that seek to increase the number of women and URG students of all gender identities in computing. I used this program as a particular case study to
explore the student experience in the PINC program and understand the impact of peer mentor

collaborative learning in I-STEM courses on students’ self-perception and academic
achievement. My rationale for using a qualitative case study methodology was to elevate
students’ voices and lived experiences during participation in I-STEM courses (Saldaña, 2015).

Research Questions

RQ 1. How does peer mentor coaching in a university interdisciplinary STEM program
affect the URG students’ sense of belonging?

RQ 2. What is the impact of mentoring on the mentors’ STEM leadership skills
development?

The rationale for investigating this problem was the importance of institutional
responsibilities to assist URG students to succeed and persist in I-STEM majors through positive
self-perception. Any improvement in STEM andragogy will benefit all students tremendously as
it impacts institutional response to the issue.

Significance of the Study

When educational leaders address STEM education issues, they can have a positive
impact on URG students’ success in STEM-based majors (Ladson-Billings & Tate, 2006; Patton,
2016). Shields and Hesbol (2020) described transformative educational leadership as including
the implementation of effective pedagogy and meaningful interaction among faculty and
students; therefore, the design and implementation of an effective peer mentor program
constitutes a notable change in persistence of URG students in I-STEM and requires institutional
support to succeed.
Considerations for the implementation of a collaborative learning environment include approaches to instruction, student support, and adequate funding (Beach et al., 2012; Borrego & Henderson, 2014). These approaches help students develop greater learner autonomy, self-regulation, commitment, and individual responsibility for academic performance (Wolfe & Dilworth, 2015). Transformative teaching is essential to I-STEM identity development through building confidence in students to connect to materials, and peer mentor collaborative learning results assist URG students in navigating through the challenging path and persisting in their I-STEM education (National Academies of Sciences, Engineering, and Medicine, 2016). These connections come from positive interactions in peer mentor collaborative learning environments where students’ interests in learning the topic are intrinsic, as demonstrated by how they invest themselves in learning and dive deeply into topics, resulting in persistence in STEM, which ultimately contributes to the URG students’ persistence in I-STEM (Graham et al., 2013; Xu, 2018). Developing persistence in I-STEM students requires a teaching and learning environment that encourages students through curiosity and creativity to use their prior knowledge without fear, and peer mentor collaborative learning is helpful in reducing such obstacles through interaction with a peer who has navigated through similar experiences (Chickering & Reisser, 1993; Flores, 2019). Instructor preparation and curriculum are crucial factors contributing to student achievement in mathematics and consequently STEM education (Handal & Herrington, 2003; Hill et al., 2005). Therefore, a curriculum design that evolves around peer mentor collaborative learning contributes tremendously to the I-STEM students’ success.
Chapter 2: Literature Review

The purpose of this literature review is to explore the effects of peer mentor collaborative learning on URG students’ continued persistence in I-STEM education and how peer mentor relations evolve URG students’ self-perception as scientists. Researchers have highlighted a critical curriculum design with built-in peer mentorship, effective design of peer mentor collaborative STEM learning, and faculty professional development as essential elements in creating a positive self-perception in students to feel a sense of belonging and persistence in continuing their learning journey (Sithole et al., 2017). A critical curriculum design in STEM is defined as andragogy that is socially and academically responsive (McGee, 2020; Pearson et al., 2022). This type of critical curriculum centers on I-STEM students’ needs and has a crucial element, such as peer mentor involvement, for creating an inclusive environment to help students feel course materials relate to their studies, and provides support from peer mentor students who have embarked on a similar journey.

Effective design of a collaborative I-STEM learning environment constructs a community of learning, where students bounce ideas, voice their concerns, and finally find answers to their questions (Brown et al., 2003; Crippen & Antonenko, 2018). Therefore, a collaborative learning environment requires effective course instruction, meaningful interaction among faculty and students, and institutional support (Emdin, 2011a; Langer-Osuna, 2017; Turner et al., 2013). Faculty support and collaboration with mentors and students in an I-STEM environment is a crucial element in building a relevant curriculum, creating a collaborative learning environment, and encouraging students to engage in dialogs that ultimately center around the student experience, where peer mentors’ feedback reshapes what is necessary for the I-STEM student
success and persistence (Stelter et al., 2021). Peer mentoring affects the self-perception of I-STEM students and how they see themselves as scientists, which contributes to their identity development and persistence in I-STEM (Rockinson-Szapkiw et al., 2021; Wendt et al., 2019; Zaniewski & Reinholz, 2018).

Peer Mentoring, Self-Perception, and Persistence

The persistence of I-STEM depends on many factors in a student’s life, and each course that a student takes shapes their educational trajectory. Graham et al. (2013) introduced the persistence framework that integrates evidence from psychology and education with the emphasis on student agency, rather than on the institutional perspective of retention (see Figure 1).

Figure 1

The Persistence Framework

The persistence framework identifies learning and professional identification as determinants of persistence, which indicates that each step of the student’s learning journey affects a prospective student’s confidence and, consequently, their motivation, which in turn spurs academic success and feeling like a scientist (Graham et al., 2013). Colvin and Ashman (2010) highlighted the peer mentor role in collaborative learning as one of the essential factors in building confidence and motivation in students, which is the result of relationships among students, mentors, and instructors that contribute to self-perception. Hanuaer et al. (2016) extended the persistence framework by incorporating a six-factor structure consisting of (a) networking with peers, (b) self-efficacy, (c) science identity, (d) scientific community values, and (e) project ownership (i.e., emotion and content).

According to 10 years of institutional data from a large public U.S.-based university (see Figure 2), STEM majors had higher exit rates at 38% for all students with an even higher rate of 65% for underrepresented minority (URM) students, which has been attributed to the student experience in STEM majors (Haak, 2011; Palmer et al, 2011; Tinto, 2017; Whitcomb et al., 2021). Xu (2018) emphasized that institutional conditions and the gap in student support, particularly the quality of the academic program and faculty teaching and accessibility, have dominated the STEM students’ college experience and their persistence in academic majors and to graduation. Such gaps have translated to student struggles, which are critical in URG I-STEM students’ experience, and researchers have attested to the importance of peer-monitoring to mitigate the negative impact of such deficiencies in teaching and learning (Spaulding et al., 2020).
Figure 2

Ten Years of Institutional Data on Student Drop Rate in STEM and Non-STEM from Fall 2005 to Fall 2014

*Note.* Ten Years of Institutional Data on Student Drop Rate in STEM and Non-STEM from Fall 2005 to Fall 2014 inclusive; students had either graduated and earned a degree or not attended the university for at least 1 year as of Spring 2019. For each major, the percentage of students who declared the major but subsequently dropped the major is plotted along with its standard error for (a) all students, (b) Asian students, (c) URM students, and (d) White students. Adapted from “Underrepresented Minority Students Receive Lower Grades and Have Higher Rates of
Peer mentorship as an afterthought is not effective and needs to be integrated into the fabric of the academic program and curriculum design, where faculty realize student challenges and actively collaborate with mentors to identify issues students face and provide just-in-time solutions.

**Peer Mentor Integration in Critical Curriculum Design**

Yosso (2002) defined critical race curriculum (CRC) as a continuum of critical race theory (CRT; Ladson-Billings, 1998) that exposes contemporary forms of racial inequality, which are disguised as neutral and objective structures, processes, and discourses of the school curriculum. A CRC reveals the multiple layers of racialized inequality perpetuated by traditional curriculum processes that do not include the impact of peer mentors in assisting I-STEM students throughout their learning journey. These deficit discourses serve to rationalize discriminatory curricular processes that maintain structures of racial, gender, and class inequality in schools (Darling-Hammond, 2015). Curricular structures, processes, and discourses inform and comprise classroom interactions at all levels of education, from prekindergarten through university (Yosso, 2002). Therefore, to achieve an equitable I-STEM education, colleges and universities need to dismantle practices that marginalize students. Building an effective course instruction that includes a peer mentor learning environment to address URG students’ issues in I-STEM instruction is a critical step in dismantling these discriminatory practices. Instruction involving
collaboration with students is important for their self-perceptions as emerging scientists. Wilson et al. (2010) suggested agentive participation is higher in inquiry-based instruction, which is one of the elements of peer mentor learning. Springer et al. (1999) particularly talked about the effectiveness of small group learning and how it promotes greater academic achievement, more favorable attitudes toward learning, and increased persistence through STEM courses and programs.

Curriculum design and instructional methods shape students’ self-perception. Therefore, the inclusion of any support such as peer mentor learning, which draws its strength from experiences to which students can easily relate, is essential for improving I-STEM students’ self-perception. McGee (2017) characterized mathematical identity development in Black students through an evolving sense of self-efficacy and discovery inspired by student learning in the classroom. Larnell (2016) defined collaboration as positive interactions incorporated into the instruction, where students’ learning experiences transition students toward a positive association with mathematics learning. Langer-Osuna (2017) examined how intellectual authority becomes constructed, organized, and distributed among students, and the implications of classroom instructions and interaction on both mathematics learning and the development of mathematics-linked identities. A peer mentor collaborative learning environment is an important method for improving student self-perception. A study by Huerta et al. (2018) conducted in a public high school addressed the lived experiences of students before attending 4-year universities. The study emphasized the importance of collaboration through project-based learning, as project-based learning was a positive contributor to students’ self-perceptions as scientists. Although distinct from STEM in higher education, studies on STEM teaching and learning at the high
school level have provided important background on how STEM students learn better in a collaborative learning environment, which colleges need to continue as a way to focus on the development of sophisticated scientific thinking among students (Brown et al., 2019; Langer-Osuna, 2017). Peer mentor collaborative learning that evolves around I-STEM projects is essential in removing the stigma of I-STEM courses in URG students. Higher educational institutions need to carry on such praxis to take advantage of advancements in student development methods (Bruffee, 1999; Scager et al., 2016). Thomas (2000) argued that peer mentor project-based learning is a type of experiential learning that engages students to develop their understanding of a domain by applying its methods and principles; as such, it is a form of active learning. Peer mentor project-based collaborative learning is one of the methods of creating collaborative STEM learning environments, which helps students collectively discuss and learn diverse ways of addressing a challenge where instructors and mentors can provide healthy feedback to students (Beier et al., 2019). I-STEM needs to use methods that engage in building a positive self-perception and confidence through mentor-led project-based learning to engage students in collective learning and remove barriers imposed by traditional STEM education.

In contrast to these collaborative and agentive models, much of traditional STEM education has been focused on individualism, privatization, and competition embedded in neoliberal conceptions of education (Hoeg & Bencze, 2017). A model that extends collaborative learning even further is that of culturally relevant education (CRE), which represents pedagogies of opposition committed to collective empowerment and social justice (Ladson-Billings, 1998) conceptualized through teaching and pedagogy reform (Aronson & Laughter, 2016). Gay (2010)
defined culturally responsive teaching “as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them” (p. 31). Gay’s perspective applies to all students including in the college setting, where education is needed for the whole I-STEM student (Aronson & Laughter, 2016). Although this notion has been argued in K–12 education, its existence in higher STEM education has not been widespread. Implementation of a CRE curriculum connects the URG student to the topic and increases the student’s confidence in the topic through emotional connection, both of which contribute to the student’s persistence in STEM (Gorski, 2016). Challenges to the CRE implementation in I-STEM have included a lack of prep time to develop new curricular content, institutional grading policies, and limited time to cover the materials necessary for completing the course (Bowen & Cooper, 2021; Whitcomb et al., 2021). Faculty may push back as they may perceive limits to their academic freedom or that such modifications in instruction may not align with their teaching philosophy (McGee & Bentley, 2017). For instance, a biology major who is minoring in data science for natural sciences is expected to achieve an elevated level of proficiency in both biology and computer science. Given the differences in biology and computer science andragogy and curriculum, the biology students may not have the mindset of computer science students who are highly trained to follow logic and algorithm-based problem solving. This mismatch of pedagogical approaches creates gaps where such students feel alienated because the biological sciences require a different method of rigorous reasoning to achieve a level of proficiency in the subject. Therefore, creating peer mentor collaborative problem-based learning with a cohort of interdisciplinary students
would ensure students succeed in their I-STEM education through positive interactions with their peers and curricular content (Langer-Osuna, 2017; McConnell et al., 2020).

Developing courses that aim to address student challenges with the best instructional design for student achievement fosters a meaningful learning environment in which students engage in learning practices related to the topic of study (Lozano et al., 2017). Brown et al. (2019) emphasized that students’ involvement in a classroom increased in an environment that fostered collaboration rather than using an instructor-centered authority model. This issue is significant for women in I-STEM as women have experienced bias and backlash related to performing as authority figures in the classroom (Bowles et al., 2007; Uhlmann & Cohen, 2005). For example, women often have to provide more evidence of competence than men to be seen as equally competent (Eagly & Mladinic, 1994; Foschi, 2000). Therefore, the implementation of content in which students have the opportunity to voice their perspectives helps students to feel involved and gain confidence in the subject, and helps in their I-STEM identity development (Kim et al., 2018). Inclusive instructional design of courses including solutions for I-STEM student challenges benefits students with the latest pedagogical approaches that combat imposter syndrome, which ultimately leads to the persistence of I-STEM students. Therefore, it is imperative to design I-STEM curricula in a way that integrates peer mentor collaboration as an essential part of the course.

**Effective Peer Mentoring Collaborations in a STEM Learning Environment**

Meaningful interaction among faculty and students and student support are two important considerations for building a peer mentor collaborative learning environment. Such a collaborative environment relies on increased communication among faculty and students,
mentors, and tutors to help students complete the course or even the program (Griffith & Main, 2019; Salomone & Kling, 2017). Students’ acquisition and application of knowledge requires an adequate support system from subject matter experts who are also close to the student role (Kosslyn, 2017). Therefore, peer mentors who have previously taken the class provide valuable insight on how to tackle issues students face in learning the topic (Boud et al., 2014). These peer mentors are the bridge between faculty and students, which makes managing classrooms more friendly for students who may feel intimidated in needing to make frequent requests to faculty for help. Race and ethnicity tremendously impact the education system (Darling-Hammond, 2010). This impact is more detrimental to URG I-STEM whose prior experiences with schooling may have led them to shy away from confronting the authority figure in class (McGee, 2020). Therefore, moving away from the instructor-centered lecturing style to teacher-involved peer mentor collaborative learning provides greater support for URG students in STEM.

The quality of a peer mentor collaborative learning environment depends on student and faculty discourse in the learning environment, which also impacts the quality and outcomes of instruction. Davies and Harré (1990) defined discourse as “an institutionalized use of language and language-like sign systems” (p. 45). This institutionalization can happen at various levels. For students working in a small group in their science classroom, their language system may have been institutionalized by their group, their science classroom, or the broader school context, which for I-STEM students translates to how the peer mentor interaction with the mentee has been positioned in their educational context. Davies and Harré (1990) distinguished between two kinds of positioning. First, there is reflexive positioning, “in which one positions oneself” (Davies & Harré, 1990, p. 48) through discursive practices such as how one frames their ideas or
contributions as aligned (or not) with the ideas of others and how one talks about her/his roles, competencies, and experiences. The second is interactive positioning, which captures “what one person says, positions another” (Davies & Harré, 1990, p. 48). The peer-mentor and mentee position themselves based on how the learning environment, including the instructor, sets the ambiance of the classroom. Creating the learning groups, rules, and governance of the classroom positions students to transition from the recipient role to an interactive positioning where students participate in active learning and discussion among their peers, and it is the responsibility of the instructor to lead students to collectively discuss and learn as a group (Turner et al., 2013). Such positioning in the I-STEM peer mentor learning groups sets the stage for how mentees conceive peer mentor-mentee relations in their classroom. For instance, if a student dismisses a peer’s idea as irrelevant, this position restricts the peer from contributing to the group. However, if a student invites a peer to explain their ideas and directs others to attend to the explanation, this affirmation creates an opportunity for the peer’s authority and asserts a positive interactive positioning. In this way, both reflexive and interactive positioning functions shape, expand, and/or constrain an individual’s options for participation, which over time affects their identity development (Harré & Van Langenhove, 1991). This type of interactive STEM learning environment in and out of the classroom in peer mentor meeting groups creates rigorous learning habits for students and helps them in the development of teamwork in I-STEM, which contributes to the sense of belonging and persistence in I-STEM. Constructing a supportive peer mentor collaborative environment requires faculty training in supporting peer mentors and being cognizant of the role of such an important function in the I-STEM course.
Faculty Professional Development to Support Peer Mentors

Faculty professional development is a critical factor in building peer mentor collaborative I-STEM learning environments (Avery & Reeve, 2013; Derting et al., 2016). The instructor’s preparedness to instruct the student is one of the fundamentals that Gay (2010) referred to as part of the requirements for a responsible education (Lozano et al., 2017). As such, California K–12 science teachers have not had adequate time to prepare for science classrooms (Windschitl & Stroupe, 2017). This inadequacy in the educational system penalizes URG STEM students when they are in college. The teacher preparation inadequacy in K–12 education has been evident in college STEM courses where students have not been adequately prepared for learning STEM courses (Emdin, 2011a; Tyson et al., 2007). Although almost 90% of teachers surveyed by Dorph et al. (2011) felt very prepared to teach English language arts and mathematics, only about one third felt very prepared to teach science. Therefore, higher education institutions need to address this pattern of teacher underpreparation, which leads to students’ struggles in I-STEM courses. Higher education institutions need to emphasize efforts to assist students in learning fundamentals, develop I-STEM study skills through peer mentor collaborative learning, and build on the experience and knowledge of students who have already gone through the I-STEM learning path. Hence, education needs to shift from the existing instructional methodology toward teamwork through a peer mentor collaborative project-based I-STEM. Such a shift in the andragogy of I-STEM will prepare URG students to work collaboratively, which is the norm in the workforce teams and contributes to peer mentor skills development.
Peer Mentor Leadership Skills Development

Peer mentorship is beneficial to I-STEM students in a reciprocal way as the URG students benefit from the skills developed by engaging in peer mentorship. Mentors develop leadership skills acquired during interaction with peers, faculty, and training to support fellow peers to embark on the same endeavor. Anderson et al. (2019) concluded that peer mentoring and training strengthened traditionally underrepresented undergraduate students’ persistence in the sciences, and such responsibilities contribute to their leadership skills development. Anderson et al.’s (2019) research explored the career trajectories of undergraduates and recent postbaccalaureates in an undergraduate research experience who mentored younger students from 2004 to 2015 and reported that all but one of the 40 participants were engaged in either STEM-related careers or education. The positive effects of leadership skills of peer mentors were not limited to STEM persistence, and it additionally helped create a tier of professionals who not only persisted in STEM but also retained an active commitment to helping younger students gain an appreciation for science (Anderson et al., 2019).

Mentor training is essential for creating a positive outcome from peer mentor relationships, and it strengthens undergraduate persistence in the sciences and creates a sense of belonging in mentors. The sense of belonging is a crucial factor in creating a community of learning that feels inclusive and responsible to its members. Such a community assists I-STEM students who engage in peer mentor programs to feel a sense of accomplishment and purposefulness (Smith, 2017). The peer mentor role serves a critical role in creating a positive influence on mentees and increasing the students’ level of engagement and success in academic and nonacademic fields of study, and this seems evident in URG students (Anderson et al., 2019;
Mentor training in I-STEM additionally creates an environment in which peer mentors are repeatedly exposed to the same topic with peer mentors in the position to dive deeper into the subject and prepare for mentees, deepening the mentor’s understanding of the subject (Rockinson-Szapkiw et al., 2021; Spaulding et al., 2020). Rockinson-Szapkiw et al.’s (2021) findings demonstrated mentors and mentees participating in the mentorship program at two historically black institutions experienced increased levels of community, self-efficacy, better academic success, and intent to persist in STEM disciplines and careers.

Research focused on the impact of peer mentors on grade point average (GPA) has concluded that peer mentor collaborative learning improved the mentee’s GPA. For example, Drane et al. (2014) examined the grades (i.e., GPA) of peer mentors for five disciplines and seven classes over 10 years. The data suggested that mentor grades in five of the seven courses saw a positive impact. This impact was also seen in four classes that were part of a set of sequenced courses. The authors also noted an impact on mentors regardless of ethnicity or gender, even though effect sizes were larger for students in underrepresented groups. Studies that have examined the benefits of peer-based mentors at the undergraduate level have found the acquisition of skills that range from improving time management to relationships to a better sense of self and a better understanding of the content taught (Drane et al., 2014; Russomanno et al., 2010; Windsor et al., 2015).

Servant leadership in education builds on compassion and empathy (Greenleaf, 1998; Hayes, 2008). Peer mentors who have struggled through similar experiences empathize with fellow students and have compassion that develops through lived experience. In addition to
serving as positive role models, peer mentors engage with mentees in interpersonal qualities, which are critical for the mentees’ success in academia and a multitude of contexts (Rubin, 2009). Leadership skills development also increases the confidence of mentors and acquiring skills on how to interact with peers.

In conclusion, the literature review suggests researchers have found elements of effective I-STEM education through meaningful interaction among faculty, students, and mentors combined with effective course instruction that integrates peer mentor collaborative learning backed by institutional support. Such an environment highlights the importance of students learning collaboratively in I-STEM and fosters dialogues rather than an instructor-centered monologue.

The success of I-STEM students in each STEM class builds the student’s confidence and positive self-perception. Peer mentorship helps I-STEM students’ self-efficacy and confidence so students can continue their journey in I-STEM with their colleagues rather than feeling alone in their STEM education ahead. Although effects of peer mentorship are evident, there has been very little published research on the role of mentorship in the I-STEM and its impact on URG I-STEM students. Therefore, researchers need to see the impact of peer mentorship on URG I-STEM students, how it impacts their sense of belonging in I-STEM education, and what the impacts of peer mentoring are for URG mentors’ skills development and educational trajectory. Examining the role of peer mentorship in I-STEM granted an exploration of peer mentor relationship influence or impact on URG I-STEM students’ sense of belonging, and whether such role in I-STEM has any effect on the peer mentor’s skills. Such a study is needed to examine the effects of peer mentoring on the URG I-STEM student’s sense of belonging in I-
STEM course, program, and learning community as well as the reciprocal effects of peer mentorship on the peer mentor leadership skills and education trajectory. Is this impact is mutual, and are there any side effects or unexplored areas of peer mentor collaboration?
Chapter 3: Methods

The literature review in Chapter 2 highlighted the importance of peer mentor coaching, components of peer mentor coaching, and how peer mentor collaboration with mentees may assist science, technology, engineering, and math (STEM) students to navigate through the challenges they encounter in higher education (Hurtado & Carter, 1997; Maestas et al., 2007; Riera et al., 2017; Trujillo & Tanner; 2014). The underrepresented group (URG) students in interdisciplinary-STEM (I-STEM) education encounter even more challenges due to first-generation status, under preparation, or severe societal pressures. Studying the URG students’ experience in I-STEM would require a case study of a higher education setting where peer mentor coaching is an integral part of a program to understand how peer mentor coaching in I-STEM shapes students’ sense of belonging, self-perception, and persistence in STEM (Yazan, 2015; Yin, 2012). My research questions were: (a) How does peer mentor coaching in a university I-STEM program affect the URG students’ sense of belonging?; (b) What are the impacts of mentoring on the URG mentees’ sense of belonging?; and (c) What is the impact of mentoring on the mentors’ STEM leadership skills development? Therefore, qualitative research with one-on-one interviews with mentees would reveal mentees’ lived experiences and question their effects on mentors’ skills development and leadership skills. I selected a cross-sectional approach in my case study to gather data through interviews with I-STEM program mentees, mentors, and faculty (Creswell & Creswell, 2017). In addition, analyzing the student persistence in the I-STEM program would help to triangulate data (Klaassen, 2018).
Research Design

The research design for this study was a qualitative case study of an interdisciplinary STEM program—Promoting Inclusivity in Computing (PINC)—in a major public 4-year university. To explore the impact of peer mentorship on the URG students’ sense of belonging, self-perceptions, persistence, and reciprocal effect of peer mentorship on mentors in an I-STEM program, I selected the PINC program for the case study. Because of the PINC program’s unique approach to I-STEM education, which emphasizes inclusivity for the URG students and includes an integrated peer mentor coaching as part of the program design, I could see the effect of mentorship in I-STEM. In this case study, I collected interview data from URG mentees and mentors and PINC program faculty to explore the sense of belonging, perceptions, and persistence in mentees, and leadership skills development in PINC mentors.

Description of Setting

This case study took place at San Francisco State University (SFSU), which is a public urban university located in San Francisco, California. The PINC program is a joint venture among the biology, chemistry, and computer science departments, which are part of the College of Science and Engineering. The PINC program started as a grant proposal to the National Science Foundation (NSF) through a collaboration among the SFSU Computer Science, Biology, and Chemistry department faculties in 2016 to provide noncomputer science students from underrepresented groups a platform to assist them in persisting in computing. The PINC program promises support to URG students to advance in their interdisciplinary studies and apply the knowledge from their major (e.g., chemistry, biology) in another science discipline such as computer science. To materialize its support, the PINC program offered a special curriculum
design relevant to the PINC students’ majors and mentor support for its interdisciplinary students to help them feel part of the community.

Due to the interdisciplinary nature of the PINC program, the number of students participating in the program is smaller than a typical STEM course. PINC program offers introductory courses during Spring and Summer semesters such as CSC 306/CSC 210 and CSC 219/CSC 220, which are designed with a computational approach to solving biology-related problems. This approach gathers prospective students for their elective courses such as CSC 307 or CSC 308 during the Fall semester. Then PINC students take their elective courses to obtain their minor in computer science (see Table 3) through introductory courses such as CSC 306 and CSC 219 and application of I-STEM in CSC 308, CSC 508, and CSC 509. However, computer science major students need to enroll through introductory CSC 210, CSC 211, and CSC 220 courses, then application of I-STEM in CSC 308, CSC 508, and CSC 509 (see Table 4). This approach ensures that I-STEM students from a different discipline from computer science do not feel the pressure and imposter syndrome that they are less familiar with the programming in comparison to the computer science students.

Table 3

*PINC Program Pathways for I-STEM students in Computer Science Minor (Pathway for Biology/Chemistry Majors)*

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course(s)</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CSC 306</td>
<td>Fall and Spring</td>
</tr>
<tr>
<td>2</td>
<td>CSC 219</td>
<td>Spring and Summer</td>
</tr>
<tr>
<td>3</td>
<td>CSC 308 and 508</td>
<td>Fall</td>
</tr>
<tr>
<td>4</td>
<td>CSC 509</td>
<td>Spring</td>
</tr>
</tbody>
</table>
Table 4

PINC Program Pathways for Computer Science Major Students (Pathway for Nonbiology/Chemistry Majors)

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course(s)</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CSC 210 (and CSC 211 is recommended)</td>
<td>Fall and Spring</td>
</tr>
<tr>
<td>2</td>
<td>CSC 220</td>
<td>Fall and Spring</td>
</tr>
<tr>
<td>3</td>
<td>CSC 308 and 508</td>
<td>Fall</td>
</tr>
<tr>
<td>4</td>
<td>CSC 509</td>
<td>Spring</td>
</tr>
</tbody>
</table>

Note. Adapted from PINC Program Guide, 2022 (https://pinc.sfsu.edu/pinc)

Target Population

The PINC program intends to increase the participation of URG students from different disciplines in computer science. PINC, as an I-STEM program, intends to address issues URG students face, such as impostor syndrome, to improve the participation of URG students in computing. PINC’s unique approach is in building mentorship as part of the program, in which PINC and computer science students peer-coach students to navigate through the program and obtain a minor in computer science certificate. This joint venture among the biology, chemistry, and computer science departments seemed a perfect match to determine the impact of peer mentor coaching on I-STEM students. Hence, the research for this dissertation was based on data collected through interviews with students as mentees, mentors, and PINC faculty who opted to participate in the study.

The study population was I-STEM students from the SFSU’s PINC program. The intended sample participants in this study consisted of current I-STEM program students and
alumni at SFSU. The sample size was around 110 students during an academic year. These students were 4-year university students varying in age (see Figure 3.1). A traditional college student is defined as being between the ages of 18–21. At SFSU, 47.02% of students fall into that category (see Figure 3), compared to the national average of 60% (College Factual, 2021).

**Figure 3**

*SFSU Student Demographics*


The sampling frame for the study was from PINC program students enrolled in PINC courses in the 2021–2022 academic year. The PINC interdisciplinary program students are
primarily URG students. The student body is composed of URG male and female students from socioeconomically disadvantaged backgrounds. Most PINC students are from biology, chemistry, or biochemistry majors who are interested in obtaining a minor in computer science; however, at the time of this research, PINC was working on offering this opportunity with a customized curriculum to other majors. Participant sampling was done by outreach through the program administrator and faculty to students in fundamentals courses (i.e., CSC 306/CSC 210), intermediate courses (i.e., CSC 219/CSC 220), elective courses (i.e., CSC 307/CSC 308), and PINC alumni to opt-in and participate in the study.

In the 2021–2022 academic year, 64 students enrolled in the fundamentals course (i.e., CSC 306/CSC 210). They identified themselves as 30.8% Asian, 6.2% Black or African American, 40.0% Latinx, 12.3% White, 4.6% other, 4.6% two or more races, and 1.5% international. In the same academic year, 16 students were enrolled in CSC 219/CSC 220, which is the next class after the fundamentals course; they identified themselves as 31.2% Asian, 6.2% Black or African American, 37.5% Latinx, 18.8% other, 6.2% two or more races. In the same academic year, in the CSC 307/CSC 308, which are the elective courses offered after CSC 219/CSC 220, the 37 students enrolled in the class identified themselves as 29.7% Asian, 5.4% Black or African American, 29.7% Latinx, 10.8% White, 2.7% did not provide their race data, 2.7% two or more races, 8.1% international, and 10.8% selected N/A as their response to the ethnicity question.

The sampling method for this study was a purposive method to recruit the URG students in the I-STEM program. The recruitment took place through direct emails sent by the PINC program administrator to PINC students enrolled in PINC courses and alumni, PINC faculty
distribution of the recruitment emails to enrolled students in the PINC Program, direct recruitment from PINC students through students who had responded to the program administrator, and the direct emails to PINC mentors through their training faculty. In the initial screening, I selected students that were part of the URG groups defined by the study. Because this study focused on the undergraduate URG I-STEM students’ sense of belonging, I did not recruit graduate students in the PINC program.

The PINC students who responded to the research participation invitation were from CSC 306/CSC 210, CSC 219/CSC 220, and CSC 307/CSC 308. However, one of the mentors participating in the research was a PINC alumnus who was still involved in the program. The faculty participating in the research interviews were current faculty in the program teaching these courses. As such, the resulting sample size for this study was 11 students. Nine of the participants were active PINC students enrolled in the course, and two of these students were actively mentoring in other PINC courses while taking their elective PINC courses. One of the mentors was a PINC alumnus who actively mentored after his professional job.

**Data Collection, Management, and Analysis**

Research data were collected through one-on-one interviews with PINC mentees, mentors, and faculty. These interviews aimed at gauging the influence of peer mentor coaching on the PINC mentee’s sense of belonging in the course, program, and community as well as determining its impact on the mentor’s leadership skills development and possible effects on their STEM career. I analyzed PINC students’ responses with a focus on the student’s sense of belonging in I-STEM. The PINC students’ responses in one-on-one interviews to questions about their lived experience while going through PINC’s interdisciplinary STEM education was a
crucial factor in understanding how peer mentor coaching affects these students. Interviews were structured as one session with a length of 45–60 minutes depending on the student’s availability, with follow-up questions in case clarification was necessary. I used Zoom software due to the COVID-19 restrictions and transcribed interview data using the Otter software. For capturing the faculty feedback and experience, I interviewed interdisciplinary STEM faculty to explore best practices and document faculty experience with mentors and the faculty’s role in peer mentor coaching.

I adopted the framework for the interview protocols (see Appendices A, B, and C) for the PINC mentee and mentors from Trujillo and Tanner’s (2014) research. Their research was based on previous research that referenced the national survey for the sense of belonging (see Table 5), which gauges students’ sense of belonging in their academic community (Hurtado & Carter, 1997). Good et al.’s (2012) framework for the sense of belonging in math; Stout et al.’s (2013) belonging construct for the calculus-based introductory physics; 1st-year STEM students belonging to the department and program from Cabrera et al. (1992); Smith et al.’s (2013) research; and Walton and Cohen’s (2007) research were the guiding principles for my interview questions. This study’s guiding questions for gauging the PINC students’ sense of belonging were based on determining how PINC mentees felt in the PINC courses and program, which is why I adopted the framing questions from an existing study about the students’ sense of belonging in STEM (see Table 5) with the modification from the “campus community” to “student’s sense of belonging in the PINC program.”
<table>
<thead>
<tr>
<th>Sample statement</th>
<th>Implementation context</th>
</tr>
</thead>
<tbody>
<tr>
<td>• I see myself as a part of the campus community.</td>
<td>National survey, Sense of Belonging Scale (Hurtado &amp; Carter, 1997).</td>
</tr>
<tr>
<td>• I feel that I am a member of the campus community.</td>
<td>Calculus class, Math Sense of Belonging Scale (Good et al., 2012)</td>
</tr>
<tr>
<td>• I feel a sense of belonging to the campus community.</td>
<td>Calculus-based introductory physics, Survey Construct-Belonging (Stout et al., 2013)</td>
</tr>
<tr>
<td>• When I am in a math setting, I feel a connection with the math community.</td>
<td>First-year STEM graduate students (in Smith et al., 2013; modified from Walton &amp; Cohen, 2007)</td>
</tr>
<tr>
<td>• When I am in a math setting, I feel respected.</td>
<td>College Satisfaction and Persistence Scale (Cabrera et al., 1992)</td>
</tr>
<tr>
<td>• When I am in a math setting, I feel comfortable.</td>
<td></td>
</tr>
<tr>
<td>• When I am in a math setting, I trust my instructors to be committed to helping me learn.</td>
<td></td>
</tr>
<tr>
<td>• When I am in a math setting, I enjoy being an active participant.</td>
<td></td>
</tr>
<tr>
<td>• When I am in a math setting, I try to say as little as possible. (reverse scored)</td>
<td></td>
</tr>
<tr>
<td>• I feel like I belong in physics.</td>
<td></td>
</tr>
<tr>
<td>• People in physics accept me.</td>
<td></td>
</tr>
<tr>
<td>• I feel like an outsider in physics. (reverse scored).</td>
<td></td>
</tr>
<tr>
<td>• I feel I belong within my department.</td>
<td></td>
</tr>
<tr>
<td>• I am satisfied with my academic experience.</td>
<td></td>
</tr>
<tr>
<td>• I feel comfortable at the [university].</td>
<td></td>
</tr>
<tr>
<td>• People at the [university] accept me.</td>
<td></td>
</tr>
</tbody>
</table>


This study’s conceptual variables (i.e., mentees’ sense of belonging in the PINC course[s] and program and mentees’ sense of belonging to the PINC community) focused on
understanding the relationship between the mentee and mentor and how it affected the mentee’s sense of belonging in the course, program, and community (see Table 6). The interview questions aimed to ask the mentee to describe their relationship with their mentor, how their mentors helped them with their academic study in the PINC course(s), and if the mentor helped them in anything related to their major. I then asked the mentee directly about the sense of belonging construct to determine if the relationship was evident that a mentor made an impact on the mentee. Table 6 outlines the conceptual, operational measures, and the data source for the study.
### Table 6

**Conceptual Variables and Operational Measures**

<table>
<thead>
<tr>
<th>Conceptual variables</th>
<th>Operational measure</th>
<th>Data source</th>
</tr>
</thead>
</table>
| Mentees’ sense of belonging (PINC program and courses)                               | • Could you describe your sense of belonging in computer science courses?  
• Tell me about how PINC courses are taught, and how they are different from typical computer science and major courses.  
• Could you describe your sense of belonging in the PINC program?  
• How do mentor interaction and involvement help you feel that you belong in the PINC program?  
• Tell me about how faculty members in PINC interact with you and make you feel.  
• What was your experience during Covid? Did online learning hinder and/or support your learning and communication with your mentor and faculty?  
• How does PINC curriculum design help you feel that you belong to the program?  
• How do you feel about collaborative learning (you, mentor, faculty) in the PINC program?  
• What are the impacts of mentoring on your sense of belonging in the PINC course(s) or program?  
• What are the impacts of peer mentor coaching in terms of your mentees’ persistence in the PINC courses and ultimately the PINC program?  
• From your perspective how does the difference with the regular computer science courses affect your mentees’ sense of belonging in the program?  
• What are the impacts of mentoring on the URG mentees’ sense of belonging?  
• How does peer mentor coaching contribute to the persistence of URG students in the PINC courses and ultimately program?  
• How do collaborative learning experiences among mentors and mentees affect URG students’ learning? | Mentee interview |
<p>|                                                                                     |                                                                                                                                                                                                                                                                                                                                                     | Mentor interview |
|                                                                                     |                                                                                                                                                                                                                                                                                                                                                     | Faculty interview |</p>
<table>
<thead>
<tr>
<th>Conceptual variables</th>
<th>Operational measure</th>
<th>Data source</th>
</tr>
</thead>
</table>
| Mentees’ sense of belonging to the PINC community | • Tell me about how faculty members in PINC interact with you and make you feel.  
• How do mentor interaction and involvement help you feel that you belong in the PINC program?  
• What are the impacts of mentoring on the URG mentees’ sense of belonging?  
• How does peer mentor coaching contribute to the persistence of URG students in the PINC courses and ultimately program?  
• How do you think that the experience of mentor-mentees shapes their experience in the program? | Mentee interview |
| Mentor’s leadership skills development (communication skills development) | • What are the different communication styles you use with your mentees?  
• What are the strategies you employ to improve communication with your mentees?  
• How do you provide constructive feedback to your mentees?  
• Does it help that you have a similar major to the mentee?  
• How would you describe your communication with the course mentors? | Mentor interview |
| Developing mentor’s leadership skills? | • What kinds of goals do you help your mentees set (e.g., academic and/or professional)?  
• Tell me how you help mentees develop strategies to meet their academic and professional goals.  
• Describe how you help mentees balance their lives, academic work, or their personal life?  
• How does collaborative learning between you and your mentee affect your learning? | Faculty interview, Mentor interview |
| Mentor’s leadership skills development (leadership skills) | • Tell me how your experience of being a mentor impacted your leadership skills.  
• How has your experience of being a mentor impacted your own professional or academic goals?  
• Tell me about the ways that you motivate your mentees.  
• How do you stimulate their creativity?  
• In what ways do you believe the peer mentor coaching model influences PINC mentors? | Mentor interview, Faculty interview |
This study’s conceptual variables (i.e., mentees’ sense of belonging in the PINC course[s] and program and mentees’ sense of belonging to the PINC community) focused on understanding the relationship between the mentee and mentor and how it affected the mentee’s sense of belonging in the course, program, and community. The interview questions aimed to ask the mentee to describe their relationship with their mentor, how their mentors helped them with their academic study in the PINC course(s), and if the mentor helped them in anything related to their major. I then asked the mentee directly about the sense of belonging construct to determine if the relationship was evident that a mentor made an impact on the mentee.

Data Analysis

I intended to understand whether peer mentor coaching and mentorship helped students develop a sense of belonging in an interdisciplinary science program. Additionally, it was important to determine the efficacy level in developing leadership skills in PINC mentors. I analyzed the collected data from the PINC program materials, mentors, mentees, and faculty interviews. I used student responses for the first cycle of coding through the NVivo coding. I applied pattern coding for second cycle coding to analyze emerging themes (Saldaña, 2016). I was cognizant of the participants’ rights, needs, values, and desires of the participants (Creswell, 2018). Therefore, many elements of this research’s design safeguarded the privacy of participants. For anonymity, all participants were referred to in the findings by pseudonyms chosen by the participant. Any reference to participants’ locations used general region and population density designation like “Pacific Northwest region.”

I analyzed the data compiled through the mentees, mentors, and faculty interviews. These interviews examined the relationship among the mentors and mentees and how it affected the
student’s sense of belonging in the I-STEM program. The qualitative analysis examined the responses from the mentors about their interaction with their mentees, and mentee expressions about how these interactions shaped their experience in the program. Because the research questions sought to understand the student experience in an interdisciplinary program, both the sense of belonging and mentees’ reflections on the support from the peer mentor coaching were essential to evaluate how students interpreted the mentor support in the program.

The qualitative interview with the mentors and mentees in the program helped in triangulating the issues that these students and mentors felt while they were going through the program. I designed elements of the research to ensure the safeguards of the privacy of participants and inform participants about their rights in recruitment and orientation letters, including a verbal explanation at the beginning of each interview. Due to the COVID-19 global pandemic, interviews and the STEM learning community were conducted and recorded via Zoom. I used the Zoom application to record audio and transcribed meetings with Otter software.

**Data Management**

I used Zoom for virtual meetings. Subsequently, I used the Otter application to transcribe audio meetings. After transcription, any audio and video were stored in the university’s approved data storage system to limit access to raw data. To ensure the confidentiality of participants, only transcripts and field notes that had been scrubbed of any identifying information were stored. The deidentified transcripts and field notes will be stored on my SFSU Box account for 3 years. These files require two-factor authentication for access, and the password needs to be changed every 6 months. Only me and my chair, Dr. Sheldon Gen, have access to the data.
Internal and External Validity, Reliability, and Transferability

The PINC program has been evaluating its outcomes through a program evaluation with a third party. This program started as an initiative from a grant from the National Science Foundation (NSF) and has entered its second phase as PINC 2.0 after its program evaluation from the initial program inception. The PINC faculty have been collecting data from student surveys and testimonials that have been transparent at the San Francisco State University College of Science and Engineering. I collected data from PINC students, and interviews were conducted with the consent of the PINC program.

The PINC program is an interdisciplinary collaboration among biology, chemistry, and computer science departments at San Francisco State University. Any findings from this case study would be valuable information for participating departments and faculty who have been trying to make a difference in I-STEM education and attest to the trustworthiness of the study (Algozzine & Hancoc, 2017; Merriam, 1998). The findings of this research may become the groundwork for reform in I-STEM education praxis.
Chapter 4: Findings

Of the 11 Promoting Inclusivity In Computing (PINC) students who participated in the study, three of them were underrepresented group (URG) mentees who were serving as mentors in the program, which reaffirmed the effect of peer mentorship in turning interdisciplinary-science, technology, engineering, and math (I-STEM) mentees into peer mentors. These mentors reengaged in I-STEM because of the sense of community that they felt while going through the program and because they had noticed the impact of peer mentorship on URG I-STEM students (Hayes, 2008; Rubin, 2009). I captured the sentiment of servant leadership in mentors who were dedicating their time to help follow PINC students, and they felt the connection with URG I-STEM mentees even after graduation from the program and university. Michael, who was one of the previous PINC mentees who participated in the program as a mentor after his job, said, “I feel that I gained tremendously from the program, and I spend as much time as I can in between my job to mentor in the course to help students discover a similar experience to what I had.”

The following sections detail the study’s finding process, how the students’ learning was affected by their learning environment, and how the URG students felt about their sense of belonging in the I-STEM. Their sense of belonging led to their persistence in I-STEM and changes in their educational trajectory. Because there are a handful of PINC faculties, I did not create profiles for them as it would be very easy to guess the faculty identity.

The following section describes the PINC mentees and mentors. Of the 11 PINC students that participated in the study, there were seven females and four males. In response to the interview questions about their pronouns, none of the participants identified themselves as nonbinary. Of the 11 participants, six were Latinx, two Asian, two mixed race, and one Black.
Seven of the students majored in biology, two majored in biochemistry, and two were from other disciplines. Six of the participating students had enrolled in the PINC program after hearing about it in the class they were attending for their majors from their professor who taught a course in the PINC program. However, most of the students mentioned they were motivated when they noticed other colleagues in the PINC program were students like them. Four of the students were first-generation students. Only four of the participating mentees had prior computer programming experiences, such as R programming and introductory Python programming, and others had an introduction to programming through the CSC 306 course or the summer introductory course. Seven of participating students were interested in pursuing the Genentech Scholar program. One of the female students had seen a positive impact on her perspective about her studies and her academic trajectory. She would like to become a Genentech scholar and hoped to help PINC program students as she progressed through the program.

The four mentors (i.e., two men and two women) that participated in the study described their experience as transformational when they saw the impact of the PINC program and how peer mentorship helped these students in their studies. A female mentor described her experience as a turning point for her to move to the next phase, including pursuing graduate studies up to a PhD program. Mentors described the positive impact of peer mentorship on their academic and professional experience that has helped them look at their studies from a different perspective.

Of the 11 PINC students who participated in the study, three of them were URG mentees who were serving as mentors in the program, which reaffirmed the effect of peer mentorship in the program, how these mentees felt about the sense of community, making it through the program through participation in the PINC community, and taking a servant leadership role to
help fellow I-STEM students (Hayes, 2008; Rubin, 2009). I captured this sentiment in mentors who were dedicating their personal time to help PINC students who they felt a connection with even after graduation from the program and university. Michael said, “I feel that I gained tremendously from the program, and I spend as much time as I can in between my job to mentor in the course to help students discover a similar experience to what I had.”

The following analysis details the study’s finding process, including how the students’ learning was affected by their learning environment and how the URG students felt about their sense of belonging in the I-STEM program, which led to persistence and changing their educational trajectory. Because there were only a handful of PINC faculty members, I did not create profiles for them as it would be quite easy to guess the faculty identity. The following profiles depict portraits of PINC mentees and mentors.

**Analysis**

The interview questions used to explore these I-STEM students’ perspectives on the peer-mentor interactions in the program and course highlighted that most students had a similar experience; however, the students’ differences were related to whether their mentor was from their major, the availability of the mentor, and the mentor’s approach in helping students. The following describes the analysis of mentees and mentors in the program.

The first cycle coding of PINC mentee, mentors, and faculty revealed that the relationship between the mentee and mentor depended on the strategic positioning of such interaction in the I-STEM program (Saldaña, 2015). Positive interaction among the mentee and mentor with faculty support was an essential element in creating a positive self-perception in I-STEM URG students, their sense of belonging, and ultimately persistence in their I-STEM
learning journey (Kosslyn, 2017; Sithole et al., 2017). The first-cycle coding of gathered data from I-STEM URG students (see Table 7) revealed that student confidence, personal experience, connectedness, feeling a part of the group, and struggles learning course materials were part of their learning journey that needed continuous support from a fellow student who understood such feelings and had experienced it (Griffith & Main, 2019; Salomone & Kling, 2017; Wilson et al., 2010).

Table 7

**Emerging Themes From First Cycle Coding**

<table>
<thead>
<tr>
<th>Emerging themes from mentee–mentor interviews</th>
<th>Emerging themes from faculty interviews</th>
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<tbody>
<tr>
<td>Self-confidence</td>
<td>Going above and beyond</td>
</tr>
<tr>
<td>Connectedness</td>
<td>Deeper understanding (proficiency learning)</td>
</tr>
<tr>
<td>Personal</td>
<td>Student challenges</td>
</tr>
<tr>
<td>Going above and beyond</td>
<td>Mentor training</td>
</tr>
<tr>
<td>Personal experience</td>
<td></td>
</tr>
<tr>
<td>Feeling a part of a group</td>
<td></td>
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<tr>
<td>Student challenges</td>
<td></td>
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<tr>
<td>Keep going</td>
<td></td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Understanding each other</td>
<td></td>
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<tr>
<td>Struggles during learning</td>
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</table>

The second cycle coding themes (see Table 8) show that the URG student experience is dependent on how they interact with their peer mentors. The PINC student interviews highlighted the importance of the structure of the interdisciplinary program, and how focusing on the needs of these students affected their self-perception, educational experience, and personal goals, thereby impacting the student’s persistence and personal and professional goals (Graham
et al., 2013). The cross-sectional approach for gathering data involved interviews with PINC students, mentors, and faculty about the conceptual variables of the sense of belonging through mentees’ sense of belonging in PINC courses, programs, and community. Results revealed the traditional STEM approach to transferring technical expertise did not seem sufficient for the success of URG students in interdisciplinary education (Klaassen, 2018; Merriam, 1998).

Table 8

*Emerging Themes From Second Cycle Coding*

<table>
<thead>
<tr>
<th>Combined emerging themes from interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-perception Community</td>
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<tr>
<td>Self-efficacy</td>
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<tr>
<td>Experience</td>
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<tr>
<td>Support</td>
</tr>
<tr>
<td>Sense of belonging</td>
</tr>
<tr>
<td>Proficiency learning</td>
</tr>
<tr>
<td>Persistence</td>
</tr>
<tr>
<td>Student learning challenges</td>
</tr>
<tr>
<td>Mentor training</td>
</tr>
<tr>
<td>Empathy</td>
</tr>
<tr>
<td>Leadership</td>
</tr>
</tbody>
</table>

The challenges of STEM education have compounded in I-STEM education because students have faced various challenges exacerbated by acquiring knowledge and skills in an extremely new field. Gay’s (2010) responsive curriculum design fit well with the I-STEM course design, where PINC courses were carefully constructed to suit the needs of URG students from disciplines such as biological sciences who had minimal exposure to the computer science discipline. The responsive curriculum design issue is a more serious threat for the URG students who have not had institutional support to prepare them for rigid STEM education that is
completely new to them (Palmer et al., 2011; Tinto, 2017). The built-in peer mentor coaching in the PINC interdisciplinary courses seemed to break the stigma of student versus system. The human bonding, individualized touch, and connection with someone like them who had already gone through and conquered interdisciplinary challenges gave URG I-STEM students hope, stamina to persist, and a future in acquiring a new skill that would help their upward mobility (Brown et al., 2019; Ceolin et al., 2018; Hanuaer et al., 2016). Based on the feedback from PINC mentors and mentees, peer mentor coaching affects the mentee’s sense of belonging in the course, program, and community. As such, mentors learn skills in coaching, leadership, and professional goals.

I-STEM students’ sense of belonging is essential to their self-efficacy, self-perception, validation, and persistence in their interdisciplinary STEM education, and subsequently STEM education (Beier et al., 2016; Linares, 2011; Rainey et al., 2018). The answer to the research questions about the I-STEM student’s sense of belonging sought to explore how peer mentor coaching in a university interdisciplinary STEM program affected URG students’ sense of belonging, and what impacts of mentoring on URG mentees’ sense of belonging. The case study participants deemed the relationship as one of the most important factors in the PINC program. Paula, who felt she would not have lasted in the program if it were not for the support of her mentor, said, “I meet with my mentor when I am stuck, and I don’t feel like I have to stress about the course. She [peer-mentor] helps me focus and I ask a lot of questions to understand if I am missing something.” Paula further added that her relationship with each mentor has been different from course to course, and she has had a previous mentor who was a computer science major who would help with the homework and understanding the concepts; however, having a
mentor from her major who had taken the course was different because she could ask her questions about her major as well.

Exploring the sense of belonging of I-STEM students in this case study revealed different dimensions to the sense of belonging, such as one’s sense of belonging in the course, program, and community. A sense of belonging in the course, program, and community relied on the mentee’s positive interactions in the course and peer mentor relations.

**Sense of Belonging**

**Sense of Belonging in I-STEM Course.** Mentorship is essentially a collaborative learning relationship between the mentee and mentor that relies on trust, intentionality, and effectiveness of interaction. The PINC program mentorship design is an intentional integration of mentors into the PINC curriculum. Mentors who have taken the PINC course and have experienced similar challenges to the I-STEM students have the best intentions for the URG I-STEM students’ success in the program. A mentee’s connection with a mentor who has come across similar issues is one of the important themes that emerge from the PINC students’ feedback. The PINC mentor selection process is one of the essential processes that impact the PINC mentee experience in the course and the program. A mentor who has struggled through the course materials and has succeeded has empathy for the student who is struggling through similar problems and they can share similar experiences and lessons learned from their experience. Mentors and mentees participating in the program experienced an increased sense of belonging and improved academic success and experience (Rockinson-Szapkiw et al., 2021; Spaulding et al., 2020). This theme seems to be one of the distinguishing factors for the PINC
program’s success in helping students progress through the program. Regarding her first I-STEM course experience in the PINC program, Emma explained:

Yeah, it my first computer science class. And I mean, I would say that I do feel like I belong because I see that other people, they’re like biology students or other researchers in biology. And then they’re also taking this class. I think I do see a lot of students in my class, they actually have more experience in coding than I do. Because if our professor mentioned, like, oh, have you heard about this? And a lot of them will say, oh, yeah, I’ve done that a little bit before. So, but I think in general, I do feel like this class is really like, yeah, it’s really meant for biology students, and I felt like I fit in, especially because my mentor is like me. But I always say, if I went to like a computer science course, that was meant for computer science majors, and I don’t think I would not feel like I would fit in.

Because PINC peer mentors have gone through the same experience in the program, sharing their experience during interactions with student mentees is relevant and URG I-STEM students can relate; sharing these experiences is common among peer mentors and mentees, and contributes to URG I-STEM students’ sense of belonging. Both mentors and mentees from the program reflected on this topic. Jaywin, a PINC mentor, reflected on how he connected with what his mentees’ experiences in the I-STEM course. When he was asked about how he works with students to help them feel that they belong in the program, Jaywin said:

Like, I also tell them that, you know. This is how I usually worked. I write something if it doesn’t work, then I usually because this is a programming class. If you write code, it doesn’t work usually go line by line, we try to do this, see if this works. I give them reference from my experience, so that rather than calling out what’s right, the solution
may have a different approach to the problem. So yeah, I think using my experience and working through the problem, to get to a solution, works. I provide constructive suggestions to help lead them to a solution or work toward the solution. Yeah. This helps me connect with the students.

Paden, another PINC mentor, shared his experience with URG students by showing them how he used to make mistakes. In reflecting on his interactions with mentees, he said:

So, I feel like by expressing that verbally, they actually feel more comfortable that I’m admitting like, yes, I make mistakes, we all make mistakes. If you feel that I’ve made a mistake, please let me know. So that when we go through, like a review for the midterm or go over a project, and I’m explaining stuff to them, they feel free to interject with their opinions. So that we can both communicate to form an answer that everyone understands and is confident in.

The interaction between mentor and mentees and how mentors relate to the students was echoed in the mentee’s reflections, and contributed positively to the URG I-STEM students’ sense of belonging. Carlos, a PINC mentee, said:

I saw other people like me who like you know, had no experience. They have been studying this course, and it has changed their career path. I have learned how to work with my classmates to learn about coding. So as far as my sense of belonging, I feel like I belong there. Like I have my own claim, and I like what we’re doing.

**Sense of Belonging in the Program.** PINC mentees’ interactions with the peer mentors in PINC courses create a channel between the faculty and PINC students to help students receive help and support without worrying about the pressure of asking faculty about trivial questions
that may be intimidating to students. This method of communication for the program creates a sense of trust and belonging and PINC students because they do not feel they are against the system. As students progressed in the program, they felt the PINC faculty, program, and community were there to help them succeed in their quest of learning a new discipline. Even though this discipline may be challenging, empathy and support from the community compelled students to feel that they would be able to succeed due to the feeling that they belonged in the program.

Paula, a PINC mentee, described her belonging in the program as a result of the combination of interactions with her mentor and the support of the faculty. She described how the program made her feel she could do it by seeing others who have already achieved the goal. She said, “I would not have been able to go through the program on my own. I heard about the program from a friend of mine who was in the program, and I already feel that I belong here even [though] this is my first class.”

A sense of belonging for students who had mentors from similar majors and could share a bit more than just a PINC course increased the PINC mentee interaction, because the interaction between the mentor and mentee seemed to be deeper into the personal connection and an academic and professional network. According to Madeline, a PINC mentor, this professional interaction went beyond the role of mentorship and helped PINC mentees beyond their academic success. Madeline said:

Maybe I would encourage them to connect on LinkedIn also. Maybe it’s not too late, I suppose the semester. So going on. Perhaps, in the end, I could encourage them all to connect and communicate on LinkedIn as well. Because you know, they’re all trying to
be young professionals. And when you’re trying to build up your reputation at first, it can be difficult when you don’t know very many people. So, the pink program could be a great way to meet new people. I’ve added a lot of my classmates I’ve had on LinkedIn.

The URG I-STEM student’s sense of belonging in the program seemed related to the support they received from the program, and their peer mentor contributed to these students’ sense of belonging. Ariana described the way she felt about her sense of belonging in the program by stating:

Oh, yeah, I think I feel like I fit in. I mean, I have a few other classmates that are in the same cohort as me in the marine industry and sciences program that is doing it with me. I feel like we have bonded and kind of like to know each other. So yeah, I think we’re going through the same experiences and have the same struggles. So yeah, I feel like I belong. And I don’t feel like an outsider.

When the mentee feels a fellow peer mentor student is remarkably similar to the I-STEM URG student, a safe environment is created for them to avoid feeling the imposter syndrome. Madeline described her interaction with their peer mentor and mentor group in the I-STEM class by stating:

The mentor interaction was particularly important to me, and specifically that she was a woman of color. So, I thought that was nice to, you know, both be women of color. And it was nice to see that she was very much like me, really into computer science as well. And she was like, knowledgeable in her subjects. I think that helped me to survive in the class, and yeah, our, mentor group was all women too. So, it helps feel not too
intimidated to ask questions or feel like you’re dumb. Like, yeah, it was a very, I think it was a very safe space.

**Sense of Belonging in the Community.** I-STEM students’ sense of belonging in the community of learning is an important indicator of how these students adapt to their studies. Being part of a community of learners can increase a student’s sense of belonging (Chickering et al., 2015), feelings of validation from having ideas accepted, and feeling valued by peers. This is essential to improve I-STEM students’ self-perception (McConnell, 2020; Salomone, 2017) and opportunities to problem solve and succeed in increasing a student’s self-efficacy, and increasing their motivation to persist (Mistele et al., 2019; Zavala & Hand, 2019). I had anticipated hearing from students in I-STEM about their sense of belonging in the community; however, I discovered students formed bonds with two communities: a community of learning in their discipline, such as biology, and a community of learning in the I-STEM discipline of computer science. Peer mentorship was the bridge that made such connections because this study was during the COVID-19 global pandemic, and most of the students participated in classes via Zoom. They did not have much interaction in the classrooms to form a community; however, the peer-mentor sessions were the hub for fostering such relations with mentors or other I-STEM students in the meeting. In their mentor session discussions, Danvi emphasized how her peer mentor had talked about other students who had the same set of problems, and she had reached out to see how these students had overcome their challenges.

Aligning with the students from other disciplines and exchanging information and collaboration were other factors that helped I-STEM students in this program to build a community essential in creating a sense of belonging in the program. Emma explained the reason...
for feeling her sense of belonging in the community and program by stating, “All of a sudden, I did not feel deterred from the computer science concepts since I had friends that I could rely on, who I got to know in the mentor session.”

**Peer Mentor Leadership Skills Development**

The psychosocial support of peer mentor coaching impacts PINC students, and creates a model where mentees who become mentors in other PINC courses feel a deep connection to the program and notice transformation in themselves. Many of these mentors stated that the transition to becoming a mentor had changed their academic achievement, goals, and trajectory. In addition, because these mentors saw the impact of peer mentor coaching, they became more active students and would like to pursue teaching careers and engage with the faculty in research activities in their field of study.

Madeline, a PINC mentor who was a PINC mentee, believed her ambition to go to graduate school did not exist before the PINC program. She stated that becoming a mentor was the turnaround point for her that made her feel she was not against the system and professor. As she seemed proud of this, she said:

I am in my mid-career, and I never felt that I will go to academia. I entered the biology major to transition to a new field in my career. But, entering the PINC program changed it all for me. I was struggling in the beginning, and during the first class, my mentor had a big impression on me. She was thriving in biology and PINC courses, and she was also dedicated to mentoring, and I said why shouldn’t do the same, and it changed my life. Now, I have submitted my applications for graduate schools looking for a PhD program,
and the PINC faculty are writing recommendation letters for me and supporting me. I never imagined this!

Peer mentors in the PINC program felt their participation in the program had changed their perspectives on how they study and view helping other students. They empathized with other students more because the mentors developed a connection with them, confirming the impact of a peer mentor on mentor skills development (Drane et al., 2014; Russomanno et al., 2010; Windsor et al., 2015). Ashwin, a PINC mentor, felt his experience in the PINC program helped him in his studies, goals, time management, and skills in how to engage in discussions with faculty and other peers. He said:

So as a mentor, I tried to put students in groups, so that they feel comfortable speaking to me as a student, more than a mentor. So that helps them break the barrier of reaching out to me. Sometimes I look at the ways to remove their barriers, so they don’t feel that I am only grading their work. Working with students helped me realize what I can do better in my classes, how I approach my professors about the course or other areas in my studies and setting my goals for my academic future.

PINC mentors saw a reciprocating impact on their learning when they noticed that students assisted them in shaping their skills. Paden, a PINC mentor, said that his learning through the program changed his thinking and interactions with mentees are teaching and shaping him. He said:

So I think it’s been positive. I’m currently working on some independent projects for myself. So, working with my mentees and seeing some of the issues that are arising from their problems inspires me to solve some of my issues. So, you know, it’s, it’s
coursework that I’ve done before, but I have forgotten some of it. So going back, and, you know, teaching is, you know, it makes you a better. You know, anytime you have to teach someone else how to do something, you truly have to understand it better yourself. So, I feel that in teaching, I have gained a greater grasp of what machine learning is. So, I feel like that is how our collaborative learning has positively impacted me.

Faculty Perspectives

The PINC faculty interviews showed their perspective on the peer mentor program. The PINC faculty described their interaction with the mentors as a relationship that helped them to be more in touch with students through this channel. Three of the faculty highlighted the changes they noticed in the mentors during the program, and how dedicated their mentors were to helping their mentees; however, they had a few comments from the students explaining finding time to meet with mentors were challenging. One of the PINC faculty felt that he would not have been able to sustain PINC students in the class if he did not have mentors’ help. He added, “My class mentors were great. Their interactions with the students gave me a better understanding of where students were struggling, and how to help them.” He added that he saw a difference between the teaching assistant and the mentor, in that he felt that students looked up to mentors as someone like them rather than a graduate student just trying to get the homework done and make sure that they understood the class materials. However, one of the faculty noted mentors spent their personal time to assist students, and it would be better if they received academic credit for their work in support of mentees.

In terms of leadership skills development, two of the PINC faculty mentioned that transformation of mentees to mentors has been apparent for mentees with more academic rigor
and more interest in pursuing a graduate degree. In response to the impact of the peer mentor on the PINC student’s sense of belonging, faculty felt the positive impact on students; however, they were interested in learning more about the students who did not continue the program and their reasons for that, including the peer mentor relations.

**Culture of Inclusivity**

The PINC students felt that the program created a culture of inclusivity that helped them feel they were part of a movement. Their feelings were more validated by the program administration and the opportunities created for them. PINC’s culture of promoting student collaboration fostered a community that focused on elevating students and supporting the development of positive experiences. Javi described this as a fail-safe environment in which inclusiveness brought students to work together in a more collaborative way, and he attributed such collaboration to the peer mentor sessions he attended. Such sentiment was widely reflected by other PINC research participants (i.e., Paula, Emma, and Paige) who felt the inclusiveness of the program made their success more connected to the program design where their peer mentors’ sessions created an inclusive environment with a tone that helped them with challenges in their I-STEM education. The PINC program’s emphasis was on student development, where they could receive support from students other than their peer mentors, PINC faculty, program mentors, alumni students, and program administrators. I-STEM students who entered the program widened their academic and professional network, which established opportunities for I-STEM students for their educational goals and broadened their prospects. Mentees distinguished the fact that peer mentors went above and beyond and touched mentees in academic and a multitude of contexts at the personal level (Greenleaf, 1998; Hayes, 2008; Rubin, 2009). When describing his
interaction with the PINC mentors, Carlos said: “At first, I was confused about what mentoring meant. I thought it was like working with your TA and office hours, but I noticed that PINC TAs are different. Their approach is different, and more direct. It is not about getting your grade better, it is about you getting better.”

PINC’s inclusive culture is inherent in all programs in which the program administration, faculty, students, and mentors are aligned to help I-STEM students. This leads to doing what is needed to ensure student success, including recruitment of mentors, training, and working with the program administrator to ensure student support continuity. This expands beyond support for instruction and peer mentoring, and is more geared toward ways to enrich students in their educational journey through its internship opportunities, and faculty support for students after graduation from the program. PINC peer mentors showcase their internships and how they are using the skills they gained in the program in their academic and professional lives. This inclusive environment resembles an ideal solution similar to Gay’s (2010) suggestion of an environment that considers the student as a whole and supports URG I-STEM students by improving their self-efficacy.

**Mentee–Mentor Relationships**

Peer mentors in the PINC program relied heavily on their relationship between the mentee, mentor, and faculty. Communication to ensure students attended their peer-mentor session created a connection between the peer mentor and mentee that relied on a good relationship between them. Such relationships fostered the necessity to stay in touch and communicate with the peer mentor about issues I-STEM students faced even outside the classroom and program, easing student stress as the peer mentors would communicate with the
faculty about issues I-STEM students were facing. Without the peer mentor sessions, the URG I-STEM students would be gaining knowledge through the instructor–student relationship in the classroom. If an I-STEM student missed a class, they could rely on learning the topic from the peer mentor and rely on the transfer of knowledge through another channel. However, this nonhierarchical sharing of knowledge is not available in a typical I-STEM course or program.

Although most students described their relationship with their mentors as interactive and helpful to them, two of the study participants mentioned connecting with their mentor was an issue when mentors were not from a similar major, and they only focused on the homework. In these students’ experiences with mentors not from their majors, the mentors acted like teaching assistants, and focused on the semantics of the homework rather than relating to it. For example, a participant said: “Our mentor sessions were just to ask questions and see if we understand how the code works since my mentor was a CS major, and we did not discuss any other topics.”

In summary, the findings of this study highlighted the importance of the peer mentor program through which mentees could receive support to help them develop a positive self-perception, develop I-STEM identity, and persist in the program. Mentees saw their peer mentor as someone like them who had already learned what they were trying to learn, and such a relationship has positive impacts if the peer mentor understands the importance of this interaction. The peer mentor relationship is essential and needs to be part of training, where the mentor sees the importance of the role they play in their mentee’s educational experience.

Mentor interaction with faculty is critical in supporting I-STEM URG students. The mentor’s skill development is reliant on their acquisition of knowledge on how to improve the mentee experience. Training mentors as an integrated part of the I-STEM curriculum is critical
for URG students’ experience. The URG mentees who turn into mentors in the I-STEM program, gain leadership skills that are helpful in interacting with students, finding ways to help I-STEM mentees resolve issues they face beside their academic work, and gaining academic skills.
Chapter 5: Implications

Peer mentor coaching in the interdisciplinary-science, technology, engineering, and mathematics (I-STEM) program is an essential part of the student experience that assists underrepresented groups (URG) students in their learning journey through the challenging I-STEM path of learning two disciplines together. If the I-STEM program has a built-in and well-formed peer mentor program, students develop a sense of belonging, self-efficacy, and community that helps them persist in their academic journey. Compassion and empathy from peer mentors stems from the shared lived experience that connects the mentor to the mentee. Faculty interaction is an essential and integral part of this process. Peer mentors bridge the faculty–student relations to remove barriers in communication and imposter syndrome for URG I-STEM students, and subsequently train URG mentors with leadership skills. Such leadership skills help mentees who have turned into mentors to feel connected to STEM and dedicated to academic excellence. Feeling the connection to the I-STEM group as mentors creates empathy for their fellow students who need someone to help level the road for them and see that achieving their goals is possible.

This case study revealed that peer mentoring in an I-STEM program impacted the program mentees, especially URG students who needed such positive enforcement to persist in the I-STEM program. The URG students’ sense of belonging in the course, program, and community increased with a well-formed peer mentor program. In a reciprocal way, an effective I-STEM peer mentor program, designed in the program curricula, shaped the peer mentors’ skills, especially the peer mentors’ leadership skills. This study’s results indicated an influence on mentors’ sense of belonging, leading them to participate and give back to the community. The
URG mentors engage with the I-STEM peer mentor program to assist other I-STEM students, especially URG students, who are experiencing similar phenomenon when taking I-STEM course. Empathy for I-STEM mentees who are experiencing what the I-STEM mentor has witnessed before creates a deep connection and obligation to ensure students do not feel imposter syndrome.

**Study Limitations**

I did not observe any students outside the PINC program at San Francisco State University (SFSU) in this study. No participants had dropped out of the PINC program. Although the study recruitment email distribution included all PINC program participants from its inception, I did not have any responses from students who had dropped out of the program or program alumni. Because student email discontinues after their graduation, the alumni response may be related to the discontinued email; however, an exit survey for students who leave the program could be used as an instrument to capture the reason for dropping out of the program, including any reasons related to the peer-mentor relationship. This warrants further study with a different methodology to understand the reason students may not continue their I-STEM studies.

**Educational Equity**

Peer mentoring in I-STEM contributes to educational equity. Educational institutions need to consider developing peer mentor programs for all STEM majors as there is a dire need for such support in I-STEM programs. Peer mentors are the backbone of the I-STEM program, creating a positive experience for the URG I-STEM students. I-STEM program needs are essential in creating equity-based education to materialize theories such as critical race education (CRE) and what educators such as Ladson-Billings (1998) and Gay (2018) have suggested. Any
improvements to the I-STEM peer mentor program such as peer mentor training, faculty support for mentors, and enforcing student participation in peer mentor sessions would require design, implementation, and evaluation of a peer mentor training program. Integrating the peer mentor program and considering its importance in strengthening faculty-student relations through positive interactions is an important factor for URG students’ persistence in I-STEM. With an increase in URG students’ persistence in I-STEM, educational institutions would be able to address part of the educational equity gaps.

PINC program leadership in addressing I-STEM issues has positively impacted I-STEM students. However, considering peer mentorship helps the URG students’ self-perception, the program administration needs to highlight how peer mentor relations can help students in their learning journey, and create a channel for students to voice ways to improve the program from their perspective. Assigning peer mentors from the same major as their mentee strengthens the mentee–mentor relationship, and it would be beneficial to highlight the importance of mentees turning into mentors in the I-STEM program.

**Educational Leadership**

In designing the I-STEM peer mentor program, mentors’ value needs to be highlighted to both mentees and mentors to emphasize the outcome of positive self-perception of I-STEM students. The peer mentor program requires institutional support to provide academic credits for mentors dedicating their personal time to helping students. Institutional support for faculty professional development helps to create a robust I-STEM mentorship program and improve understanding of I-STEM student challenges and how to address them through peer mentors. Mentors need to be rewarded for their exemplary effort, and in developing peer mentor
programs, educational institutions must offer educational credits for their challenging work. Such recognition would strengthen the peer mentor program and would make it more attractive for students to join.

Higher education institutions need to consider including peer mentor programs for STEM and non-STEM majors. Evaluating the impact of such programs would be essential in creating a positive learning environment and community for students. Integration of peer mentor programs in the educational process may require a change in the way that student involvement is engaged in higher education rather than instruction-only methods. PINC program administration should study the implications of the peer mentor program further, including a way to capture the voice of students who have dropped out of the program, and determine if any intervention from the program and peer mentor would have helped these students. Disseminating such findings in peer-reviewed publications would be beneficial to other institutions and educational leaders.

**Educational Policy**

Peer mentor training needs to consider challenges mentors encounter in the curriculum, including challenges in supporting I-STEM students academically, training for positive interaction with mentees and faculty, and the importance of the community of learning. Having a wider network of peer mentors translates to I-STEM students’ success and students’ positive experiences. An effective peer mentor program contributes to student competency with the curriculum and provides a vast variety of educational resources to help URG I-STEM students plot a better educational and career trajectory. Such efforts would positively impact URG I-STEM students and provide them with a better educational outcome. STEM faculty members need to embrace the peer mentor programs and their impact on URG students. STEM faculty
must realize peer mentors improve students’ overall experience, and other peer mentors would contribute to better learning outcomes for I-STEM courses. The curriculum design needs to build peer mentorship as part of the course interaction, and educators should meet with peer mentors regularly to catch a glimpse of student concerns, accomplishments, or suggestions for the curriculum design. As an I-STEM educator, I have noticed the positive impact of peer mentors, and I strongly believe in supporting these mentors to help students overcome barriers that may not be possible through faculty-only intervention and traditional STEM instruction.

**Wider Application of Study**

Understanding I-STEM student persistence in relation to the peer mentor program was essential in finding ways that educators can support the URG I-STEM students. Although student persistence in higher education is dependent on many factors, if peer mentor programs are contributing to their success, educators need to pay attention to how such programs can be expanded in different disciplines. Such expansion may require evaluation of the ways that educational institutions can improve peer mentor programs; however, implementation of these programs will strengthen the student role and their inclusion in the system.

**Further Directions**

This study’s findings are helpful in determining what helps URG students’ self-perception, and identity development in I-STEM. The research questions for this study were: (a) how does peer mentor coaching in a university interdisciplinary STEM program affect the URG students’ sense of belonging? and (b) what is the impact of mentoring on the mentors’ STEM leadership skills development? In answering these questions, I noticed that such experiences change the students’ educational trajectory for both mentees and mentors. However, due to the
limitations of the study, this research could not determine the degree of impact on the I-STEM mentors’ educational trajectory. Therefore, a subsequent study researching the impact of peer mentorship on these URG I-STEM mentors would be of immense value to understand how this experience changes their educational and professional career trajectories. Educational leaders need to further study the peer mentor impact on STEM and other disciplines. Any program evaluation that includes peer mentor effects on students would be essential in finding how students’ educational experience can be improved.


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Appendices

Appendix A: PINC Program Mentee Interview Protocol

The PINC program mentee protocol was a semistructured interview with the PINC student as a mentee. Thank you for joining me today and participating in my research. What we will discuss is confidential and your name will not be used in the research. I am going to have a few framing questions about teaching and learning in the PINC program.

Mentee Questions:

Introduction/Demographics

- Please tell me about yourself (including your pronouns, race, or ethnic group you identify yourself with), and how you ended up in the PINC program.

Relationship with mentors

- How do you feel about your PINC mentors?
- How do mentors help you in your courses and PINC program?
- How would you describe your collaboration with your course mentors?

Sense of Belonging is:

How you feel that you fit within a social system, group of people, or community. In our case, I am interested in if you have a sense of belonging in the PINC course, program, and community.

That you do not feel like an outsider or imposter.

- Could you describe your sense of belonging in computer science courses?
- Could you describe your sense of belonging in the PINC program?
- How do you feel about a sense of belonging in the PINC community more generally?
• How do mentor interaction and involvement help you feel that you belong in the PINC program?

Andragogy

• Tell me about how PINC courses are taught, and how they are different from typical computer science and major courses.

• Tell me about how faculty members in PINC interact with you and make you feel.

• What was your experience during Covid? Did online learning hinder and/or support your learning and communication with faculty?

• How does PINC curriculum design help you feel that you belong to the program?

• How do you feel about having mentors from your major?

Collaboration with your mentor

• How do you feel about collaborative learning (you, mentor, faculty) in the PINC program?

• How does collaborative learning between you and your mentor affect your learning?

Please tell me any suggestions you have for improving teaching and learning in the PINC program.
Appendix B: PINC Program Mentor Interview Protocol

The PINC program mentee was a semistructured interview with the PINC mentor.

Thank you for joining me today and participating in my research. What we will discuss is confidential and your name will not be used in the research. I am going to have a few framing questions about teaching and learning in the PINC program.

Mentor Questions:

Introduction/Demographics

- Please tell me about yourself (including your pronouns, race, or ethnic group you identify yourself with), and how you came to be a mentor in the PINC program.

Communication

- Tell me about your communication with mentees.
- What are the different communication styles you use with your mentees?
  - What are the strategies you employ to improve communication with your mentees?
- How do you provide constructive feedback to your mentees?
- What aspects of your relationship with your mentees have worked best?
  - What aspects of your relationship with your mentees could be improved?
  - What challenges have you had regarding communication with your mentees?

Mentee Support

- What kinds of goals do you help your mentees set (e.g., academic and/or professional)?
- Tell me about the student collaboration in the course or program.
  - How do you help students collaborate with their peers in an effective way?
- Tell me about the ways that you help mentees figure out coding problems.
How do you help them be more self-sufficient with coding?

- Tell me how you help mentees develop strategies to meet their academic and professional goals.
  - Describe how you help mentees balance their lives, academic work, or their personal life?

**Leadership Skills**

- Tell me how your experience of being a mentor impacted your leadership skills.
- How has your experience of being a mentor impacted your own professional or academic goals?
- Tell me about the ways that you motivate your mentees.
  - How do you stimulate their creativity?

**Mentors’ role in the course and mentors’ impact on mentees**

- How does peer mentor coaching affect your mentee’s self-perception as a scientist?
- What are the impacts of mentoring on your mentee’s sense of belonging in the PINC course(s) or program?
- What are the impacts of peer mentor coaching in terms of your mentees’ persistence in the PINC courses and ultimately the PINC program?

**Andragogy**

- Tell me about PINC course design and where mentors fit in it.
- Tell me about how faculty members in PINC interact with you and make you feel.
- Tell me about the ways that the PINC curriculum design affects your mentees.
• From your perspective how does the difference with the regular computer science courses affect your mentees’ sense of belonging in the program?

• Does it help that you have a similar major to the mentee?

_Collaboration_

• How do you feel about collaborative learning in the PINC program?

• How does collaborative learning between you and your mentee affect your learning?

Please tell me any suggestions you have for improving peer mentor coaching in the PINC program.
Appendix C: PINC Program Faculty Interview Protocol

The PINC program mentee was a semistructured interview with the PINC course faculty. Thank you for joining me today and participating in my research. What we will discuss is confidential and I will not use your name. I am going to have a few framing questions about teaching and learning in the PINC program.

Faculty questions:

Introduction/Demographics

- Please tell me about yourself (including your pronouns, race, or ethnic group you identify yourself with), and how you ended up in the PINC program.

Relationship among faculty and mentors

- How do you feel about your PINC mentors?
- How do mentors help you in the course?
- How would you describe your collaboration with your course mentors?
- How would you describe your communication with the course mentors?

Mentors’ role in the course and mentors’ impact on mentees

- How does peer mentor coaching affect URG students’ self-perception as scientists?
- What are the impacts of mentoring on the URG mentees’ sense of belonging?
- How does peer mentor coaching contribute to the persistence of URG students in the PINC courses and ultimately program?

Andragogy

- What is the difference between teaching PINC and non-PINC courses?
  - Tell me about your curriculum design for PINC courses.
- Do you feel that your teaching style affects PINC students’ sense of belonging?
- In what ways does it help to have mentors from the student’s major?

- How does peer mentor coaching affect PINC students’ self-perception and persistence?
- What are the impacts of mentoring on the URG mentees’ sense of belonging?
- From your perspective, how do curriculum design decisions change students’ sense of belonging in the PINC program?
- How do cross-curricular activities in interdisciplinary STEM courses impact URG students’ persistence? For example, including projects associated with their major in their PINC course assignments.
- What was your experience during Covid? Did online learning hinder and/or support your learning and communication with mentors and students?

**Impact of peer mentor coaching on PINC mentors**

- What is the impact of mentoring on the URG mentors’ STEM career preparation? For example, leadership skills development.
- In what ways do you believe the peer mentor coaching model influences PINC mentors?
- How do you think that the experience of mentor-mentees shapes their experience in the program?

**Collaboration**

How do you feel about collaborative learning in the PINC program?

- How do collaborative learning experiences among mentors and mentees affect URG students’ learning?
Please tell me about suggestions you have for improving teaching and learning in the PINC program.