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# Factors That Contribute to Lower Enrollments of Underrepresented Minority and Female Graduate Students in Computer Science and Engineering (CSE) at Bay Area California State University Campuses and Mitigating Factors From Student Perspectives

Noah G. Price  
*San Jose State University*

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FACTORS THAT CONTRIBUTE TO LOWER ENROLLMENTS OF  
UNDERREPRESENTED MINORITY AND FEMALE GRADUATE STUDENTS IN  
COMPUTER SCIENCE AND ENGINEERING (CSE) AT BAY AREA CALIFORNIA  
STATE UNIVERSITY CAMPUSES AND MITIGATING FACTORS FROM STUDENT  
PERSPECTIVES

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Presented to

The Faculty of the Educational Doctoral Program in Educational Leadership

San José State University

In Partial Fulfillment

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Doctor of Education

by

Noah G. Price

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by

Noah G. Price

APPROVED FOR THE EDUCATIONAL DOCTORAL PROGRAM IN EDUCATIONAL  
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SAN JOSÉ STATE UNIVERSITY

May 2022

Bradley Porfilio, Ph.D.

Department of Educational Leadership

Eduardo Muñoz-Muñoz, Ph.D.

Department of Teacher Education

Tricia Ryan, Ed.D.

College of Graduate Studies

## ABSTRACT

### FACTORS THAT CONTRIBUTE TO LOWER ENROLLMENTS OF UNDERREPRESENTED MINORITY AND FEMALE GRADUATE STUDENTS IN COMPUTER SCIENCE AND ENGINEERING (CSE) AT BAY AREA CALIFORNIA STATE UNIVERSITY CAMPUSES AND MITIGATING FACTORS FROM STUDENT PERSPECTIVES

by Noah G. Price

The California State University (CSU) system provides accessible higher education, prepares graduates for professions in California's distinct regions, and affirms student body diversity. Graduate education is a lever of social mobility, and provides opportunities to access knowledge economy professions. The Bay Area CSU campuses are situated at the nexus of the knowledge economy, dominated by technology professions, professions that lack ethnic and gender diversity. CSU enrollment data indicates underrepresentation of minority and female graduate students in Computer Science and Engineering (CSE), disciplines that lead to technology professions. Lack of URM enrollment in CSE at the graduate level is a problem of practice and raises questions of the role and mission of the CSU. Equity in opportunity for graduate education in an economy dominated by technology has implications for social change and social mobility. This qualitative research study attempts to uncover the sense making and meanings URM graduate students construct through graduate education. This study aims to explore experiences and perceptions of URM graduate students in CSE disciplines at three Bay Area CSU campus situated in the Silicon Valley knowledge economy. This research may guide education reform to recognize inherent assets, talents, and aspirations URM students bring into academic culture and thus reshape campus cultures toward diversity and inclusion.

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## **Chapter 1 Introduction**

Diversity in graduate education at the California State University system is a problem of practice at three Bay Area campuses. Minority graduate student enrollment rates at the graduate student level decrease when compared to minority undergraduate student representation rates at three Bay Area California State University campuses. Across the Bay Area CSUs, African American/Black, Hispanic/Latinx, Pacific Islander, and Native American undergraduate students do not enroll in graduate study at the same rates as non-minority peers. Three-year underrepresented minority (URM) undergraduate enrollment averages, 2019 to 2021, at California State University East Bay is reported as 49% of the undergraduate student body; three-year URM undergraduate enrollment averages at San Francisco State University are reported at 42%; and three-year URM undergraduate student enrollment at San José State University is reported at 34% (The California State University, 2022). Moreover, undergraduate student enrollment by gender is balanced or stable across three years. Female students comprise 52% of California State University East Bay undergraduate student body, 50% of the San José State University undergraduate study body, and 61% of San Francisco State University undergraduate student body (The California State University, 2022). The undergraduate student body composition is trending toward balance and characteristic of the equity and inclusion mission and values espoused by the CSU (Office of Public Affairs, 2020).

The CSU system is mission driven, by values of social justice, and accessible education. However, URM enrollment declines at the graduate level at each of the three Bay Area California State University campuses pose a problem of practice. Three-year underrepresented minority (URM) graduate enrollment averages, 2019 to 2021, at California State University East Bay is reported as 27% of the graduate student body, or a decrease of 22 points from the

undergraduate level. The URM graduate enrollment at San Francisco State University is reported at 26%, or a decrease of 16 points. Finally, URM graduate student enrollment at San José State University is reported at 21%, or a decrease of 13 points from undergraduate levels. (The California State University, 2022). Female students comprise 65% of California State University East Bay graduate student body, 58% of the San José State University graduate study body, and 65% of San Francisco State University undergraduate student body (The California State University, 2022). Student body demographics are important for regional CSU campuses with a history of responding to the students who they serve (Gerth, 2010). The CSU provides broad access to higher education, particularly for marginalized students, and graduate education is an important trajectory for social mobility. The Bay Area region is distinct, innovative technology sectors and a high wage Silicon Valley workforce are factors to which the CSU must respond.

The decrease in URM enrollment in Computer Science and Engineering disciplines at the graduate level is even greater than general graduate student body decreases noted at each of the three Bay Area campuses when compared to the undergraduate population. Significant decline in female enrollment in in Computer Science and Engineering is also evinced by 2019 to 2021 enrollment data (The California State University, 2022). A three-year enrollment average at California State University East Bay positions URM participation in computer science programs at 24% at the undergraduate level and 2% at the graduate level, a 22-point decline. Female participation in computer science programs averaged 18% at the undergraduate level and 53% at the graduate level. Three-year enrollment averages at San José State University positions URM participation in computer science programs at 11% at the undergraduate level and 3% at the graduate level, an 8-point decline. Female participation in computer science programs averaged 27% at the undergraduate level and 36% at the graduate level. These averages at San Francisco



State University position URM participation in computer science programs at 25% at the undergraduate level and 7% at the graduate level, an 18-point decline. Female participation in computer science programs averaged 27% at the undergraduate level and 36% at the graduate level. While female participation in computer sciences at the graduate level increases when compared to undergraduate participation, participation in this discipline declines when compared to overall female graduate student enrollment at each campus (The California State University, 2022).

A three-year enrollment average at California State University East Bay positions URM participation in engineering programs at 43% at the undergraduate level and 3% at the graduate level, a 40-point decline. Female participation in engineering programs averaged 11% at the undergraduate level and 42% at the graduate level. Three-year enrollment averages at San José State University positions URM participation in engineering programs at 27% at the undergraduate level and 11% at the graduate level, a 16-point decline. Female participation in engineering programs averaged 19% at the undergraduate level and 32% at the graduate level. These averages at San Francisco State University position URM participation in engineering programs at 40% at the undergraduate level and 11% at the graduate level, a 29-point decline. Female participation in engineering programs averaged 16% at the undergraduate level and 25% at the graduate level. Although female participation in engineering at the graduate level increases when compared to undergraduate participation, participation in this discipline declines when compared to overall female graduate student enrollment at each campus (The California State University, 2022). Detailed enrollment data from 2019 to 2021, by degree program and academic level, is presented in Tables 1 through 6 in chapter two.

The CSU enrollment data presents challenges for graduate deans, department chairs, graduate faculty, and directors of admission, and calls for critical inquiry into potential barriers or deterrents to URM participation in graduate education. The overall campus climate and academic department cultures in these disciplines must align with espoused systemwide mission and values and be assessed from this lens. In the Bay Area region, a parallel ethnic, racial, and gender diversity problem in Silicon Valley technology professions exists (Tomaskovic-Devey & Han, 2018). In the context of the growing technology sector, graduate education often a pathway into these professions, John and Carnoy (2019) argue, “graduating more women and underrepresented minority STEM from universities could be viewed as a way to equalize gender wage differences and increase minority social mobility (p. 421). Furthermore, current scholars position the lack of diversity in higher education STEM disciplines, including computer science and engineering, as a matter of national security, a threat to our position in the global knowledge economy, and critical to democratic ideals (Burt & Johnson, 2018; Figueroa & Hurtado, 2013; Griffith, 2010; Stockard et al., 2021). As a public university system, the CSU must serve students and stakeholders in the region to ensure equitable opportunity in graduate education and pathways to computer science and engineering fields. The purpose of this study is to explore the experiences, perceptions, and attitudes of underrepresented minority (URM) graduate students as they navigate student life in Computer Science and Engineering (CSE) disciplines at three Bay Area California State University campuses.

## **Background**

The Bay Area is home to three of the California State University (CSU) campuses: California State University East Bay, San Francisco State University, and San Jose’ State University. Each of these institutions experience underrepresentation of African American/Black, Hispanic/Latinx, Pacific Islander, and Native American students, and a gender imbalance, in Computer Science

and Engineering graduate programs. This phenomenon parallels a lack of diversity in the high wage technology workforce in the region (The California State University, 2022). Consequently, these campuses are failing to meet several legislation charges, such as creating an inclusive relevant curriculum, co-curricular activities, and research opportunities that prepare a diverse student body for the high wage jobs of the knowledge economy (ICF International, 2010).

The CSU in the Bay Area is also vital for broadening participation as well as enhancing ethnic, racial, and gender diversity of the knowledge economy workforce. One way for the CSU to achieve these aims is to engage with the Silicon Valley technology workforce. The CSU academic senators (Academic Senate, 2004) understand the “interdependence of economic and social forces” (p. 5) as central to the evolution of the university system’s graduate programs. A social justice approach to graduate education in disciplines that provide professional and civic opportunities to lead in the Bay Area knowledge economy is an integrated approach that addresses both economic and social issues simultaneously.

The lack of diversity in the Bay Area knowledge economy is also responsible for dominant social groups controlling digital infrastructures and applications. The lack of diversity in the technology professions results in less diversity in thought and imagination, and more homogeneity in the professional workforce that build and sustain the knowledge economy in the region (Williamson, 2017). Consequently, the giant technology firms continue to reproduce structural inequalities and biases connected with computing technology-centered career fields (Benjamin, 2019; Posselt & Grodsky, 2017). Furthermore, graduate education is a lever of social mobility, often necessary for professional advancement in the Bay Area region, and provides access to the managerial class. Conversely, lack of access to graduate education may contribute

to the closing of high wage technology professions, resulting in a less diverse workforce (John & Carnoy, 2015; Posselt & Grodsky, 2017).

### **Regional Context**

A dominant ethos of the Bay Area resides in a libertarian celebration of technology, innovation, and knowledge creation. An ethos affirmed by the culture of start-ups, venture capital firms, multinational corporations, and higher education institutions that shape the global economy (Scott & Kirst, 2017). The Salesforce Tower is a boast of this ethos. The venerated Bay Area technology workforce is not without criticism, and the criticism is rightly focused on lack of workforce diversity (Bay Area Council Economic Institute, 2019a; Chamings, 2020; Guynn, 2019; Tomaskovic-Devey & Han, 2018; Williams, 2018). In summer 2015, the Obama administration joined calls for increased diversity in the tech sector, and Silicon Valley firms pledged to mandatory interviews of minoritized groups in recruiting and partnerships with universities to improve the pipeline for talent (Kang, 2015). Diversity efforts stalled, prompting the Congressional Black Caucus to visit the Bay Area and continue dialogue with Silicon Valley technology firms on improving diversity (Romm, 2018). In September 2020, the California governor signed AB 979 into law, requiring publicly held corporations headquartered in California to have at least one director from an underrepresented community. The governor was quoted “when we talk about racial justice, we talk about empowerment, we talk about power, we need to talk about seats at the table” (McGreevy, 2020). The California State University system has a significant role to play in the region and in diversity efforts targeting the Silicon Valley technology workforce.

This dissertation study explores the parallel lack of diversity in the region’s California State University graduate programs, pathways into the technology workforce professions (The California State University, 2022). The global technology giant Salesforce published employee

demographics for 2020 and Underrepresented Minority Population (URM) totals including Black, Latinx, Indigenous, and Multiracial Employees accounted for 11.2 % of the company workforce (Prophet, 2020). The CSU similarly defines URM and experiences parallel URM enrollment rates in its Bay Area CSU computer science and engineering graduate programs (The California State University, 2022). These parallel problems of diversity present opportunities for higher education administrators and graduate faculty to engage Silicon Valley technology firms in new ways to mediate lack of diversity in both spheres.

The Salesforce Tower looms over Mission Street, imposes itself on one's eastward gaze down Post or Sutter Streets; the tower is a serration in the blue-sky view of the city from west end vistas. Even after dark, Campbell's "Day for Night" six story LED art installation capping the Salesforce Tower, captures our gaze and reminds us of the pervasive culture of technology in the Bay Area (Stewart & Zhou, 2018). Nonetheless, Salesforce presents us with an even more imposing higher education problem. This global technology giant and its predominantly white male leadership workforce, employs engineers who design software platforms sold to higher education institutions. These platforms mediate the online spaces of student recruitment, admissions, student life, education data architecture, and university advancement (Salesforce, 2021). Higher education reform pursued by equity and social justice minded administrators, staff and faculty occurs on the physical campus, while a homogenous male workforce, that is often not fluent in the discourse of equity and social justice in higher education, rebuilds a digital campus infrastructure in the online space. The questions, who builds this infrastructure, who builds this online campus? matter. Higher education equity reform is at risk of erasure in the online space if software engineers of this technology build from a homogeneous dominant cultural vantage point.

The CSU has a role in the diversification of the Silicon Valley technology workforce, so that more voices are in the design and board rooms. The lack of diversity impact is far reaching, and the CSU must partner with Silicon Valley firms on diversity efforts to avoid a reinvention of racist, classist, and male-centered structures in the digital space, prevent algorithmic racism, and shape an ethical conversation around technology in our daily lives. Williamson (2017) argues, “colleges and universities are being reconfigured by education data science as a metrological flat platform or the science of measurement” (p. 100). Ironically, these platforms, used by mission driven institutions, are built by a homogenous technology workforce and overlaid onto social justice and equity work in education. Digital spaces and big data science influences on daily life have far reaching social justice implications, particularly when these technologies are created by a homogeneous group of men. Selwyn (2020) states, “all data systems, processes and procedures are based on design decisions that have impacts that are determinative for society” (p. 2). These systems are designed to capture a vast array of data, interpret meanings, and provide outputs. Design decisions made by a homogeneous group may impact multicultural societies in negative ways.

Benjamin (2019) coins the phrase “the New Jim Code” in a critical analysis of the tyranny of the algorithm. Benjamin argues that claims of neutral and objective technology actually hide how new technologies reinforce racism and inequality. Governor Newsom’s statement, “we need to talk about seats at the table” (McGreevy, 2020) in reference to lack of diversity in the technology professions is warranted. Benjamin offers evidence of a “New Jim Code” expressed in outcomes of technologies. Benjamin exposes the problem of Artificial Intelligent (AI) and facial recognition software as it is experienced by minorities with darker skin. There is duality in this problem. On the one hand, surveillance software can specifically target Black and Brown people,

while on the other hand, this technology often just ignores black and Brown people. An effect that affirms and enshrines whiteness as the norm. Benjamin (2019) states, “racist structures do not only marginalize but also forcibly center and surveille racialized groups that are trapped between regimes of invisibility and spectacular hyper visibility” (p. 125). Benjamin’s work includes problems with “racist robots” and algorithms that exclude or distort.

Williamson (2017) and Benjamin (2019) critique these technologies through a social justice lens. These inquiries uncover the ways in which lack of diversity in technology professions manifests in our social spheres. These technology systems, a recursion of the status quo, are designed by a homogenous technology workforce, likely uneducated in culturally responsive pedagogies or leadership. The impacts of these systems are yet to be seen but are a consequence of the lack of diversity in the design rooms or board rooms. The related low URM participation rates in graduate education in the Computer Science and Engineering disciplines across each of the three Bay Area campuses means that potential URM professionals and leaders do not contribute to the design and development of the knowledge economy infrastructure.

### **Purpose of the Study**

The purpose of this qualitative research study is to explore the experiences, perceptions, and attitudes of underrepresented minority and female graduate students as they navigate the student lifecycle in Computer Science and Engineering (CSE) disciplines at three Bay Area California State University campuses. These students are minorities in California State University graduate programs. The students in this study gained access to “selective” graduate education and persist in academic disciplines that lack ethnic, racial and gender diversity. They navigate structural barriers to and persist in Computer Science and Engineering graduate program culture that was not built with them in mind. This research may guide campus climate reform, the development of graduate student support programs, foster a sense of belonging, and inform future curriculum,

co-curricular programs, and faculty development. The URM graduate student body in the CSE disciplines at the three Bay Area campuses decreases significantly when compared to the URM undergraduate student body in these disciplines, and is gender imbalanced (The California State University, 2022). The qualitative data revealed through narratives of underrepresented minority and female graduate students enrolled in CSE disciplines at the Bay Area California State University campuses are of interest to graduate deans, graduate faculty, directors of admission, and institutional change agents.

This dominance of technology in the regional economy, the social implications of technology impact on our daily lives, and lack of diversity in the workforce that designs these technologies elevate the interest in mediating underrepresentation in higher education and in the region's knowledge economy professions. The attitudes and perceptions of minority graduate students in CSE disciplines may guide diversity and inclusion efforts in these disciplines. The aim of this study, and analysis of the qualitative data collected, may further guide higher education reform. Reform toward diversity and inclusion includes critical analysis of recruitment and academic socialization practices that has historically disenfranchised and excluded URM and female graduate students in the Computer Science and Engineering disciplines.

### **Research Setting**

The research setting is a public university system that espouses values of equity and social justice, coupled with graduate education teaching, research, and scholarship that is highly specialized. This study includes a purposive sample of students who self-identify as an underrepresented minority (URM) or female student, are classified as a California resident paying resident tuition and fees, are currently enrolled in a graduate program in Computer Science or Engineering at San José State University, California State University East Bay, or San Francisco State University, or a new alumnus. The URM and female graduate student experience



likely varies from dominant student groups. Students may experience historical structures in academia in ways that differ from non-minority cohorts. This study is limited to the academic culture in CSE disciplines at the three Bay Area California State University campuses and a purposive sampling of graduate students. This study utilizes a qualitative research methodology to uncover the narrative data of URM and female graduate students as they experience graduate education socialization, and either adapt to, cope with, or reject the habitus of the discipline in which they are engaged.

### **Significance of the Study**

The San Francisco Bay Area is home to Silicon Valley, a global center of innovation and the Twenty-First Century Knowledge Economy (Scott & Kirst, 2017). The Twenty First Century knowledge economy requires advanced education in specialized fields and the role of graduate education in mediating social and economic mobility, racial and ethnic economic inequalities, is more pronounced in competitive fields. Graduate education is fundamental to social mobility outside of an inherited privileged class trajectory, and the economic returns to graduate education attainment are significant (Posselt & Grodsky 2017). This claim of economic return is supported by U.S. Bureau of Labor Statistics data that suggests full-time workers ages 25 and over who hold a master's degree realize a significant median annual wage premium over bachelor's degree holders; those who earned graduate degrees in STEM and CSE disciplines realized even higher wage differentials (Torpey & Terrell, 2015). The concept of equity and social justice in higher education includes opportunities for advanced study that lead to high wage, high skilled professions. Of further significance, increased diversity in these professions may contribute to cultural and social changes in this distinct sector of the knowledge economy over time.

Moreover, the California State University system traverses Silicon Valley with three campuses, San Francisco State University, California State University East Bay, and San José

State University. Each campus educates undergraduate and graduate students for the region's workforce. Parallel issues of diversity in the Silicon Valley technology workforce and the region's three public university CSE graduate programs, compel this research. University administrators, directors, and faculty at the California State University are charged with upholding values of equity, access, and excellence in higher education. These educators and leaders must implement a social justice mission to prepare a diverse and changing populace for future technology professions that comprise the knowledge economy. These social actors also have an opportunity to expand participation and infuse social and ethical considerations into the CSE curriculum.

The three Bay Area CSU campuses, distinct from the University of California, exist to offer "access and excellence" to residents who may be otherwise unable to pursue higher education. The California State University was created in 1960 with the advent of the California Master Plan for higher education and designed to address "access to graduate programs and continuing education" (Gerth, 2010, p. 210). California State University graduate programs provide access and address the regional and statewide need for professional and graduate education. In 2003, the statewide Academic Senate prepared a document "Rethinking Graduate Education in the CSU: Meeting the Needs of the People of California for Graduate Education in the 21<sup>st</sup> Century" that conceptualized the future of graduate education (Gerth, 2010). The statewide Academic Senate argued that the graduate program "impact on California's economy and social and cultural structures has been great" (Gerth, 2010, p. 236). Nonetheless, issues of diversity in graduate education at the California State University remain. The state mandates its twenty-three California State University campuses to provide accessible undergraduate and graduate education that is responsive to the people and the distinct regions in which they are situated.

A regional response from graduate programs at each of the CSU campuses requires critical analysis of barriers to access or deterrents, relevant curriculum, co-curricular activities, and research opportunities that prepare a diverse student body for the highly skilled jobs in this knowledge economy. The CSU campuses in the region are vital, not only to broadening participation, but to enhancing diversity of the knowledge economy workforce. A highly educated, highly paid Silicon Valley workforce that lacks the diversity of its region, calls into question the California State University role as an equalizer of educational opportunity. A response to the region, its economy, in the spirit of the mission and values of the CSU, includes academic rigor, holistic student development, and mediation of uneven social or cultural capital that generally guarantees entry into these high wage professions. The California State University mission and values demand such a response.

The triad of CSU campuses in the Bay Area integrate and respond to a Twenty-First Century knowledge economy differently (Scott & Kirst, 2017), yet operate under shared values of diversity and inclusion. The California State University, the state system to which these universities belong, boasts a higher education mission of “inclusive excellence.” CSU systemwide promotional and marketing materials define itself in service to the most diverse student body in the country, as providing an inclusive higher education opportunity for the historically marginalized, first generation, and socioeconomically disenfranchised students. The CSU claims a prominent role in social mobility opportunity (Office of Public Affairs, 2020).

However, public CSU institutional data raises issues of equity and opportunity for graduate education at the three Bay Area campuses. This data suggests a less diverse student body in the disciplines that lead to Bay Area knowledge economy professions (The California State University, 2022). The CSU campuses are situated at the nexus of a knowledge economy fueled

by innovations in computer science and engineering. These campuses must respond at the graduate level through expanding education opportunities in computer science and engineering disciplines. Rigorous curriculum development in these disciplines must be informed by Bay Area innovation, its industry and workforce need. The three Bay Area CSU campuses, true to mission and institutional values, can ensure equity in access to the higher education necessary for the highly skilled jobs of this knowledge economy, including professional and managerial positions. Equity in higher education translates to equity in opportunity to compete for knowledge economy jobs, particularly through graduate education in computer science and engineering disciplines.

### **Sociopolitical Context of the United States**

In the U.S sociopolitical context, the Department of Education National Center for Education Statistics indicates disparity in the award of graduate degrees across ethnicities nationwide. The percentage distribution of master's and doctor's degrees awarded by degree-granting postsecondary institutions, by race/ethnicity in the 2017/18 academic year indicate a larger proportion of master's degrees awarded to Whites. Hussar et al. (2020) reports that in fall 2018, two-thirds or 66% of U.S. resident graduate students at public institutions were White, 13% were Black, and 11% were Hispanic. Furthermore, Hussar et al. (2020) "Condition of Education report" notes graduate degree attainment in a STEM field varied by race/ethnicity where 22% master's degrees conferred to Asian students; 12% of students who were of Two or more races; 10% for White; 9% for Hispanic; 7% for Pacific Islander; 6%, and 5% American Indian/Alaska Native (Hussar et al., 2020) The statistical disparities in graduate degree participation across ethnicities is problematic for the CSU, particularly as state demographics change and more CSUs obtain Hispanic Serving Institution (HSI) designations. These statistics highlight advance degree attainment disparity, but also suggest opportunities for higher education institutions to evolve.

Hussar et al. (2020) “Condition of Education report” indicates that master’s degree attainment increased from the academic year 2000/01 to academic year 2017/18 for all ethnic groups.

The CSU Chancellor’s Office Institutional Research defines Underrepresented Minority (URM) in accordance with the Integrated Postsecondary Education Data System (IPEDS) definition to include ethnic/race reporting categories of Black/African American, Hispanic/Latino, and American Indian/Native American (Institutional Research, 2020).

However, this term is contested, may hide minoritized ethnic status within non-URM groups. For example, the URM term excludes Asian American and the significant number of ethnicities that comprise this group. The URM definition excludes individuals who self-identify as two or more races. The California State University acknowledges language around these groups continues to evolve (The California State University, 2021). The URM term is used for reporting aggregate student data (Institutional Research, 2020), which is the rationale its use in this dissertation. A comparison URM to non-URM and female undergraduate and graduate data of the three Bay Area campuses indicate a less diverse graduate student body (The California State University, 2022).

The CSU data raises questions of barriers or deterrents URM and female students face in participation in graduate education. In practice, barriers to graduate admission pose challenges to equity minded graduate faculty, graduate deans, and directors of admission. Furthermore, the decreases in URM and female participation rates in graduate education versus undergraduate education are even greater in the Computer Science and Engineering disciplines across each of the three Bay Area campuses. CSU institutional data poses challenges for graduate faculty, deans, and directors of admission, and calls attention to potential barriers to URM participation in graduate education.

## Research Questions

The following research questions guide this study and aim to uncover characteristics of the underrepresented minority and female graduate student experience:

1. How do underrepresented minority and female graduate students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities?
2. How do underrepresented minority and female graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities?
3. How do underrepresented minority and female graduate CSE students view themselves as Silicon Valley knowledge economy professionals?

This research uses the underrepresented minority (URM) definition that the California State University system defines to include race/ethnicity categories Hispanic/Latinx, African American/Black, Pacific Islander, and Native American (The California State University, 2020a). The CSE students in this study included individuals who self-identify as URM or female pursuing Computer Science and Engineering (CSE) at the graduate level, or recent alumnus.

This research consists primarily of in depth semi-structured interviews. Study participants described their experiences, perceptions, and opinions of their graduate student experience at a Bay Area CSU campus. Furthermore, student opinion data collected focused on access, participation, and completion; perceptions of academic department climate; culturally relevant curricula, the graduate student lifecycle, and students' self-concepts as academics and researchers within opportunities to build professional networks, engage in research and publish.

This research will expand the current literature and inform educational leaders interested in institutional change toward diversity and inclusion.

### **Qualitative Research and Theoretical Framework of the Study**

This study assumes a transformative worldview approach to qualitative research, designed to include a case study methodology consisting of in-depth interviews of graduate students at the three Bay Area CSU campuses. The intent of this exploratory study is to bring understanding to the meanings underrepresented minority and female graduate students construct as they navigate the graduate student lifecycle in Computer Science and Engineering disciplines at one of the three Bay Area California State University campuses. These students may experience graduate school differently than non-minority peers, as they develop as academics, researchers, and professionals through a graduate program. A transformative philosophical worldview is necessary as the basis of this study because of the inherent structures in higher education that perpetuate marginalization, gatekeeping of graduate education, and the closing of professions through such gatekeeping (Posselt & Grodsky, 2017). Creswell and Creswell (2017) remind the researcher that inquiry guided by a transformative worldview goes beyond a constructivist worldview to advocate change, confront social oppression, and address issues of empowerment, and inequality. The transformative research in this study aims to amplify study participant voice and to inform inclusive best practices in the administration of graduate education.

The advance degree attainment data of both NCES and the CSU confirm a disparity across ethnicities, and in the context of social mobility, professional advancement, and access to levers of power in society; this discrepancy is a problem of higher education practice. Creswell and Creswell (2017) define research from a transformative world view as politics linked with social action in study of inequalities based on race, class, gender, ethnicity, sexual orientation, and disability that result from uneven power in society. The transformative worldview attempts to

understand why these problems exist and to inform change. The habitus of an academic department or campus climate is worthy of study in the context of graduate degree attainment and the disparity that exists nationally and locally. Furthermore, education research identifies challenges of academic socialization in university life that historically underrepresented and female students face, particularly in STEM fields, that the dominant group cohort does not. The questions posed in this qualitative research study attempt to identify how historically underrepresented minority graduate and female students engage as active scholars, researchers, and co-creators of knowledge with faculty and administrators in the context of a public university situated in a dominant, hegemonic culture.

### **Definitions and Key Terms**

**Academic Socialization** This study defines academic socialization as student engagement and learning outcomes resulting from what Gonzáles (2006) identifies as an understanding of the flow of social and cultural capital in the habitus of the academy resulting from “institution-wide support systems” (p. 356) and strong academic department support.

**California Resident** A student who resides in the State of California for whom a campus admissions office determined to be qualified to receive the in-state tuition rate by meeting requirements established under California law. (The California State University, 2021).

**Computer Science and Engineering (CSE)** CSE in this study refers broadly to the academic departments or Schools of Science and Engineering at the three Bay Area California State University campuses that focus on academic disciplines of Computer Science and Engineering at the graduate level.

**Cultural Capital** This study uses Yosso’s (2005) expanded definition of cultural capital, inclusive of “cultural wealth” URM student already possess; decentering Bourdieu’s



concept understood as a “White, middle-class culture as the standard” and advantaged by “specific forms of knowledge, skills and abilities that are valued by privileged groups in society” (p. 76).

**Graduate Faculty Mentor** This study uses the Council of Graduate Schools definition as faculty who are “eligible to teach graduate courses, direct graduate student research, design graduate curriculum”, and who are eligible to serve on thesis committees (Denecke, 2004, p. 30).

**Graduate Education** This study uses the Council of Graduate Schools definition of graduate education as advanced, either research or practice-oriented, focused, and scholarly education beyond a baccalaureate degree (Council of Graduate Schools, 2007).

**Graduate Student** This study defines a graduate student as a student who holds a bachelor’s degree and is currently pursuing a master’s degree or who has earned a master’s degree.

**Graduate Student Lifecycle** This study defines the graduate student lifecycle to include all university administrative phases of graduate student support, outreach, recruitment, admission, retention, graduation, and alumni relations.

**Habitus** Bourdieu (1984) describes habitus as people in “homogeneous conditions of existence imposing homogeneous systems of dispositions capable of generating similar practices; and who possess a set of common properties, objectified properties” (p. 101). Inquiry of habitus in academia may reveal underlying structures, hierarchies, and cultures that are self-perpetuating and self-reinforcing with each new incoming class of graduate students, and, left unchallenged, may continue to disenfranchise.

**Social capital** Bourdieu (1984) defines social capital to be, “understood as the set of actually usable resources and powers” (p. 114). Social and cultural capital in the context of graduate school act as currency that enables holders to access higher education, and those students who possess higher degrees of social and cultural capital are assumed more likely to succeed.

**Underrepresented minority (URM)** This study adopts the California State University system definition of underrepresented minority to include race/ethnicity categories Hispanic/Latinx, African American/Black, Pacific Islander, and Native American (The California State University, 2020a).

## **Summary**

The California State University system holds values of inclusion, equity, and social justice at the core of its mission, and broad participation in CSE disciplines at the graduate level in the context of the Bay Area technology economy is a social justice initiative. University administration must act on the real or perceived experiences of historically underrepresented minority and female graduate students face in acclimation to the habitus of the academic department and campus in general. Interventions and programmatic strategies that enhance this academic socialization must be experimented with and scaled up when successful. Policy makers have the power to redistribute resources to improve the institutional climate. These policy makers, particularly the academic senate, have the charge to reshape curriculum, learning outcomes, and the academic department habitus through directives in the form of policy. This proposed research study may inform institutional change to include a disruption of the selective graduate admission process, and refocused recruitment for diversity. Graduate education is an avenue for social mobility for those students who have been traditionally excluded, specifically from STEM fields. The Twenty-First Century knowledge economy requires advanced higher

education credentials, particularly in highly skilled and highly compensated positions. The social justice minded university administrator must therefore take the role of student advocate and lobby for system-wide support at the state level. We are obligated to the students whom we serve and must ensure inclusive practices and equitable outcomes in the graduate school experience.

## **Chapter 2**

### **Review of Literature**

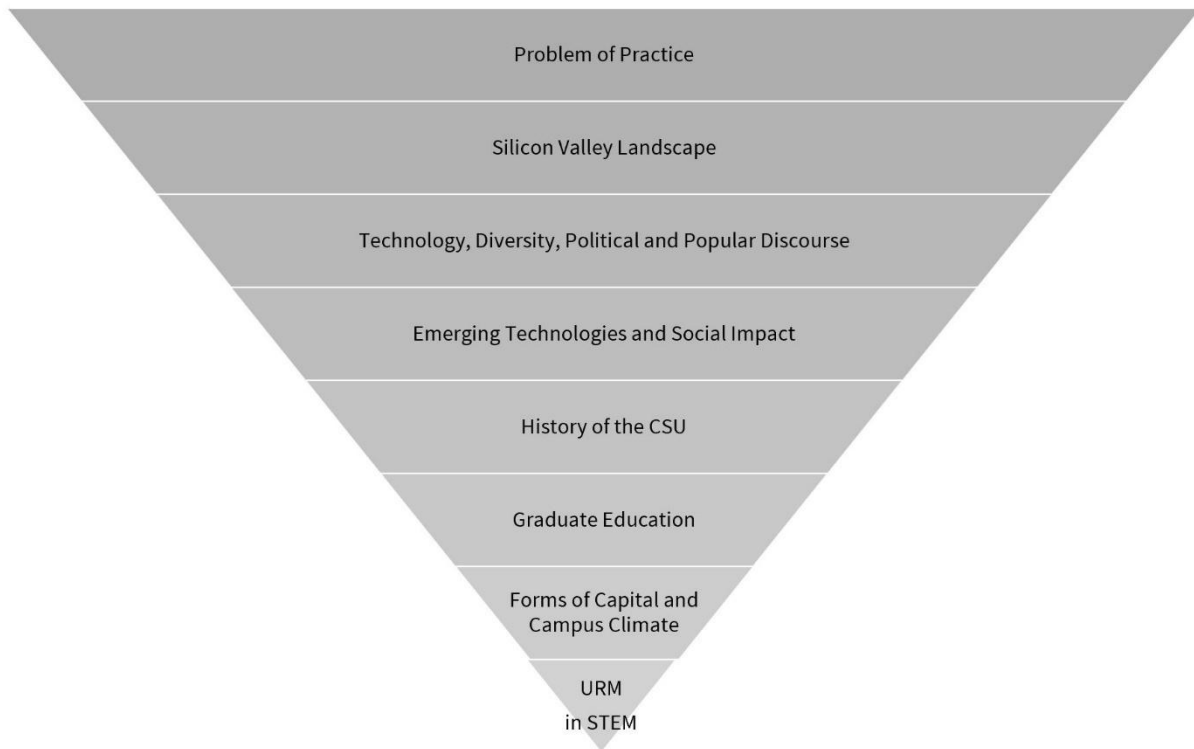
#### **Purpose of the Study**

The purpose of this study is to explore the experiences, perceptions, and attitudes of historically underrepresented minority (URM) and female graduate students in Computer Science and Engineering (CSE) disciplines at three public universities situated in the Silicon Valley knowledge economy. A summary of the review of literature is shown in Figure 1. The graduate student body is more homogeneous than the undergraduate student body at each campus (The California State University, 2022). This significance of this study is raised by issues of equity in opportunity interpreted through the mission of the California State University and a regional economy dominated by technology professions. This knowledge economy lacks diversity in its workforce. The review of literature includes a restatement of the problem of practice and the research questions that guide this research. The literature review explores the Silicon Valley landscape, an analysis of the lack of diversity in technology professions, and popular media criticism at the lack of diversity.

Furthermore, this literature review presents social consequences of technology designed by a homogenous workforce culture. These consequences build an argument for diversity in the Silicon Valley knowledge economy, through making the negative social impacts on our multicultural society visible. Moreover, a discussion of the history, mission and values, and student profiles of the California State University system is included. A case for graduate education as a route to social mobility is presented. An in-depth discussion of Bourdieu's (1984) concepts of social and cultural capital and habitus through education research, expanded by Yosso's (2005) research to include community cultural wealth provides a critical theory

framework for the study. Finally, an analysis of current research on minority graduate student participation in STEM fields concludes the literature review.

**Figure 1**  
*Review of the Literature Summary*



## **Introduction**

The Bay Area region is markedly distinct; it notably encompasses the cities of Oakland, San Francisco, San José, and the Silicon Valley sub-region. The Bay Area is an epicenter of the global knowledge economy, underpinned by innovative technology sectors and a high wage workforce. The economic prosperity of the Bay Area is exceptional. This economic prosperity is clustered in the Silicon Valley workforce, which critics argue, has a diversity problem (Bay Area Council Economic Institute, 2019a; Guynn, 2019; Manjoo, 2018; Tomaskovic-Devey & Han, 2018; Williams, 2018). The role the California State University plays in affording educational pathways to the Silicon Valley workforce is of interest to educators and leaders who value

diversity and inclusion. The Bay Area is home to three of the California State University (CSU) campuses, a vital lever for social mobility for many historically marginalized students and has a role in enhancing diversity of the knowledge economy workforce. A highly educated, highly paid Silicon Valley workforce that lacks the diversity of its region, calls into question the California State University role as an equalizer of educational opportunity. A response to the region, its economy, in the spirit of the mission and values of the CSU, includes academic rigor, holistic student development, mediating uneven social and cultural capital that generally guarantees entry into these high wage professions. The California State University mission and values demand such a response. The social justice argument for a higher education role in mediating access to the Silicon Valley knowledge economy professions through graduate education is both economic and sociocultural.

### **Problem of Practice**

San Francisco State University, San José State University, and California State University East Bay, three public higher education institutions in the Bay Area, integrate and respond to a Twenty-First Century knowledge economy differently (Scott & Kirst, 2017), yet operate under shared values of diversity and inclusion. The California State University, the system to which these universities belong, boasts a higher education mission of “inclusive excellence.” CSU Systemwide promotional and marketing materials define itself in service to the most diverse student body in the country, as providing an inclusive higher education opportunity for the historically marginalized, first generation, and socioeconomically disenfranchised students. The CSU claims a role in social mobility opportunity (Office of Public Affairs, 2020).

However, CSU institutional data raises issues of equity and opportunity for graduate education at the three Bay Area campuses. This data suggests a less diverse student body in the disciplines that lead to professions of the Bay Area knowledge economy (California State

University, 2021). The CSU campuses, at the nexus of a knowledge economy, integrated with information technologies and fueled by innovations in computer science and engineering, must respond to residents of the region by expanding education opportunities in these disciplines. Professionals in computer science and engineering design the Twenty-First Century digital spaces and technological infrastructures; however, a lack of diversity in this sector of the economy has social consequences that are now emerging as visible (Benjamin, 2019; Williamson 2017). Equity in higher education translates to equity in opportunity to compete for knowledge economy jobs, particularly through graduate education in computer science and engineering disciplines. A closer analysis of CSU institutional diversity data and participation rates at the graduate level is warranted, as is inquiry into the graduate student experience.

Graduate degrees enhance opportunity for professional advancement and social mobility (Posselt & Grodsky, 2017). In the Bay Area, Computer Science and Engineering disciplines prepare students for entry or promotion in the knowledge economy jobs of the Silicon Valley workforce. Diversity in this sector has implications for society beyond equitable access to social mobility opportunity. A point for social implications, California State University institutional data suggests Underrepresented Minority (URM) student participation in graduate education drops significantly from undergraduate to graduate study at all three Bay Area CSU campuses. The CSU data raises questions of barriers or deterrents URM students face in decisions to participate in graduate education. In practice, barriers to graduate admission pose challenges to equity minded graduate faculty, graduate deans, and directors of admission. Furthermore, the decreases in URM and female participation rates in graduate education versus undergraduate education are even greater in the Computer Science and Engineering disciplines across each of the three Bay Area campuses. A gender imbalance in these disciplines persists. The Chancellor's

Office of Institutional Research race/ethnicity, collapsed into URM and non-URM categories, and gender data from 2019 to 2021 for both Computer and Information Sciences and Engineering degree programs is presented for each institution in Table 1 through Table 6.

**Table 1.**

*CSU East Bay Computer and Information Sciences Enrollment 2019 - 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	17%	27%	28%
UG Non-URM	74%	68%	72%
Female	18%	18%	18%
Male	82%	82%	82%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	2%	3%	2%
GR Non-URM	98%	97%	98%
Female	52%	61%	47%
Male	48%	39%	53%

**Table 2.**

*CSU East Bay Engineering Enrollment 2019 – 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	43%	43%	43%
UG Non-URM	57%	57%	57%
Female	11%	9%	13%
Male	89%	91%	87%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	8%	0%	0%
GR Non-URM	92%	100%	100%
Female	40%	43%	44%
Male	60%	57%	58%



**Table 3.***San José State University Computer and Information Science Enrollment 2019 - 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	12%	11%	10%
UG Non-URM	88%	89%	90%
Female	27%	27%	27%
Male	73%	73%	73%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	2%	3%	3%
GR Non-URM	98%	97%	97%
Female	38%	37%	33%
Male	62%	63%	67%

**Table 4.***San José State University Engineering Enrollment 2019 - 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	26%	27%	28%
UG Non-URM	74%	73%	72%
Female	19%	20%	19%
Male	81%	80%	81%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	8%	11%	13%
GR Non-URM	92%	89%	87%
Female	33%	33%	31%
Male	67%	67%	69%

**Table 5.***San Francisco State University Computer and Information Science Enrollment 2019 - 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	25%	25%	25%
UG Non-URM	75%	75%	75%
Female	21%	21%	20%
Male	79%	79%	80%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	5%	7%	8%
GR Non-URM	95%	93%	92%
Female	36%	37%	37%
Male	64%	63%	63%

**Table 6.***San Francisco State University Engineering Enrollment 2019 - 2021*

	2019	2020	2021
<b>Undergraduate Student Body</b>			
UG URM	38%	40%	44%
UG Non-URM	62%	60%	56%
Female	17%	17%	15%
Male	83%	83%	85%
	2019	2020	2021
<b>Graduate Student Body</b>			
GR URM	10%	13%	10%
GR Non-URM	90%	87%	90%
Female	26%	25%	24%
Male	74%	75%	76%

Significantly, URM participation in Computer and Information Sciences decreases significantly from the undergraduate to graduate student level across the three Bay Area campuses. A URM student decrease in participation at the graduate level in Engineering is also demonstrated across the three Bay Area campuses, but to a lesser extent. Female graduate student participation increases from undergraduate to graduate levels at each campus; however, the gender imbalance in these disciplines is significant when compared to the gender composition of the general

graduate student body at each campus; 65% female graduate student body at CSU EB, 58% at SJSU, and 65% at SFSU (The California State University, 2021). Nonetheless, CSU institutional data poses challenges for graduate faculty, deans, and directors of admission, and calls attention to potential barriers or deterrents URM and female students may face in CSE graduate education.

### **Research Questions**

The decrease in URM enrollment from the undergraduate to graduate level, and gender imbalance, in CSE disciplines is at the core of this research study. Enrollment disparities, across the Bay Area CSU campuses in these disciplines, presents a problem of practice for educators. The following research questions guide this study and aim to uncover characteristics of the underrepresented minority and female graduate student experience:

1. How do underrepresented minority graduate and female students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities?
2. How do underrepresented minority and female graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities?
3. How do underrepresented minority and female graduate CSE students view themselves as Silicon Valley knowledge economy professionals?

Understanding the intersectional experiences of URM and female graduate students who persist and succeed in CSE graduate education may inform programmatic interventions to mediate lower enrollment and lack of diversity in CSE graduate programs. For clarity, this research uses the underrepresented minority (URM) student designation the California State University system defines to include race/ethnicity categories Hispanic/Latinx, African American/Black, Pacific

Islander, and Native American (The California State University, 2021). The CSE students in this study will include individuals who self-identify as URM or female students from the disciplines of Computer Science and Engineering (CSE) at the graduate level. The recruitment phase of this study aimed to identify URM and female students who are reflective of their experience. This research included semi-structured interviews of graduate students in CSE disciplines at the three Bay Area CSU campuses; students detailed their graduate student experience in CSE. Furthermore, student perceptions connected to access to graduate education in the CSU; participation and degree completion, perceptions of academic department climate, culturally relevant curricula, and the graduate student lifecycle were explored. This study aimed to understand how CSE URM and female graduate students perceive themselves as researchers and emerging professionals in the context of the Silicon Valley knowledge economy. This research may uncover barriers or deterrents to graduate education and will inform educational leaders interested in institutional change toward diversity and inclusion.

### **Silicon Valley Economic Landscape**

The Bay Area economy thrives because of the dynamism of its higher education system, strong university research and corporate development partnerships, and a highly educated workforce. Economic interdependencies that are simultaneously local and global emerge through a network of venture capital funds for innovation, emerging firms, and an immediacy to the globe through technology. The Bay Area's economic growth is located in professional and scientific information sectors and median wages are much higher than comparable regions (Bay Area Council Economic Institute, 2018). Scott and Kirst (2017) identify incredible sources of venture capital funds that nurture the growth of technology start-ups and create professional highly skilled jobs that accompany growth in the region. These incredible resources may

translate to incredible opportunities for higher education in the region to more fully engage, bringing values of equity and inclusion into any engagement.

Favorable professional outcomes are indicative of effective university and graduate program engagement with relevant industry and constituencies. Favorable outcomes may be defined in social mobility terms. The Bureau of Labor Statistics data indicates the 2018 median annual salaries for computer science occupations for the San Francisco-Oakland-Hayward Metropolitan area are \$120,730 and \$95,577 for engineering related professions. The 2018 median annual salaries for computer science related occupations for the San Jose-Sunnyvale-Santa Clara Metropolitan area are \$120,040 and \$108,019 for engineering related professions (U.S. Bureau of Labor Statistics, 2019). The salary data is evidence of uneven economic prosperity in the region.

The Bay Area maintains a highly educated workforce; 46% of adults over the age of 25 hold a bachelor's degree, compared to a 31% United States average (Bay Area Council Economic Institute, 2018). Graduate degrees may enhance professional opportunities and career advancement. The Bay Area Council Economic Institute argues that the region's three California State University campuses impact the workforce by graduating most of the Bay Area's engineering bachelor's and master's degree holders (Bay Area Council Economic Institute, 2019b). The California State University is certainly a major stakeholder with a responsibility to the citizens of the region to equalize opportunity. Furthermore, the CSU affirms a distinct commitment to diversity and equity. The decrease in CSE historically underrepresented minority student participation rates from undergraduate to graduate study across the three Bay Area CSUs is an issue worthy of inquiry within the context of the broader Silicon Valley economy and professional pathways to the knowledge economy. While the prosperity of the Bay Area

economy is uneven, the California State University education has the potential to serve as an equalizer.

### **Diversity in the Silicon Valley Workforce**

Lack of ethnic, racial, and gender diversity in the Silicon Valley workforce makes headlines and critics pressure technology firms to improve talent recruitment and hiring practices (Guynn, 2019; Manjoo, 2018; Williams, 2018). The Center for Employment Equity at the University of Massachusetts, Amherst investigates Bay Area employment demographics noting lack of diversity criticism. The Center's researchers, Tomaskovic-Devey and Han (2018), invoke the 1964 Civil Rights Act role in workforce data reporting requirements. They analyze confidential EEO-1 reports by Silicon Valley firms to the Equal Employment Opportunity Commission and conclude an uneven distribution of prosperity in the Bay Area in the technology workforce by race and ethnicity (Tomaskovic-Devey & Han, 2018). This research suggests more prominent Silicon Valley technology firms hire fewer women and Black or Latinx employees, and find that in higher ranks, women and minorities are even less numerous. Significantly, across the largest Silicon Valley technology firms, only 4.4% of all employees were Black, while 7.3% were Latinx. The low rate of hiring at entry level positions translates to Black men being one among 100 executives, while Latinos comprise 3.4% of professionals, 3.6% of managers, and 2.1% of executives. Moreover, this research suggest firms with White female management representation may translate to higher employment of under-represented minority women (Tomaskovic-Devey & Han, 2018). Nevertheless, recent Salesforce workforce demographic data presented in the introduction of this study suggests little has changed (Salesforce, 2021).

John and Carnoy (2019) deepen the lack of diversity argument in the Silicon Valley workforce and tether it to the higher education pipeline. These researchers conducted similar research on the participation of women and historically marginalized individuals in the Silicon

Valley technology workforce, finding disparity in gender and racial representation. These researchers frame their findings in the context of higher education CSE disciplines and argue expansion of the education pipeline may mediate lack of diversity. John and Carnoy identify the “leaky pipeline” in higher education streams to be the lack of minority participation in CSE disciplines (John & Carnoy, 2019). The significant drop in URM and female participation in graduate study in CSE at the three Bay Area CSU campuses is one example of a “leaky pipeline.” These researchers claim that graduating more women and Underrepresented Minorities (URM) in STEM disciplines is one strategy to equalize social mobility opportunities afforded by software programming and engineering careers. These strategies may ensure that diverse voices are in the design and decision rooms in the technology firms.

Similar to Bay Area Council Economic Institute policy papers (Bay Area Council Economic Institute, 2018; Bay Area Council Economic Institute, 2019a), John and Carnoy argue the validity of studying lack of diversity resides in lack of opportunity to high wage software developer or programmer positions that afford opportunity for social mobility in the Bay Area. These professional roles also shape the technological infrastructures of modern life. Silicon Valley employs the highest levels of the nation’s technology labor force, which is highly educated. Furthermore, the California State University offers broadly accessible higher education opportunities that may mediate a “leaky pipeline;” and study of the diversity of the student body in the CSE disciplines is parallel to that of diversity in the Silicon Valley workforce.

This Silicon Valley workforce study suggests that non-immigrant Asian Male visa holders shifted representation significantly in the 1990s, while female participation went down significantly from 1980. John and Carnoy (2019) find the number of degrees awarded in Computer Science to Latinx students increased, but Latinx employment participation remained

flat. Presently, the majority of the Silicon Valley technology labor force is male, highly educated, and majority non-citizen. Asian men who enter Silicon Valley technology labor force often do so through university graduate education in CSE or STEM. A contradiction seems to emerge in the leaky pipeline argument. While Latinx CSE degree attainment increased, their entry into the technology workforce remained flat, while non-citizen Asian men employment increased, with graduate education as a point of entry. John and Carnoy (2019) conclude that the “pipeline” argument may apply to gender imbalance, finding that the more women were involved in computer science higher education, the more their representation increased in the technology professions. Nonetheless, questions remain for the leaky pipeline argument and the role graduate education plays in student and professional development.

The three Bay Area California State Universities face a diversity problem of low URM participation and gender imbalance in graduate CSE education, despite residing in Silicon Valley. The Bay Area Council Economic Institute argues inequity in social mobility opportunities for URM individuals in Silicon Valley is a regional economic problem (Bay Area Council Economic Institute, 2019a). Inequity in social mobility opportunities for disenfranchised and minority graduates is also a social justice issue to which the California State Universities must respond. Increased URM and female enrollment in CSE disciplines at the three Bay Area universities may not be enough to mediate lack of workforce diversity, but higher education pressure on industry, through engagement, and in the interest of its graduates, may. The CSU is supposed to broaden access to high wage jobs that offer a middle-class lifestyle through its higher education mission; however, the three Bay Area universities have not yet been able to mediate inequity in CSE educational opportunity to include historically underrepresented students.



A gap in literature exists and the point of degree completion and entry into the technology workforce in Silicon Valley. This research study will attempt to broaden understanding of lack of diversity in CSE education in the California State University at the graduate level as a parallel to the lack of diversity in the Silicon Valley technology workforce. Posselt and Grodsky (2017) survey the extant literature on graduate education and call for more research at the intersection or “juncture” of graduation and employment. These scholars highlight gaps in the literature and recommend future research for deeper understandings of educational and career trajectories. John and Carnoy (2019) suggest research into hiring practices and conclude that policies must be developed to enhance hiring a diverse workforce. Universities have a role to play in the bridge between graduation and employment through faculty professional ties to the technology sector and the dialogues that inform the evolution of the curricula. These authors understand the social justice implications of the lack of diversity in the Silicon Valley technology workforce. Given California’s demographics, universities and technology firms must institutionalize diversity and inclusion (John & Carnoy, 2019).

### **Lack of Diversity in Silicon Valley & Implications for Society**

The California State University graduate disciplines of Computer Science and Engineering (CSE) at three Bay Area campuses experience a lack of diversity that parallels a lack of diversity in the Silicon Valley technology workforce. State legislation mandates the CSU to serve the region; furthermore, local academic senates affirm equitable and inclusive opportunities that prepare a diverse student body for the knowledge economy (ICF International, 2010). From this perspective, CSU in the Bay Area is vital, not only to broadening participation in, but to enhancing diversity of the knowledge economy workforce. The social impact of the lack of diversity in the technology professions results in less diversity in thought and imagination, and more homogeneity in this unique sector of the economy.

This lack of diversity has profound consequences for society at large; lack of diversity in the Silicon Valley technology professions results in end use infrastructures and information systems, digital media spaces, and software technologies that maintain a potentially biased status quo. We are only beginning to understand the implications of big data, its potential misuse, and the negative impact on various public spheres and contexts (Williamson, 2017). Furthermore, technology outputs and products are not scientifically objective, and biases of the designer may be expressed through outputs of the design (Benjamin, 2019). Lack of diversity as a problem becomes clear; a homogenous Silicon Valley technology workforce may design products that reinforce the dominant culture and maintain the status-quo. A multicultural democracy entrenched in technological comforts and instruments that transform all facets of our lives, is at risk with the lack of ethnic, racial, and gendered voice and imagination in the design rooms and boardrooms of technology firms that create such technology infrastructures.

Recent scholarship on the impact of big data may broaden an understanding of the social impact diversity issues in the knowledge economy and technology workforce specifically have on society and higher education itself. Technology firms such as Salesforce and Oracle build student information systems for higher education, a digital infrastructure for learning. Williamson (2017) claims that the higher education landscape is fundamentally altered by the big data impact, specifically educational data. The vast amounts of data collected throughout the student lifecycle is comprehensive and made to be available on any device at any time. Williamson (2017) states, “a new software layer has been superimposed onto the political layer of education in ways that are producing novel kinds of interventions and programs in the practice layer of the school” (p. 68). The big data enterprises and resulting data mining processes are not

unique to education, these phenomena are found in all spheres of public life. Representation in the design and decision rooms matter.

As big data impacts higher education, university administrators, faculty, and professional staff may not be appropriately trained to manage these vast amounts of data or cast a critical lens at automated patterns or process outcomes. Furthermore, Selwyn (2020) claims, “all data systems, processes and procedures are based on design decisions that have impacts that are determinative for society” (p. 2). Again, the designer or designers of such technologies are critical for the health of a multicultural democratic society. University administrators, faculty, and professional staff may not have appropriate understandings of the design decisions and resulting determinations. These technology outputs, seemingly objective and neutral, may not align with the mission and values of public higher education. Big data is shaping institutional values, and transforms “the question of what counts as a worthwhile activity in education into the question of what can be counted and of what account can be given for it” (Williamson, 2017, p. 75). In this view, data science and the tools higher education professionals use to capture the data are focused on reforms and efficiencies, not development of an educated, engaged citizen. Design decisions made by a homogeneous group may impact multicultural societies in negative ways.

Therein lies the contradiction: the CSU, a system built to serve marginalized and minoritized Californians is subjugated to technological infrastructure built by a workforce that does not resemble the student body and does not account for cultural nuance. A recursion of white male supremacy is unfurling through layers of technology. The adoption and integration of various software platforms, student information systems, and data processing technologies have transformed the higher education student service profession from outreach, recruitment, and

admissions, to advising, retention, and alumni relations, prioritizing data collection processes and managerialism over face-to-face student interactions (Williamson, 2017). Unintended consequences of technology outcomes are relevant to the discussion of lack of diversity in the Silicon Valley technology workforce and the lack of diversity in CSE graduate programs in the region.

The CSU is uniquely situated as a higher education institution to engage with Silicon Valley and broaden graduate education opportunities. California State University URM and female graduate students of CSE may bring different views and perspectives into the current workforce culture. Benjamin (2019) offers concrete examples of emerging technologies that reinforce bias and racism. This research is important to consider in the context of the problem of practice in CSU CSE graduate programs and lack of diversity in the region's knowledge economy.

Benjamin (2019) exposes the flaw in technologies that appear "objective scientific or progressive" such technologies "too often reinforce racism and other forms of inequity" (p. 2). Benjamin (2019) investigates a series of studies and summarizes her findings as the "New Jim Code" defined as new technologies that reproduce existing inequalities and discrimination.

Algorithms are the focus of this research. Benjamin (2019) offers an example of a team of computer scientists at Princeton University who researched a popular algorithm, human trained, to determine if it would exhibit bias, and found "white sounding names were coded as pleasant black sounding names as unpleasant" (p. 5). The design has reproduced discrimination in digital social spheres. Furthermore, Benjamin (2019) offers an account of "racist robots" or Artificial Intelligence (AI) judging a digital beauty contest. In this contest, AI judged contestant photos. AI deep learning, trained by humans, applied image recognition technology to user submitted photos. The results excluded "dark skinned" participants, and the majority of winners across age

groups were white (Benjamin, 2019). Moreover, algorithm design bias is seen in “automated risk assessments to determine the likelihood of a person committing a crime” (Benjamin, 2019, p. 82). Again, algorithms have implications for economic prosperity, particularly in the recruitment and hiring process, profiling candidates on names or other characteristics. Benjamin (2019) offers Amazon as an example, in October 2018, she states, “Amazon scrapped an AI recruitment tool when it realized that the algorithm was discriminating against women” (p. 142). Governor Newsom’s statement to the press “we need to talk about seats at the table,” upon signing AB 979, the diversity in leadership law, is relevant in this context (McGreevy, 2020).

Similarly, digital photography and imaging software technologies have potential for bias and discrimination. Benjamin (2019) critiques AI and facial recognition software and suggests a duality in potential problems. On the one hand surveillance software can specifically target black and Brown people. On the other hand, these technologies often just ignore Black and Brown people because recognition software does not adjust for variations in skin tone, thereby affirming whiteness as the standard. Benjamin (2019) argues that emerging technologies have potential for racist structures that, “not only marginalize but also forcibly center and survey racialized groups that are trapped between regimes of invisibility and spectacular hyper visibility” (p. 125). Benjamin argues that technology designers code judgement into the systems; bias of the designer is coded in judgements that shaped the design. The designer or design team matters when the social impact of these technologies infringes upon the rights and liberties of marginalized people.

The California State University mission and values suggest a social justice approach to engagement with government, economic and community stakeholders in the region. The case made by Benjamin (2019) is evidence as to why the Silicon Valley technology workforce must be diversified. The social implications are significant. From this position, the Bay Area CSU

campuses not only have an obligation to diversify the Computer Science and Engineering disciplines at the graduate level, but they also have the power and moral position to do so. The California State University must reaffirm its role in preparing a diverse, highly educated workforce demanded by Silicon Valley. Doing so may help to ensure that the software engineering, algorithms that underpin daily technologies that comprise the internet of things, and emerging artificial intelligences are representative of a multicultural democracy. There is a risk to reproducing structural racism, patriarchy, and white supremacy in the knowledge economy infrastructure and the digital spaces in which we conduct ourselves. If different cultures, ethnicities, races, and genders are not represented in the design rooms or board rooms, they will not be acknowledged or be as visible in the end products created by the software engineers in the design room.

### **Silicon Valley Survey**

The changing economic landscape of the Bay Area puts pressures on higher education institutions to ensure a student body representative of California's demographics graduate and realize a return on the investment in one's future, through an ability to compete for highly skilled, higher wage jobs (Scott & Kirst, 2017). Scott and Kirst (2017) present findings that sharpen the leaky pipeline argument, focus directly on the three Bay Area CSU universities. They survey the higher education landscape in the Bay Area from the 1970s to 2017 with particular attention paid to state universities. These scholars argue that state universities are not as strategically engaged with the Bay Area economy as they could be. The CSU could strategically position itself in educating CSE graduates to better compete for the over 400,000 technology positions in Silicon Valley at present, with 330,000 at the managerial or professional level (Scott & Kirst, 2017).

Scott and Kirst (2017) identify regional organizational fields composed of higher education and technology firms acting in coordination and in tension through a high degree of interdependence and locate the CSU campuses as actors in these fields. Tensions arise when public higher education institutions compete with each other for students and funding, corporate and government partnerships, conform to market forces, remain transparent to the taxpayer, and offer curricula that are relevant to the student. Student preferences nudge universities to establish unique brands and the California State University systemwide promotional and marketing materials attempt to brand an educational commitment to diversity and inclusion that is distinct in the country (Office of Public Affairs, 2019). The CSU data for general undergraduate student body composition is promising, but disaggregation by degree program and academic level, calls the brand into question (The California State University, 2021). The lack of diversity in CSE disciplines at the three CSU universities and parallel lack of diversity in the Silicon Valley technology workforce may be understood together through expanding research to fill gaps. Silicon Valley is an example of a post-industrial community, a leading knowledge economy that is both dependent on the region and local connections, but simultaneously and equally dependent on a global presence and global connections in those communities (Scott & Kirst, 2017). The California State Universities are charged with serving the regions in which they reside, and this charge requires focus on the lack of diversity in CSE education and the Silicon Valley technology workforce.

### **The Bay Area California State Universities**

San Francisco State University, California State University East Bay, and San José State University are broad access comprehensive institutions that espouse values of equity, diversity, and inclusion. These universities have the potential to mediate lack of diversity in the Silicon Valley technology workforce by expanding access to relevant graduate curriculum. Scott and

Kirst (2017) and their research partners set out to investigate how organizations in the higher education arena and Silicon Valley workforce connect and collaborate. Their research into public and private universities offers a comparative analysis of the three CSU campuses, and findings reveal various levels of intention in connectedness and collaboration.

Scott and Kirst (2017) analyze the complex interdependencies of higher education in the Bay Area economy, and argue higher education, corporations, and organizations share a common interest in the knowledge economy. However, the CSU is the only entity truly accountable, by democratic means to Californians. These case studies, juxtaposed with university mission and values statements on diversity and inclusion, amplify the need for research into the lack of diversity in both CSE disciplines and the Silicon Valley workforce. The mission and values statements published on university websites are aspirations to which the public should hold universities accountable. Simultaneously, the case studies presented by Scott and Kirst (2017) demonstrate how each campus differs in approach to finding its place in the Silicon Valley technology workforce.

Mission statements and values are guideposts for educational approaches to mediating the dilemma of lack of diversity in the Bay Area technology workforce. The San Francisco State University Academic Senate revised the university mission statement to reaffirm a historical legacy to equity and social justice in serving a diverse student body (Academic Senate, 2020). The academic department of Computer Science and the School of Engineering offer less pronounced iterations. The department of Computer Science commits to providing educational opportunities to all students (Department of Computer Science, 2020), while the director of the School of Engineering states these programs serve a diverse student body in a teacher, practitioner model (Siong Teh, 2020). In practice, Scott and Kirst's (2017) case study finds that



San Francisco State University administration and faculty struggled to develop connections to the local technology sectors and characterize this collaboration to be of lower priority.

This research suggests the university has not been as engaged and has not taken strategic advantage of its position within the city of San Francisco. An academic senate commitment to serving a diverse student body must lead to action that broadens opportunity to high wage, high skilled professional jobs, and academic departments and schools must implement strategies that mediate. Social justice in the contexts of higher education and social mobility in the Bay Area economy must include university action that deliberately recruits and supports historically underrepresented minority students through the graduate student lifecycle in CSE disciplines. San Francisco State University's department of Computer Science and School of Engineering may be very well positioned to develop stronger ties to those companies that have a specific need for training computer scientists or engineers in evolving technologies.

The California State University East Bay espoused values which support a diverse student body as they develop into contributors to society (Cal State East Bay, 2020). The CSU East Bay department of Computer Science emphasizes its size in comparison to other departments proclaiming diversity in both the student body and faculty. (CSU East Bay Department of Computer Science, 2020). The School of Engineering is less pronounced in mission and values proclamations but does characterize the school as a community dedicated to advancing the discipline. (School of Engineering, 2020). Unlike San Francisco State University, California State University East Bay did indeed strategically operationalize its position in the Bay Area. The university developed new programs in the mid-2000s to distinguish itself in the region, including civil engineering and construction management, and expanded biochemistry course offerings that become relevant in the biotechnology sectors (Scott & Kirst, 2017).

California State University East Bay administrators reported to Scott and Kirst (2017) that the current CSU Chancellor's Office curriculum review process is bureaucratic and slow, but investment in capital projects that improved campus infrastructure, such as laboratory space renewed approaches to teaching curriculum. The university simultaneously invested heavily in student recruitment efforts in Southern California and internationally. The progress achieved by California State University East Bay over this time was the result of nurturing interdependencies with organizations in the region (Scott & Kirst, 2017). As this institution progresses and integrates, it may be better positioned to support underrepresented minority students through graduate CSE programs and entry into the professions.

In the South Bay, San José State University declares itself to be "Silicon Valley's Public University" in its mission statement and claims to offer a transformative education in collaboration with the region's industries and communities (San José State University, 2020). Less pronounced in the San José State University mission statement are values of diversity and social justice. Similarly, the department of Computer Science forgoes diversity and inclusion proclamations and focuses on providing excellence in education (Computer Science, 2020). The department of Mechanical Engineering publishes a mission statement affirming the offering of relevant and current curriculum with an educational responsibility to the profession and the industry. Research findings suggest the College of Engineering is actively engaged in maintaining the immediate relevance of its curriculum, and when bureaucratic curriculum development slows, the college administrators made improvements in laboratory and learning infrastructures similar to CSU East Bay (Scott & Kirst, 2017). Scott and Kirst (2017) acknowledge San José State University's outsized role in preparing an educated workforce for the Bay Area technology industries; however, the research questions in this study become more

pressing for faculty, deans, and other administrators in the context of SJSU URM participation rates in graduate level CSE (The California State University, 2021). It is clear that San José State University is actively engaged with Silicon Valley; what remains unclear is the university strategy to expand graduate education opportunities for historically underrepresented students in the CSE disciplines.

Scott and Kirst (2017) position higher education institutions in the center of knowledge economy forces, a position that requires collaborative engagement between the professoriate, practitioners, and researchers, in curriculum redesign, innovation to remain relevant, and to distinguish themselves from other similar institutions. These strategies may be controversial for public institutions, but as state funding shrinks, such strategies become critical for survival. The Silicon Valley knowledge economy requires a highly educated workforce, and the California State University must fill that role. The case studies presented here find the degrees to which the Bay Area CSU universities engaged, vary. The three universities operate under a systemwide banner of inclusion and commitment to diversity, still each university differs in the intensity of concurring proclamations. Nonetheless, the California Master Plan of 1960 carved out a mission for the California State University that embeds the values of broad access and inclusion for Californians (Legislative Analyst's Office, 2005). The CSU has an obligation to broaden access and participation in computer science and engineering disciplines.

### **The Role and Mission of the California State University**

The Legislative Analyst Office (LAO) presented the role and mission of the CSU in preparing the California workforce in June 2005. This role and mission are enshrined in the state constitution and reaffirmed by the state legislature. The Legislative Analyst Office called on California's government to look beyond access and learning outcomes as the only indicators of academic success, and to broaden the definition to include adaptive skills for employment,

education that enhances opportunity for economic wellbeing, and in expanding broad participation in the California economy. The LAO, in its report to the Assembly, posed questions on the role of the CSU and the efficacy of its engagement with the California workforce, beyond degree completion (Legislative Analyst's Office, 2005). The LAO makes the case that the California State University, as an economic engine for the state, should integrate itself more closely with regional industries, adapt to change and enhance a student's transition from higher education to employment. From this vantage point, the three Bay Area CSU universities not only must ensure broad access and inclusive education but ensure students at the intersection of graduation and employment are prepared for opportunity. This includes access to a graduate education experience that leads to high wage Silicon Valley technology jobs.

### **The History of the CSU and the 1960 Academic Master Plan**

Donald Gerth (2010) offers a history of the California State University, responsive to communities and regions that started as teachers' colleges, and then morphed into state colleges alongside the post-World War II economic and population expansion. These emerging state colleges pushed boundaries on education programming they were allowed by the state to offer as the demand for higher education grew. The University of California asserted itself as the authority on higher education research and graduate education; however, the University of California practiced highly selective admission, particularly at the graduate level restricting access. The state colleges evolved in response to their regions in order to meet higher education demand left unfulfilled by the University of California selectivity. The University of California's struggle to maintain control over higher education research and graduate education ultimately led to the 1960 Academic Master Plan (Gerth, 2010). The institutions that emerged and evolved to eventually formed the California State University system. The mission and values of delivering

higher education to the broader population and access was more important than admissions selectivity.

In 1959, Governor Brown established committees to manage an Academic Master Plan for the State of California, legislation that would determine the unique roles of the University of California and the State Colleges and define which institution should oversee higher education research. The state needed more higher education institutions and junior colleges, but all stakeholders agreed that the path forward would need to be addressed by the legislature. Throughout legislator committee work and the public debate, California state colleges held a shared identity and commitment to accessible higher education. The California state legislature adopted a long view of higher education for the state and passed the Master Plan in April 1960; a voter approved constitutional amendment followed that November. The California State Colleges and board of trustees were enshrined in the constitution. The Academic Master Plan did not “policy manage” and the ambiguity of the Academic Master Plan policy arena for the state colleges, created the space for them to evolve into state universities (Gerth, 2010).

### **Who Attends the CSU?**

A mission of inclusion and diversity has been a part of the California State University system from its beginning. The look back at its history may inform future practice, particularly for the three Bay Area universities and the potential impact they have on mediating the diversity of the Silicon Valley technology workforce. Gerth (2010) situates the role and mission of the California State University in the story of its evolution, a patchwork association of normal schools and polytechnics that developed into a comprehensive university system, by meeting the challenge of expanding access and opportunity to more and more Californians. The answer to the question “who attends the California State University?” is what distinguishes the CSU system. From normal school beginnings, women dominated enrollment. As state colleges, university

administrators focused on middle- and lower-class enrollment, then expanded minority student enrollment after the adoption of the Academic Master Plan in 1960. The Equal Opportunity Programs (EOP) that exist on each campus today were established in the mid-1960s; activism of the 1960s and 1970s helped shape the diversity of the California State University (Gerth, 2010).

Higher education administrators and faculty established an official director of affirmative action appointed at the Chancellor's Office level. The California State Legislature asked for a plan to mitigate ethnic and lower socioeconomic status underrepresentation on campuses. The creation of a systemwide task force on Student Affirmative Action in 1977 resulted in focused recruitment and admissions of historically underrepresented students. The CSU embraced a practice of holistic review of admissions applications, created a task force for Hispanic students, developed affirmative action recruitment plans, and served the middle and lower class. The California State University seemingly marched on unaffected by the November 1996 voter approved Proposition 209, prohibiting all government agencies and institutions from giving preferential treatment on the basis of their race or sex (Gerth, 2010). The CSU proceeded in student recruitment with a commitment to diversity. When Chancellor Reed assumed his role in 1998, he "initiated Super Sunday" where he and his colleagues would speak about the importance of higher education in predominantly black churches. This history provides a road map for navigating future challenges of expanding the education pipeline, particularly in graduate CSE disciplines.

The 2019 CSU Factbook enrollment data indicates that system-wide, more than 60% of the student body is composed of underrepresented minority students (Office of Public Affairs, 2019). This system-wide data is impressive, but the disaggregated data reveals problems in practice at the three Bay Area universities. Underrepresented minority student participation rates in graduate

education do not match those rates at the undergraduate level and decrease further in the CSE disciplines (The California State University, 2021). From the Chancellor's Office in Long Beach, the mission of the California State University is to advance knowledge, learning, and culture. The CSU provides opportunities for students to develop intellectually and professionally through accessible education (The California State University, 2020b). The California State University claims it "seeks out individuals with collegiate promise who face cultural, geographical, physical, educational, financial, or personal barriers to assist them in advancing to the highest educational levels they can reach" (The California State University, 2020b). The CSU affirms a commitment to historically marginalized student populations and encourages campuses to embrace the distinctiveness of their regions. The three Bay Area universities, San Francisco State University, California State University East Bay, and San José State University must heed this charge in the context of equity in opportunity for Silicon Valley professions.

### **Case for Graduate Education**

Higher education is a pathway to social mobility; furthermore, graduate, and professional education is increasingly required for entry into knowledge economy workforce or career advancement and has the potential to expand opportunity for those who are able to access (John & Carnoy, 2019; Posselt & Grodsky, 2017; Scott & Kirst, 2017). There are gaps in the extant literature on graduate education and its impact on student and professional development. Posselt and Grodsky (2017) view graduate education through social stratification theories and raise questions on its role in social mobility. They identify gaps in the literature on graduate admissions practices and direct inquiry into "key junctions" of graduate admission application submission, the selection process, enrollment and retention, and eventual employment (Posselt & Grodsky, 2017). Focusing graduate education through the social stratification lens is important because potential for economic and professional opportunities for advanced degree holders are

significant. The CSU incorporates this perspective in the 2010 impact report (ICF International, 2010). The CSU role in addressing uneven economic opportunities in the Silicon Valley knowledge economy provides justification for focusing on social stratification and the role of graduate education. Furthermore, the types of professions available to graduate degree holders look significantly different from those that do not. Posselt and Grodsky (2017) present data that suggests increased earning potential for graduate degree holders over bachelor's degree holders. Graduate degree holders gain social mobility with an increased earning power and are better positioned to influence workforce culture.

Issues of inclusion and diversity in graduate education are raised, Posselt and Grodsky (2017) argue that participation in graduate education is overrepresented among wealthy Americans. Research on graduate education that attempts to increase our understanding of pathways to graduate education may lead to an understanding of who holds power in this country, an understanding essential for democratic institutions. Their argument aligns Bourdieu's concept of "trajectory," in which one's pathway to a career is closer to social origins than it is to graduate academic pursuits. Wealthy are afforded more access to graduate education; however, these researchers argue, graduate education masks one's privilege. Suddenly, their wealth and privilege are characterized as the result of graduate academic pursuits, not as a result of social origin. In these moments, those who had access to graduate education and resulting professions, can engage in closure of the profession. Closure in this sense means those on the other side of entry into graduate education or profession get to determine who else joins (Posselt & Grodsky, 2017).

Further research into the graduate and doctoral selective admission process may sharpen our understanding of how the academy determines who participates in advanced education. Higher



education becomes part of the social stratification problem. Graduate admissions, in Posselt and Grodsky's (2017) view, is used to create a community of likeminded individuals. In other words, graduate admission selection is work that will keep the habitus of the status quo of an academic discipline intact at the graduate level. They argue in favor of future research into graduate admissions and the faculty decision process. Posselt and Grodsky (2017) suggest that graduate school administrators recruit, and conduct outreach aimed at increasing minority and women participation, but the selection committees in the disciplines are not in sync with institutional missions as they render admission decisions. They argue for increased coordination of administrators and faculty in the recruitment and admissions endeavor. Posselt and Grodsky (2017) argue against the "leaky pipeline" metaphor, in favor of an institutional climate that becomes a proxy for social and cultural capital development. Research into this proposition may be centered in the graduate student experience.

The historically marginalized student experience within the academy is an emerging area of research, but gaps remain. Academic survival and persistence rates may be amplified when institutions work to develop cultural, social, and educational capital of their student body. Posselt and Grodsky (2017) locate this stratification across gender, race, and ethnicity in graduate and professional degree attainment. Their call for more research on the graduate student lifecycle is warranted. Graduate education is a field in need of study, particularly in the graduate student lifecycle, the cultural and social capital bestowed on students through degree attainment and the role graduate education plays in social mobility (Posselt & Grodsky, 2017).

### **Graduate Education in the CSU**

The California State University statewide academic senate formed a 2005 task force to develop a policy statement on the role of graduate education in the CSU (Academic Senate, 2004). This policy statement positions the task force argument for increased investment in

graduate education in the context of the state's highly specialized knowledge economy, its demographic diversity, and interdependencies of "economic and social forces" (Academic Senate, 2004, p. 5). The task force recognized the CSU role in ensuring prosperity and quality of life of its graduates and a moral obligation to economic, social, and environmental spheres that intersect with the university (Academic Senate, 2004). Graduate student alumni should enter professions prepared to lead ethically, and with opportunity for an improved quality of life. The Academic Senate task force characterizes CSU graduate student alumni as leading "in the social, public and cultural life of California" (Academic Senate, 2004, p. 38) and affirm the institutional role in responding to the growing technology sector by highlighting successful graduate programs.

Nevertheless, current CSU institutional data on URM participation, and gender imbalance in CSE graduate education suggests prior policy recommendations may not be fully realized. This data suggests a less diverse student body in the disciplines that lead to Bay Area knowledge economy professions (The California State University, 2021). There is opportunity to increase equity and diversity in graduate education at the three Bay Area campuses in CSE disciplines. The Bay Area CSU campuses are situated at the nexus of a knowledge economy, integrated with information technologies, and fueled by innovations in computer science and engineering. A critical approach to understanding the graduate student lifecycle, barriers, or deterrents to participation, through the experience of URM and female graduate students may shape university reform. The 2004 senate task force claimed the CSU system is positioned to assume this role (Academic Senate, 2004).

## **Graduate Admissions**

In practice, the California State University enrollment data in CSE disciplines highlights significant decreases in URM participation in graduate education (California State University, 2020), compared to undergraduate participation; however, educational research into the phenomenon of the graduate admissions process is lacking (Posselt & Grodsky, 2017). Educational research into the phenomenon of the graduate admissions process is lacking. Denecke (2004) analogizes graduate education administration to the federalist model of government, where the university graduate school establishes baseline standards and enrollment goals, and academic departments tailor baseline standards to specific disciplines. However, the graduate school defers to academic departments in the selection of students to determine who fit within the mission and research goals of a graduate program. The California State University, through Title 5 Education Code, affirms equivalent governance of graduate education. The California State University graduate admission process is somewhat selective and graduate programs generally only offer spots in programs to the top 33% of California students (Gerth, 2010). Selectivity in graduate admission is subjective and contested; in some instances, selectivity is contested in courts.

The Council of Graduate Schools cautions on the potential for legal issues to arise in the graduate admissions process, due to the selective nature. The CGS recommends institutional best practices that include transparency in established admission criteria and the review process. (Denecke, 2004). The Association of Graduate Enrollment Management affirms institutional transparency as a best practice in graduate admissions (NAGAP: Association for Graduate Enrollment Management, 2019a). The Council of Graduate Schools invokes the 1957 case *Sweezy v. New Hampshire*, where the United States Supreme Court recognized the university right to select students as long as transparency existed in the decision process (Denecke, 2004).

Professional associations of graduate faculty, deans, and university administrators call for transparency in the selection process, still little research exists in this area.

Graduate admissions is defined as “boundary work” by Posselt & Grodsky (2017); located in this boundary is the habitus of an academic department or university. The habitus consists of research and scholarly norms, local cultures, or practices and discourse that are otherwise inaccessible unless selected in. Higher degrees of social and cultural capital influence an individual’s point of entry into graduate school and become important in navigating the academic department climate throughout the degree program. Generalizable research on graduate education admissions practice is difficult as disciplinary cultures, practices and institutional norms vary (Posselt & Grodsky, 2017). However, practice specific research into the three Bay Area university CSE disciplines may reveal patterns of experience or trends that broaden our understanding of the CSU, its role in the lives of graduate students, and its integration with Silicon Valley industries.

Promising research into the standardized test feature of graduate admission is emerging, particularly in the science and technology disciplines and health professional programs. These researchers identify standardized tests as barriers to graduate study (Levesque et al., 2015; Sealy et al., 2019; Wilson et al., 2019). Posselt and Grodsky (2017) situate the GRE debate in biases against the URM student, as do others. Research indicates a stronger relationship between a student’s undergraduate GPA as a predictor for graduate student success over the GRE, although some researchers argue the GRE is still a useful measure in admissions (Benham & Hawley, 2015). Nevertheless, professional organizations continue to advocate for a holistic review model and echo educators who value social justice, equity, and inclusion (Denecke, 2004; NAGAP Association for Graduate Enrollment Management, 2019b).

A general consensus among the professoriate in science and technology is coalescing around the need for diversity in graduate STEM education to ensure a robust highly skilled science and technology economy workforce (Levesque et al., 2015; Sealy et al., 2019). Issues of diversity in graduate education participation require in-depth study on the impact the GRE may have on access and participation across gender, race, and ethnicity (Pacheco et al., 2015). As educators raise issues of diversity in graduate education, particularly in science and technology, they also raise questions on the utility of the GRE exam. Researchers continue to suggest limited correlation between high GRE scores and academic success of graduate students in health care and science and technology disciplines (Sealy et al., 2019; Wilson et al., 2019). All three Bay Area CSU university CSE graduate programs require the GRE exam at the point of application submission. Continued research into the utility of the GRE in admissions may influence graduate faculty decisions to discontinue the use of this test in admissions.

### **Intersection of Forms of Capital, Habitus & Campus Climate**

#### ***Critical Theory and Power Issues in Higher Education***

Education research into the self-efficacy of URM and female graduate students within an academic discipline among the graduate education community is emerging in response to diversity, inclusion, and equity initiatives, as well as campus climate reform. Critical theory underpins much of this discourse and provides a framework for understanding unequal power structures in higher education institutions. Apple (1979) critiques inherent power imbalances in education, unequal power relations URM graduate students in STEM fields negotiate through graduate student life. Apple (2001) argues that educators do not act outside unequal institutional arrangements and dominant disciplinary knowledge paradigms; however, a critical theory lens focused on institutional reform may uncover institutional structures that perpetuate power.

Moreover, Figueroa and Hurtado (2013) counter deficit-based descriptions of URM student experience with critical theory to “frame the challenges that URM graduate students encounter at predominantly White institutions as social, structural, and institutional” (p. 7). A Critical Theory lens incorporates Bourdieu’s (1984) concepts of social and cultural capital, and habitus as a frame to the URM graduate student experience. Furthermore, this lens and frame are expanded by concepts of community cultural wealth, campus climate, sense of belonging, and campus health as a method for understanding URM and female graduate student life (Dodson et al., 2009; Ledesma, 2019; Pascale, 2018; Yosso, 2005).

Higher education research on diversity, inclusion, equity, and campus climate build on Bourdieu’s theories of social and cultural capital and habitus. Bourdieu’s theory established a baseline understanding of student entry into graduate education and student attributes that underline persistence at intersections of ethnicity, race, and socioeconomic status (Cole & Espinoza, 2008; González, 2006). Bourdieu (1984) critiques social class, personal agency, and the self-reinforcing structures in society through these concepts. Through his work, Bourdieu identifies symbolic power that dominant social groups use in the reproduction of the status quo (Rojek & Cashmore, 1999). Application of Bourdieu’s social theory to education research into URM student outcomes is useful; however, such application is often from a deficit-based stance.

However, Yosso (2005) reconceptualized Bourdieu’s assumptions of social and cultural capital as they are valued in a hierarchical society. Yosso (2005) repositions the concepts of social and cultural capital from the White, middle-class culture as the standard from which to measure the URM student experience; toward community cultural wealth or an asset-based lens. Bourdieu and Yosso are critical to the discussion herein. An understanding of the student experiences in the academy through the concepts of social and cultural capitals, and habitus, and

concludes with pivot to community cultural wealth and argument for an asset-based approach to educational research into successful URM and female graduate students at the three Bay Area CSU campuses.

Campus climate and sense of belonging are central tenets of equity and social justice in higher education. From this perspective, Bourdieu provides a framework for linking these concepts to social and cultural capitals students may or may not bring to the graduate education experience. Higher education institutions may restructure student services and campus support systems in ways that optimize student potential to develop in these areas. The ways of being in any given field or social system define the habitus of that particular field or social system (Bourdieu, 1984). Understanding the habitus of a graduate program or academic discipline, its impact on graduate students, is necessary if one intends to understand the overall campus climate. Those students with higher degrees of social and cultural capital are more likely to gain access to and navigate the graduate student landscape and thrive versus those students historically marginalized. A campus climate that is not perceived to be inclusive, may become a barrier or deterrent to participation in graduate education. One's sense of belonging is understood in these terms. However, institutions that are intentional in developing an inclusive campus, may mitigate these issues. Bourdieu's theories of habitus and social and cultural capital provide a framework for the critique of inclusive practices or may help to identify ways in which academic departments unintentionally or intentionally close the discipline to the underrepresented minority graduate student.

Cole and Espinoza (2008) highlight higher education as pedagogically organized around the dominant culture and invoke Bourdieu in their study of academic success of Latinx undergraduate students in STEM majors. These researchers argue a higher degree of cultural

capital lends to successful campus assimilation. This study is situated in the context of predicted Latinx population growth, a disparity in access to and persistence through STEM programs, and a theoretical framework of cultural capital, and congruity with campus climate. They conduct statistical analysis on student survey data to explore Latinx students in STEM experiences with peers and faculty. Cole and Espinoza (2008) find that students with less cultural capital, defined by parental education levels and high school GPA, are more likely to struggle. However, social networks and positive faculty mentor relationships led to persistence in STEM and the researchers conclude that the faculty-student relationship requires more attention and research (Cole & Espinoza, 2008). This study is transferable to an understanding of the graduate student experience, where degrees of capital may enhance academic success due to the close graduate faculty mentor relationship one may develop through a program. Integration of Yosso's (2005) concept of community cultural wealth helps to expand the concept of capitals and moves us away from a deficit research lens. This research study of the three Bay Area CSU university graduate CSE students may add to an understanding of various forms of capital and subsequent impact on academic success.

Graduate faculty in the computer science and engineering disciplines at each of the three Bay Area CSU universities straddle the academic and applied sides of these disciplines. They hold degrees of capital that have shaped their adoption of the habitus in both arenas. For Bourdieu, the habitus is a self-reinforcing structure that maintains the status quo or a degree of homogeneity (Bourdieu, 1984). Research into the organized practices of academia specific to the departments or schools of computer science and engineering is lacking in a robust way in the extant literature. Research into how URM and female students experience graduate education within this framework may inform interventions to increase enrollment and degree attainment in CSE.



Issues of workforce diversity and its companion “leaky pipeline” in the education pathways argument, intersect with the habitus of the academy, where the habitus or campus climate may be a barrier or leak in URM and female participation.

### ***Social and Cultural Capital in Higher Education***

Education research attempts to understand the lives of historically underrepresented minority and female graduate students and their academic socialization (Cole & Espinoza, 2008; Dodson et al., 2009; González, 2006; Pascale, 2018). This research is limited. Bourdieu’s concepts of habitus, social and cultural capital, again provide a framework through which to view student experience. Underrepresented minority and female students access levers of social mobility through the hierarchy of education, and accessible public institutions are critical. Academia and the graduate school experience are sites of inquiry with which to view habitus, and the underlying structures, hierarchies, and cultures that may be self-perpetuating and self-reinforcing with each new incoming class, and URM and female students may struggle more than peers in this environment.

Bourdieu critiques higher education qualifications as a route to social mobility, nonetheless he maintains that success in social mobility is dependent on social origins. Social class is not defined by property, race, or socioeconomic status, as we tend to view it. Instead, according to Bourdieu, social class is a construct (Bourdieu, 1984). Interdependent forces are at work in the social construction of class through higher education, the qualifications earned, and the possibility of social mobility, however selective graduate admission may be. Bourdieu’s concepts of social and cultural capital sharpen the focus on the student access to, and participation in graduate school. Those graduate students with more social capital or cultural capital are likely to be more successful in degree attainment and entry into knowledge economy professions. Higher education institutions charged with equity and inclusion missions may be

successful in implementing support systems that mediate any lack of capital and develop it through a degree program.

### *Academic Socialization in Graduate Programs*

González (2006) studies the ways in which Latina doctoral students experience academic socialization in U.S research institutions, and findings identify structural problems with support systems. A phenomenon of resistance to culturally unresponsive academics, and the struggle to find one's academic voice are recurring themes throughout this research. He focuses his research on how academic socialization contributes to the success or failure of the student. González (2006) argues that the status quo in higher education, particularly graduate education, remains static. Social and cultural capital in the context of graduate school, act as currency that enables holders to access higher education and be successful in the academic socialization of the discipline. Those students who possess higher degrees of social and cultural capital are more likely to participate and succeed. González identifies characteristics to success in graduate school that include family and mentor support, and strong cultural backgrounds. González findings resemble the concept of community cultural wealth offered by Yosso (2005). He identifies challenges such as lack of financial support, discrimination based on race, class and gender, isolation from family, and perceptions of hostile academic environments (González, 2006).

Furthermore, González' (2006) research uncovers the flow of social and cultural capital in the habitus of the academy and declares a need for university-wide adjustments to support models to mediate academic struggle. González' findings are similar to those of Cole and Espinoza (2008), whereas strong academic department support was shaped by faculty mentors, and included research opportunities, teaching assistantships and participation in professional organization conferences. A reflexive academic department could deliberately intervene in the graduate student experience to accommodate diverse ways of being in the academy, while

creating a more inclusive graduate school experience. Gonzáles also identifies the negative aspects of doctoral studies to include, experience with racism, a Eurocentric curriculum, and negative faculty mentor relationships. The students in Gonzáles' study demonstrated difficulty adapting to the social and cultural norms of the academic department. Although these students understood the need to fit into a habitus or climate that did not match their lived experience, they expressed an unwelcoming environment. Academic socialization is an area of concern for higher education administrators mediating issues of access, equity, and retention in graduate education.

A consensus is building on the integral role the graduate student faculty mentor plays in the mediation of the graduate student experience. Brunσμα et al. (2017) reviewed 80 studies on mentoring to better understand graduate school socialization and to improve mentoring of graduate students of color. These researchers conduct an analysis through the discipline of sociology and acknowledge a gap in research into factors that shape the graduate school experience for students of color. This gap, they argue, must be filled by multiple methodology and research angles (Brunσμα et al., 2017). Similar to Cole and Espinoza, these researchers raise questions on experiences that invalidate the self and note a 50% attrition rate for majority students, a 70% attrition rate for historically marginalized students (Brunσμα et al., 2017). Funding, mentoring, curriculum, social networks, faculty support, and campus climate are features of graduate school that, when delivered ethically and compassionately, enhance the academic success of graduate students of color. Good mentors care, develop productive relationships with advisees, provide space for research, publishing, and networking. Each of these components of the graduate school experience are likely to enhance a successful transition to a profession or the professoriate. Brunσμα et al. (2017) calls for training programs to develop

mentors who see their role in student development, in nurturing professional networks, and creating a department climate that is sensitive to diversity and inclusion.

Amplifying the argument for inquiry into graduate education, Pascale (2018) claims that administrators concerned with diversification of the graduate student body and of the professoriate must develop students' sense of belonging. For Pascale, measures of habitus, social, and cultural capital, were important variables in choosing to attend and to successfully complete graduate school. Answers to questions of habitus, social and cultural capital in praxis in the classroom, in the lab, on the campus, or within a cohort may shape institutional policy and practice. Pascale (2018) argues that successful academic socialization matters in graduate school. University administration and faculty who intentionally intervene to disrupt the organizational structures that maintain a dominant habitus of an academic department may be more successful in improving the experience of the historically underrepresented minority or female graduate student.

Further research focuses on mentoring students from communities and cultures that have been traditionally excluded from organization of the academy and offers evidence in support of intervention. Dodson et al. (2009) locate progress in the U.S. Civil Rights Movement in terms of access and claim that improvements to graduate education must enhance the underrepresented minority graduate student ability to thrive. Dodson et al. (2009) offer evidence of an effective mentoring and socialization program and advising models that disrupt through a deliberative transformative approach. These researchers argue the need for an intentional critique and intervention of the habitus of an academic department or campus. These ten yearlong studies at two public universities in the west and Midwest, yielded results. In general, successful mentoring programs are characterized by faculty and student collaboration in scholarship, research, group

work, and professional conferences. The intentional disruption of the habitus of academic in this research, through treatment that consisted of strong mentoring programs, led to average GPAs greater than 3.8, more than one-third of students participating in research opportunity programs, and more who received competitive fellowships and scholarships (Dodson et al., 2009).

### ***University Role in Campus Climate Reform***

Bisecting Bourdieu's theory of habitus and social and cultural and economic capitals is his concept of trajectory within a particular field, or professional route to social mobility. Bourdieu views the privileged as having arrived at their trajectories end, not by hard work and perseverance, but by the benefit of substantial social origins and resources. Those individuals with a high degree of social and cultural capital arrive at this end with ease. Nevertheless, graduate education offers a trajectory into a knowledge economy profession. In the areas of trajectory, the academic departments of computer science or schools of engineering can work to become surrogates for the social origins that guide a successful trajectory of historically marginalized students into the high wage technology professions of the Silicon Valley workforce. It is incumbent on the three Bay Area comprehensive universities and administration to mediate the habitus of the academy directly, and through local, professional, and regional ties, mediate the habitus of the profession indirectly, so much so that the space is cracked open to allow for successful trajectories of those students who may not successfully enter the profession at the juncture of graduation.

Concepts of habitus and social and cultural capital scaffold our view of the challenges graduate students and university administrators face in the call for diversity and inclusion. Researchers in this area urge policymakers to respond with intervention strategies that disrupt the negative consequences of academic socialization. Furthermore, they urge an inclusive habitus of an academic department that develops graduate student social and cultural capital required for

the professoriate or professional life. Academic socialization and mentoring models are evidence that intentional disruption can result in successful outcomes. University administration can improve curriculum, co-curricular and professional activities for graduate students through direct engagement with the student body and student voice.

The three Bay Area California State University campuses play a critical role in the preparation of the Silicon Valley technology workforce and future leaders in the knowledge economy. The California State University espoused values require our attention. Interventions at various points in the graduate school experience are identified through research findings obtained by the research questions presented in this study. Advanced degrees lead to careers in the knowledge economy, and the California State University can demonstrate a commitment to equity and social justice that includes ensuring its graduates have access to opportunity in the prosperous areas of the Bay Area economy. These universities can demonstrate cultural humility through culturally responsive curriculum, inclusive pedagogy, multiple means of engagement and multiple representations throughout a graduate career. The CSU system can continue to improve and shape its own campus climate and usher in a paradigm that negates an imposter syndrome and develops one's academic acumen, scholarship, and professional networks. The California State University has a responsibility to mediate equity.

Bourdieu is concerned with the role of social class and culture in social reproduction and unequal power relations that go uncontested in daily life. Symbolic power, in the form of social or cultural capital, performed in socially structured spaces with rules of engagements - habitus - is granted in large part by class or inherited position in society, and circulated through social structures in cultural reproduction (Johnson, 1994). Yosso (2005) provides asset-based language expanding our view of Bourdieu's concept by defining aspirational, linguistic, familial,

navigational, and resistant capitals, in addition to social capital. These capitals are understood as community and peer networks. Bourdieu's theory on hierarchical society and social reproduction is used by educators to explain uneven academic and social outcomes for URM students (Yosso, 2005). Yosso (2005) argues that “schools most often work from this assumption in structuring ways to help ‘disadvantaged’ students whose race and class background has left them lacking necessary knowledge, social skills, abilities and cultural capital” (p. 70). Yosso challenges educators to see beyond a perceived deficit lens and understand different talents and backgrounds that influence aspirational success. Understanding individual strengths each student brings to graduate school is central to equity and inclusion. Graduate faculty and administrators may develop co-curricular programming complementary to these strengths, rewarding these strengths, and developing deeper ties to the community at large. Identifying strengths that allow a student to cope, resist, or thrive, are the purpose of this research study. The concluding section of this literature review analyzes the graduate student aspirations for and experience in graduate school through education practice informed by social and cultural capitals and habitus.

### ***Inquiry of Graduate Student Participation in STEM Disciplines***

Contemporary higher education research attempts to understand the graduate student experience at intersections of race, class, and gender from a critical theory lens in the context of power dynamics and structural barriers within disciplinary norms of academic departments (Apple, 1979; Apple, 2001; Figueroa & Hurtado, 2013; Posselt & Grodsky 2017). The extant literature on graduate student diversity and inclusion is analyzed through normalizing practices of STEM graduate programs, academic department cultures, and disciplinary research paradigms. This research reveals the effect of social and cultural capital or “community cultural wealth” on graduate school aspirations, persistence to degree completion, and resiliency in

discriminatory or marginalizing contexts (Burt & Johnson, 2018; Charleston et al., 2014; Fernandez et al., 2019; Figueroa & Hurtado, 2013; Griffith, 2010; Posselt et al., 2017; Posselt & Grodsky, 2017; Singer et al., 2020; Stachl & Baranger, 2020). These educational researchers situate the significance of diversity and inclusion in STEM graduate fields in contexts of national security, global economic competition, social mobility, and social justice (Burt & Johnson, 2018; Griffith, 2010; Figueroa & Hurtado, 2013; Posselt, et al., 2017; Posselt & Grodsky, 2017; Stockard et al., 2021). The arguments for diversity and inclusion in graduate education coalesce around the societal consequences identified by Benjamin (2019) and Williamson (2017) that arise from lack of diversity in the STEM workforce.

The recent scholarship presented here focuses on diversity in STEM field graduate programs and offers insight into the underrepresented minority (URM) and female graduate student experiences that are relevant to Computer Science and Engineering disciplines. Although this research is anchored by the concepts of social and cultural capital, the habitus of a graduate program, and campus climate in general, the research findings presented here narrow in on specific factors and perceptions characteristic of URM and female graduate student life in STEM disciplines. These educational researchers adopt a position that “graduate school is an increasingly critical part of the American opportunity structure” (Posselt et al., 2017, p. 2), and that graduate education is one way to diversify STEM fields. Diversification of the STEM fields of Computer Science and Engineering (CSE) in the context of the Bay Area region is of interest to the California State University. A more diverse graduate student body may result in professionals and leaders who then influence cultural change in the STEM professions, the professoriate, and CSE in the region.



Education researchers attempt to broaden our understanding of barriers to, or reasons that may deter underrepresented minority (URM) and female graduate students from pursuing graduate school in STEM fields. This group of scholars acknowledge that so few Black/African American, Hispanic, Latinx, or Native American students enter graduate study; they represent uniqueness in graduate education. Moreover, as these scholars attempt to understand the URM and female student experience through the STEM graduate student lifecycle, critical themes emerge in analysis of their research findings. While the current literature on URM and female graduate student life explores intersections of race, class, and gender on participation; it converges around six recurring themes: 1) structural barriers; 2) identity formation; 3) community cultural wealth; 4) peer networks, 5) faculty mentors; and 6) institutional funding opportunities. These six themes are discussed in detail in the proceeding sections of the literature review.

### ***Structural Barriers***

A critical understanding of structural barriers that underrepresented minority (URM) and female students encounter in graduate education aspirations is foundational to institutional reform focused on diversity and inclusion in STEM Computer Science and Engineering graduate programs. Figueroa and Hurtado (2013) reiterate how such “structures reinforce racial inequities, social hierarchy, and White privilege” (p. 5) in the academy. These structures create intangible barriers that manifest as deterrents to graduate education pursuits. These deterrents are experienced at undergraduate stages of the higher education experience. Posselt et al. (2017) identify “cultural boundaries,” as prospective student assumptions or interpretations of STEM disciplines as individualist and competitive. The prospective student in this scenario is an aspiring undergraduate, and assumptions manifest as potential deterrents for URM and female

students, particularly because these assumptions are often in opposition to cultural backgrounds that many bring to higher education.

Furthermore, these researchers understand an academic department at the graduate level to be distinct from the undergraduate level, where normative processes, disciplinary theory, research paradigms, faculty mentorship and peer relationships act on the individual (Charleston et al., 2014; Eagan et al., 2014; Posselt et al., 2017). These normative processes create barriers that may go uncontested and otherwise work to dissuade individuals from pursuing an advanced degree, even early on in an undergraduate career. Burt and Johnson (2018) offer qualitative data that suggests the normative practice of undergraduate “weed out” courses materialize as barriers or deterrents to graduate education. This sorting of students creates deterrents that are realized early in one’s academic career. Burt and Johnson counter that such courses could be restructured to minimize barriers, to build “foundational knowledge” (p 259) that instills confidence to pursue graduate education. Similarly, Xu (2016) presents research that suggests the normative processes of an academic department may derail undergraduate student ambition for graduate study thus breaking the “pipeline” at the undergraduate level.

Posselt et al. (2017) finds a “common cultural boundary” that “assumes a Bordieuan perspective” on reproduction of the status quo in graduate education. (p. 5). This graduate education boundary privileges a social capital that resembles what is contained by the boundary and will develop a similar social capital for those students within the boundary. From this perspective graduate programs simultaneously privilege those incoming students who possess the right amounts or types of social capital aligned with the academic department habitus, or climate determined through the admission process. Eventually, the academic department will impose discipline specific social capitals onto the students through mentorship, research, and

disciplinary theories or paradigms. This study uncovers how an academic department may transgress the normalizing practices through critical reflection and awareness.

Furthermore, this research team operationalizes culture as shared “assumptions, norms, logics” that are found in graduate programs at a “nexus of universities, departments, and disciplines” (Posselt et al., 2017, p. 6). These uncontested norms and social processes create a symbolic boundary that results in inequalities in access (Posselt et al., 2017). The research team’s year-long study suggests that a “rethinking of the best students” by subordinating the GRE score at admission, to other graduate school application attributes such as portfolio work, and intentional recruitment efforts through department relevant affinity groups, such as industry or professional organizations. Academic department administrative staff support, strong faculty mentorship and liberal use of a “family metaphor” aided student success in this study (Posselt et al., 2017). A deeper understanding of structural barriers at entry points into graduate school, or deterrents, may aid higher education reformers interested in diversity and inclusion in STEM graduate programs.

### ***Identity Formation in STEM Disciplines***

Development of the scientist identity early in academic life and reinforced in the undergraduate experience is an essential factor that influences graduate education aspirations in STEM fields. Because the underrepresented minority (URM) and female graduate students who are successful in their academic achievements become role models for others, Posselt et al. (2017), attempt to move “the conversation about educational equity forward by learning from the positive examples that exist” (p. 3). The positive examples that do exist help shape identity in STEM fields. Similarly, Burt and Johnson (2018) present an “anti-deficit depiction” (p.258) of student participants in their study on the Black graduate engineering student experience. These scholars, similar to Posselt et. al, analyze scholarship that explores an early interest “advantage”

in the development of a scientist identity (Burt & Johnson, 2018). The science identity, integrated with the Black identity in formative years are factors identified by URM students in Burt and Johnson's (2018) study that led to graduate school pursuits.

Identity formation throughout one's academic career is associated with aspirations for graduate education attainment in STEM disciplines. Griffith (2010) presents findings from research on National Center of Education Statistics and National Educational Longitudinal Studies data sets that affirm the importance of scientist identity development early on. Students who had opportunity to engage in science AP classes in high school, a first semester university course, or even a first-year experience at university that developed scientific understandings were more likely to pursue and persist in graduate education. Griffith (2010) identifies the sophomore year as an educational milestone, often the year students are required to declare a major. Griffith (2010) states, "student experiences during their first two years seem to have the most significant impact on their decision to persist" (p. 917) in STEM fields. While higher education may not be easily reconfigured to affect scientist identity in high school, it is uniquely positioned to redevelop the first-year experience and offer substantial student support in the first two years of study. Educational researchers suggest that students must see themselves as emerging scientists and researchers to successfully cross the boundary into graduate school. Furthermore, Singer et al. (2020), argue that the STEM identity is a powerful indicator of one's potential for success in education. Faculty and student support services are cultural boundaries that could be restructured to foster the development of a science identity as one institutional strategy to broaden participation in graduate programs.

The lack of diversity in STEM graduate disciplines itself has a regressive effect on diversity and inclusion efforts. Singer et al. (2020) argues, "historically, however, STEM identity

formation for underrepresented students has been hampered by the lack of representation in STEM fields, which predominantly consist of white males” (p. 2). The lack of diversity among faculty, translates to the lack of diversity of the graduate student pipeline. Underrepresented minority students may struggle to see themselves as scientists and researchers through the undergraduate student experience. Griffith (2010) presents findings in agreement with Singer et al. and suggests that women and URM students in STEM are at a disadvantage at institutions that lack a diverse professoriate in the STEM disciplines. Composition of the faculty has an impact on persistence rates of women and URM students in STEM.

Moreover, Charleston et al. (2014) identify cultural barriers that shape one’s identity as a scientist or researcher. These researchers suggest exposure to technology early on may shape students’ perceptions of their own scientist identity. From this perspective, higher education interventions early in an undergraduate career may include exposure to technologies that may foster intellectual curiosity and aspirations for graduate education. Educational researchers claim academic identity formation early remains a factor that influences decisions to participate in STEM graduate programs. (Charleston et al., 2014; Singer et al., 2020). Students who view themselves as emerging scientists in undergraduate studies are more likely to persist in graduate school. Charleston et al. (2014) study the impact of culturally relevant pedagogy theory (CRPT) on student achievement in the STEM field of computing sciences; and decisions to pursue STEM and computer science fields are on socialization into academic discipline and profession. Faculty and peer networks are attributes that lead to student success. The academic preparation of African-American students, for example, is enhanced experiential learning, professional networking with computing. This multifaceted approach to mentorship, coupled with peer and community modeling, amplified the success of African American students in computer sciences

in the study. Charleston et al. (2014) claim students in this study attributed their educational success to “parents, professors, advisors, teachers, and friends who either majored in computing sciences, or encouraged and supported them” (p. 408). The Cultivation of peer and community networks becomes a tool for university and academic department leaders to use in diversity and inclusion initiatives. This approach may aid in the development of one's identity as a scientist. Charleston et al. (2014) suggest positive social influences, community, and sense of belonging, aid in the development of self-efficacy and scientific identity. These institutional practices may mitigate the misperceptions of STEM fields and computer science and engineering as individualist and competitive; instead, offering a community of practice engaged in collaborative and meaningful research.

Similarly, Singer et al. (2020) proposes challenges to diversifying STEM classrooms reside in STEM identity formation, and their findings suggest active learning is one pedagogical approach to aid in student achievement in STEM. Eagan et al. (2014) present findings from a study that indicate undergraduate research is a critical formative opportunity that translates to further academic achievement. These opportunities shape one's scientific identity. Eagan et al. (2014) state, “undergraduate research programs socialize students by connecting them with faculty and advanced peers who provide undergraduates with access to professional networks and new sources of information, and broader access to institutional resources” (p. 689). Research opportunities at the undergraduate level develop a student's social capital, acclimation to the norms of an academic department, and nurture aspirations for further scholarly pursuits.

Eagan et al. (2014) survey extant literature and find that a student's educational aspiration is one of the “strongest predictors of subsequent enrollment in an undergraduate or graduate degree program” (p. 685). Opportunities for research at the undergraduate level help develop

educational aspirations, furthermore, may reduce “imposter syndrome” and lack of sense of belonging. In undergraduate STEM populations, education research suggests a low sense of belonging is correlated with low academic achievement and self-efficacy and programmatic interventions (Stachl & Baranger, 2020) and is a likely deterrent to further academic pursuits. The formal undergraduate research opportunities presented by Eagan et al. (2014), may provide a path to mediating lack of diversity at the graduate level.

### ***Community Cultural Wealth***

Underlying assumptions in higher education research position the URM student as in a social and cultural capital deficit, which may be a reason for lack of representation in STEM disciplines. Posselt et al. (2017), Figueroa and Hurtado (2013), and Burt and Johnson (2018) take cues from Yosso (2005) to de-center notions of social and cultural capital away from the white middle class standard. Figueroa and Hurtado (2013) state, “dominant perspectives and definitions of people are perpetuated precisely because they are treated not as a point of view, but as fact” (p. 5). Higher education must reposition the URM from a social and cultural capital deficit view, and learn to recognize and integrate the rich community cultural wealth students bring into the academy. Burt and Johnson (2018) analyze a body of research into parent and school administration collaboration that shape the social and cultural capital of families themselves, while simultaneously validating the community cultural wealth cultivated in the home. The Black graduate engineering students in Burt and Johnson’s (2018) research acknowledged the impact community members had on STEM identity.

Family support is identified as key to persistence in STEM graduate programs (Burt & Johnson, 2018; Charleston et al., 2014; Posselt et al., 2017). These studies highlight the impact strong family support has on URM graduate student persistence and degree completion. While these students may be characterized by outdated capital deficit assumptions within some higher

education institutions, there is no rational basis for continuing from this perspective. Posselt et al. (2017) and Burt and Johnson (2018) advocate for an anti-deficit lens in research that promotes successful URM graduate students as role models. The relevant university is one that is responsive to the region and community in which it resides. Student support programming could replicate a relevant community in undergraduate studies that affirms the cultural wealth backgrounds of its URM students. Critical approaches to dismantling barriers to graduate education may supplant the flows of social and cultural capitals that reinforce existing power structures with features of community cultural wealth that enhance opportunities for access and persistence through graduate education.

### ***Peer Networks***

Where some education research suggests the perception of competition or individualism in STEM graduate programs is a deterrent for some underrepresented minority students, other research characterizes these perceptions as reasons for attrition in STEM graduate programs. Peers and peer networks are important features of graduate student life and when supportive and collaborative, these networks amplify potential for success. Charleston et al. (2014) acknowledge the sparsity of Black/African American representation in STEM fields, particularly in the computing sciences in higher education. For Charleston et al. (2014) the current literature “suggests that one explanation for the disparity is that the culture of computer sciences is strikingly individualistic” (p. 402). Competition in graduate school and the academy parallel and individualistic stance. This overly competitive environment becomes a deterrent to graduate school or an additional systemic structure that inhibits the ability to thrive and persist. This environment is in opposition to one that affirms a community cultural wealth stance. Posselt’s et al. (2017) research also identifies the typical competition in STEM fields and academic disciplines act as a deterrent for underrepresented minority students and suggests faculty-student



relationships and strong peer networks, that “balance rigor with support” (p. 6) may mediate this phenomenon.

A climate that is individualistic and competitive may lead to social isolation. Fernandez et al. (2019) call attention to distinct instances of isolation underrepresented minority students may face in the classroom and academic department. Graduate school is an isolating experience for many, a phenomenon amplified by racial discrimination or bias that Fernandez et al. (2019) argue, leads to “oppressive classroom climates, feelings of social isolation, dissatisfaction with the overall graduate experience” (p. 5). Mediating the perceptions of individualistic and competitive academic environments may be key to broadening interest in STEM graduate programs, particularly Computer Science and Engineering programs.

Peer networks reinforce identity formation processes and pose challenges for individual students in STEM graduate programs. Fernandez et al. (2019) argue graduate students “must learn not only to cope with academic demands but also to recognize the values, attitudes, and subtle nuances reflected by faculty and peers to succeed in their new environment” (p. 1). The URM graduate student is disadvantaged in the case of hostile campus or academic department climates. Stockard et al. (2021) acknowledge a lack of research focused on the URM graduate school experience in STEM disciplines in their analysis of American Chemistry Society (ACS) student survey data. These researchers examined peer network impact on the URM graduate student and found that URM students, particularly women, reported fewer positive interactions among peers and faculty (Stockard et al., 2021). Stockard et al. (2021) present findings suggest the URM students experienced “implicit bias” and lack of “true inclusion” (p. 4). Similarly, the URM graduate students in the Figueroa and Hurtado (2013) study reported microaggressions, and exclusion from both their international and American peers. Figueroa and Hurtado (2013)

state of the students in this study, “URM students in STEM perceived their campus environment as unwelcoming and unsupportive” (p. 7). The students in this study revealed discrimination to be a stressor, experiences cultural dissonance between family life and academic life, and experienced isolation and loneliness throughout the graduate school experience (Figuroa & Hurtado, 2013). The peer network is a feature of graduate education, and perceptions or assumptions of this feature intersect key junctures in one’s academic trajectory, such as aspirations to pursue advance study, application preparation and submission, acclimation to department culture, persistence and degree attainment. Higher education institutions must regularly assess campus climates to ensure healthy peer networks can develop and thrive.

### ***Faculty Mentors***

The role of the faculty mentor in the success of underrepresented minority or female graduate students in STEM disciplines broadly is a significant factor in educational success. The faculty mentor mentee relationship exists at the convergence of university, graduate program, and academic discipline norms and climates. Scholars argue that URM and female students who lack social and cultural capital within the department face additional pressures and challenges to graduate school achievement particularly in acclimation to the discipline specific habitus (Fernandez et al., 2019; Posselt et al., 2017; Stachl & Baranger, 2020). Reliable and effective mentorships, Fernandez et al. (2019) defined through student survey responses include, “a knowledgeable, trustworthy, and reliable mentor” who is able to mediate lack of social capital and aid in the student’s ability to “acclimate to academic culture and engage with the diverse responsibilities before and after graduation” (p. 11). Socialization into the academy, guided by a faculty mentor, aids in retention, persistence, and achievement in graduate programs (Fernandez et al., 2019; Posselt et al., 2017; Stachl & Baranger, 2020). The impact of undergraduate research opportunities on graduate education, in the context of effective mentorship, may influence

enrollment in graduate studies. Eagan et al. (2013) advance this claim through research and suggests the “opportunity to perform as scientists by conducting original research” (p. 690) under the guidance of dedicated faculty mentors may influence participation in graduate education.

Effective faculty mentorship may also mediate the “imposter syndrome” phenomenon. Stachl and Baranger (2020) investigate graduate students' sense of belonging in a research focused STEM program and find feelings of isolation, rigor of graduate academic culture affects student sense of belonging; however, the effect is mediated by effective mentorship. “Because graduate students spend most of their time within their department and laboratory” Stachl and Baranger (2020) state, “their sense of belonging is more connected to the few faculty mentors” (p. 28). Graduate student respondents in the Stachl and Baranger (2020) study who indicated the “highest belonging” indicated that they felt, “valued, accepted, that they belong, that they have faculty they identify with, that they have a supportive social network, that they are a competent scientist” (p. 27). This study, with Charletson et al. (2014) and Singer et al. (2020) affirm the importance of identity formation as a scientist and the significance of the faculty mentor in this identity formation.

In the context of the faculty mentor - mentee relationship, Mendoza-Denton and Richards (2018) challenge graduate programs to develop programmatic supports that go beyond basic bias training. These researchers argue that graduate faculty have substantial influence on who of their students is nurtured, funded and published, all subject to bias. Mendoza-Denton and Richards (2018) survey of science, technology, engineering, and medicine (STEM) departments at the University of California, Berkeley, suggest training programs resulting in department cultures with less ambiguity and uncertainty. In this context, rapport and trust is key, but programmatic efforts structured to reduce potential for bias may influence persistence and academic

achievement of URM graduate students in STEM disciplines. Mendoza-Denon and Richards (2018) recommend that departments develop “transparent policies and expectations for student progress that are communicated clearly” to all (p. 3). Transparency mediates potential for bias and supports a healthy disciplinary climate.

The significance of the graduate student/faculty mentor relationship is fundamental to understanding the URM graduate student experience and lack of representation in STEM fields. Scholars continue to identify the lack of minority representation in the professoriate as impacting participation rates of URM in STEM disciplines. (Figueroa & Hurtado, 2013; Griffith, 2010; Stockard et al., 2021). The minority PhD faculty serve as role models for the URM graduate student and may develop more supportive relationships with advisees. Figueroa and Hurtado (2013) characterized the graduate faculty mentor as an advocate, role model, mentor, and resource. The faculty mentor then becomes an important driver of inclusive and diverse graduate education reform. Figueroa and Hurtado state, “faculty represent a wonderful vehicle of change when they model appropriate interactional behavior between members of the academic community” (2013, p. 27). From this perspective, faculty mentors may mediate unwelcoming or hostile department cultures and may influence peer networks in positive ways. Properly trained faculty may also mediate social and cultural capital deficits or embrace the community cultural wealth of mentees. A highly skilled, highly networked graduate faculty mentor may also help URM graduate students obtain funding opportunities that minimize financial stressors on the graduate education experience.

### ***Funding Opportunities***

Funding opportunities for advanced study are identified by scholars as potential barriers or deterrents to the pursuit of graduate education, and more so for underrepresented minority students. The Stockard et al. (2021) analysis of ASC student survey data suggests women and

URM graduate students are not afforded funding opportunities at parity with male non-minority peers. Education researchers demonstrate that funding opportunities for graduate school increase participation, persistence, and completion rates, particularly for historically marginalized students, and evidence suggests that grant aid specifically increases the odds of degree attainment (Goldrick-Rab et al., 2016; Kim, 2012).

Historically, financial aid opportunities mediated access to academic opportunity. Kim (2012) states that formal aid programs have “established a commitment to expanding college opportunities for economically disadvantaged students” (p. 123). These students may not likely pursue graduate education without such aid. Kim claims, “the lack of adequate information about the availability of state financial aid and unsettled financial concerns may prevent African American and Hispanic students from attending any type of college” (2012, p. 143). A higher education mission of equity and social justice requires stakeholders to consider the lack of access to funding opportunities that will have on broadening the academic pipeline. The Council of Graduate Schools claims, “the primary purpose of the graduate school in a university is to define and support excellence in graduate education and the research and scholarly activities associated with it” (Denecke, 2004, p. 4); equity in graduate education cannot be realized without funding opportunities.

Furthermore, graduate programs that adopt an intentional stance to influence and secure funding or assistantship opportunities are better positioned to attract and retain URM graduate students. Kim (2012) identifies a need for universities in general to offer educational outreach on financial aid, grants, and other funding, particularly as funding relates to URM student participation. Similarly, the research findings offered by Fernandez et al. (2019) indicate graduate students who held research and teaching assistants were more productive in their

academic discipline than other students. These students persisted. These assistantships offer URM students access to funding opportunities and may shape the scientist identity in significant ways as they progress through a graduate degree program. Eagan et al. (2013) underscore the importance of faculty mentors securing funding opportunities through federal agencies, such as the National Institutes of Health (NIH) and the National Science Foundation (NSF) in order to increase the representation American Indian, Black, and Latino students in STEM graduate programs. Charleston et al. (2014) identifies parallel successes in computer science when academic departments provide apprenticeship opportunities or assist students to find other sources of funding (Charleston et al., 2014, p. 236). This strategy is an important one for graduate program recruitment in the context of diversity and inclusion initiatives.

### **Summary**

The educational research presented here identifies barriers and deterrents to graduate study converging around six themes in higher education, and suggests potential for institutional practices that may mediate diversity and inclusion efforts targeting underrepresented minority (URM) graduate students in graduate school STEM fields. Educational researchers identify barriers or deterrents, “cultural boundaries,” as prospective student assumptions or interpretations of STEM disciplines as individualist and competitive. These perceptions, early identity formation in STEM, and funding issues are indicated as barriers or deterrents for URM students. Forms of social and cultural capitals, graduate discipline specific habitus, and campus climate influence student participation in graduate education, and successful peer and faculty networks.

The counter narrative to barriers or deterrents to graduate education resides in student and programmatic success stories. The boundary work conducted by Posselt et al. (2017) suggests that other graduate programs would benefit by making changes to symbolic or other boundaries

in diversity and inclusion efforts. Posselt et al. (2017) argues that subtle boundaries persist in graduate education and continue to maintain a status quo. Graduate programs interested in diversity and inclusion must critically reflect on these hidden or subtle boundaries and work to relocate them. The study conducted by Posselt et al. (2017) identifies positive outcomes for underrepresented minority and female graduate students that result from the subordination of the GRE exam and high GPA to a holistic review of a student in the graduate admissions process. In this study, graduate students' diversity efforts were realized when the traditional line between applied and theoretical research was removed. Furthermore, URM and female graduate student diversity and inclusion efforts were successful when all actors in an academic department adopted a metaphor of “family” in support of graduate students. Posselt et al. (2017) conclude the work of removing boundaries is critical to access and inclusion of underrepresented graduate students.

The extant literature on the underrepresented minority graduate student lifecycle calls for gaps to be filled with research from multiple angles and methods. The current literature also provides a framework built on concepts of habitus, social and cultural capital, sense of belonging and academic socialization. This framework may guide research and develop successful interventions to enhance the lived experiences of underrepresented minority graduate students. These research questions grounded in this literature review attempt to uncover characteristics of the historically underrepresented minority and female graduate student experience that impact graduate school participation in STEM fields. Patterns in research may emerge among the CSE graduate education community of faculty and students at the three Bay Area CSU universities and these patterns may inform practice. Graduate faculty, graduate school deans, and directors of

admission committed to diversity and inclusion can use such future research to advocate for reform of practice.



## **Chapter 3 Methodology**

### **Introduction**

The qualitative case study research design and methodology are presented in this chapter, including descriptions on the role of the researcher, setting, participants, instruments, and a discussion of data collection and analysis. A transformative worldview and qualitative case study methodology are used to collect and analyze semi-structured interview data of graduate students in CSE disciplines at three Bay Area California State University campuses. The case study strategy used to investigate the current experiences and perceptions of historically underrepresented minority (URM) and female graduate students in master's degree programs related to the Silicon Valley knowledge economy at regional state higher education institutions is contextualized by a parallel lack of ethnic, racial, and gender diversity in both arenas. The currency of study participants' graduate education experience and regional context provide distinct rationale for the case study strategy (Yin, 2003).

The purpose of study is to explore the experiences, perceptions, and attitudes of URM and female graduate students in Computer Science and Engineering (CSE) disciplines at three Bay Area CSU campuses. The graduate student body is more homogeneous than the undergraduate student body at each Bay Area CSU campus (The California State University, 2020a). The significance of this study resides in issues of equity in opportunity in the context of the mission of the California State University and a regional economy dominated by technology professions. A parallel critique of the lack of ethnic, racial, and gender diversity in the Silicon Valley workforce circulates political, social, and public discourse. This exploratory study attempts to uncover the sense making and meanings URM and female graduate students construct as they

navigate the graduate student lifecycle in Computer Science and Engineering disciplines at each of the three Bay Area California State University campuses.

Graduate students negotiate assimilation, inclusion, resistance to, or coping with, the habitus of the academy or discipline in graduate education. The URM and female graduate students in STEM disciplines are simultaneously affected by inherent structures in higher education that may perpetuate marginalization, gatekeeping of graduate education, and the closing of professions by closing off the academic pipeline (Burt & Johnson, 2018; Charleston et al., 2014; Eagan et al., 2014; Posselt et al., 2017; Posselt & Grodsky, 2017; Stockard et al., 2021). Critical theory enables a transformative understanding of the lived experiences of historically underrepresented and female graduate students as they navigate university life and develop relationships with faculty who mentor them (Creswell & Creswell, 2017). Critical theory anchors the data collection and data analysis.

This case study is comprised of three layers: 1) three regional CSU campuses, 2) Computer Science and Engineering Academic Departments at each campus, and 3) recent alumni and current graduate students from each campus. California State University system mission and values contextualized by graduate student enrollment data in CSE disciplines and lack of ethnic, racial, and gender diversity in graduate programs and the Silicon Valley workforce guide critical inquiry. The academic departments of Computer Science and Engineering at each of the three Bay Area California State University campuses: San Francisco State University, California State University East Bay, and San José State University directly and indirectly mediate professional opportunity structures in the region. Study participants attended or attend one of these three campuses are minoritized by academia and related professions. The case study is constructed through recruitment of a purposeful sample, semi-structured in-depth interview data collection,

and subsequent qualitative analysis. Moreover, this case study is contextualized with student demographic and enrollment data.

This qualitative case study was developed through deductive analysis guided by the extant literature and inductive analysis derived through analytical memo guided cross-unit analysis of patterns of deductive codes applied to semi-structured interview data. The qualitative data analysis was conducted in a cross unit and comparative analysis of participant experiences at the three Bay Area campuses. The underrepresented minority and female graduate students at the Bay Area CSU campuses do not have substantive representation in CSE disciplines at the graduate level. These study participants did gain entry into CSE disciplines at the graduate level and shared experiences and narratives that converge into emergent themes. These experiences and narratives may inform equity and social justice-oriented university administrators and graduate deans, directors of admission, and graduate faculty through institutional change efforts.

### **Research Questions**

The decrease in underrepresented minority student participation in graduate study from undergraduate study in Computer Science and Engineering disciplines at the three Bay Area universities is a significant problem of practice. The following research questions guide this study and aim to uncover characteristics of the underrepresented minority and female graduate student experience:

1. How do underrepresented minority graduate students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities?
2. How do underrepresented minority graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities?

3. How do underrepresented minority graduate CSE students view themselves as Silicon Valley knowledge economy professionals?

These questions, answered through qualitative analysis of semi-structured interview transcriptions and researcher memos, may guide programmatic reform at the university and department level. Understanding the experience of students who persist and succeed in CSE graduate education, may inform interventions to mediate lower enrollment and lack of ethnic, racial, and gender diversity in CSE graduate programs at Bay Area CSU campuses.

### **Critical Theory Framework**

A critical theory lens to this qualitative research study aims to guide practitioner reform. Apple (1979) reminds educational researchers of the inherent power imbalances in education, which are not neutral, and from a critical theory perspective, education becomes a political act. In the context of higher education in the Bay Area and its relation to the Silicon Valley knowledge economy, a confluence of issues of power intersects with higher education. In this region, uneven economic prosperity, shifting state demographics, lack of minority representation in knowledge economy professions and parallel lack of minority representation in educational pipelines to these professions, require educational research into structures and relationships that reproduce dominant cultures. Apple (1979) advises educational researchers to, “think structurally or relationally. He or she must link this process of cultural distribution back to questions of power and control outside the school” (p. 17). Apple argues that education is not neutral; furthermore, educators do not act outside unequal institutional arrangements and dominant disciplinary knowledge paradigms. Apple views power and inequality as an economic structural issue, while fellow educational researchers view graduate education as a potential tool to mediate economic opportunity structures (John & Carnoy 2019; Posselt & Grodsky, 2017). These

perspectives position graduate education in the region as a possible mediator of access and opportunity to the Silicon Valley knowledge economy.

The research questions that guide this study aim to uncover the perceptions and experiences of URM and female graduate students navigating such structures. Power relations, family, academic, and professional cultures shape identity development and aspirations to pursue graduate education and knowledge economy professions that lack ethnic, racial, and gender diversity. Regarding hegemony, Apple (1979) challenges educators to critique ideological “frameworks which both assist them in organizing their worldview and enable them to believe they are neutral participants in the neutral instrumentation of schooling” (p. 22). Graduate education is not an objective or neutral process. The graduate admission tradition in academia (Denecke, 2004) offers an illusory neutrality in recruiting “right fit” candidates. Reflexivity on the illusory neutrality of graduate education tradition must be deliberate and followed by direct action against traditional practices (Posselt et al., 2017). The actors in CSE graduate disciplines in the Bay Area region, administrators, faculty, and students, are not engaged in a neutral education experience. If administrators and faculty structure graduate education practices for equity and inclusion to ensure student success, they act against the status quo. If these actors adopt a non-interventionist or neutral stance, they maintain the regional status quo.

Apple’s (2001) critical theory lens in education resides at intersections of cultural studies and a neoliberal impact on higher education. The academic disciplines of computer science and engineering have inherent and unique interdependencies with economic forces; however, graduate education practices hold potential to influence workforce cultures over time by expanding the boundary to participation. Because education is not neutral, Apple (2001) charges educators to cut through taken for granted norms. While educators do not act outside unequal

institutional arrangements and dominant disciplinary knowledge paradigms, they hold influence on practice. Furthermore, Apple views power and inequality as an economic structural issue. There is a social justice argument to be made in expanding opportunities for URM and female graduate students in the high wage, highly skilled professions of the knowledge economy. However, the social consequences of not expanding opportunities for knowledge economy professions, evinced by Benjamin (2019) and Williamson (2017), reinforce dominant power and ethnic, racial and gender inequality in economic and social spheres.

A critical theory lens frames the research questions of this study in the attempt to understand the lived experiences of URM and female graduate students as they navigate university life and encounter a habitus that may perpetuate inequality, racism, classism, sexism, and the status quo (Creswell & Creswell, 2017). The underrepresented minority or female graduate student in Computer Science and Engineering disciplines experience occurs at a converge of academic structures that were historically (Dodson et al., 2009) not built for them. From this perspective, individual cultural and sociopolitical perspectives in a graduate school experience are of central importance. As URM and female students navigate the graduate student lifecycle, they make meaning from their historical and social perspectives (Creswell & Creswell, 2017).

Underrepresented minority and female graduate students in CSE are at a borderland of community, culture, and social institutions, and the disparity in graduate degree attainment by race, gender, or ethnicity and the national and local context is a social justice issue. These low rates of participation amplify the need for inquiry into the experiences of URM and female students who do participate and attain an advanced degree in CSE disciplines.

The critical theory lens incorporates Bourdieu's (1984) concepts of social and cultural capital, and habitus as a frame to the graduate student experience. This lens is broadened by

Yosso's (2005) concept of community cultural wealth along with extant literature on campus climate, sense of belonging, and campus health into an understanding of graduate student life (Dodson et al., 2009; Fernandez, 2019; Ledesma, 2019; Pascale, 2018; Posselt et al., 2017; Stachl & Baranger, 2020). These concepts orient the research around the social organization of the campus, academic department norms and culture, and overall campus climate. Qualitative case study data on URM and female graduate student experiences, from a critical theory lens, may guide institutional reform efforts toward a more inclusive, equity-oriented experience. The campus may become a surrogate for acquisition of social and cultural capital, integrating the community cultural wealth one brings to an academic department habitus, to create an inclusive scholarly climate.

The qualitative research design uses a case study approach; the case consists of academic departments of Computer Science and Engineering disciplines at each of the three Bay Area California State University campuses. Rich qualitative data was collected through in-depth semi-structured interviews using open ended questions informed by the research paradigm and review of the literature. Subsequent deductive and inductive analysis of interview transcripts, researcher memos, participant feedback on interview summaries, cross unit comparative analysis of patterns informed interpretation of the data and emergent themes. The extensive length of time and outreach needed to recruit study participants is further evidence of significantly low rates of URM and female participation in graduate study in the CSE disciplines at the Bay Area CSU campuses. University administrators and the faculty have an interest in understanding the ways in which our graduate students construct their realities and develop as academics and professionals through their education. The California State University research setting consists of urban campuses that espouse values of equity and social justice in education. The qualitative

research design aimed to uncover experiences of URM and female graduate students engaged in advanced study and to make recommendations on interventions that align with the values and goals of the CSU.

### **The Role of the Researcher**

I advocate for graduate education and graduate students on my campus in my administrative role. My role as associate dean of the Division of Graduate Studies is complementary to the dean of Graduate Studies. While the dean oversees the development of graduate curriculum, manages external relationships, oversees the division budget, advocates for graduate education, resolves appeal to policy and retains the authority to admit students and award graduate degrees, I develop a strategy for general university recruitment in partnership with academic departments for all graduate programs. I lead a team of student affairs professionals responsible for collaborative outreach, recruitment, and retention with academic departments. I work to advance campus enrollment goals. I train and support the admissions evaluation team who conducts a first reading review of applications for graduate admission in accordance with California Title 5 (Title 5 CCR § 41011) graduate admission policy for general university eligibility. I oversee professional staff approvals of advancement to candidacy and audit of degree requirements for award of a graduate degree. Furthermore, I oversee student information systems, supporting business processes, procure new technologies and operationalize such technologies to enhance the student experience. I ensure that all graduate faculty involved in the admissions processes are fully trained on relevant regulations, student information systems, and technology platforms that support graduate admissions, student services, and retention. I serve as the dean's designee on senate subcommittees to advance graduate education or graduate student interests. I am committed to the values of equity and social justice in higher education, and the mission of the California State University system.



My role as a university administrator poses challenges for the role of practitioner researcher in this study. In the graduate student recruitment phase of this study, I disclosed my position as a university administrator, and provided information on the shared governance approach to graduate education on our campus and my limited role within. My administrator role does not permit me to bestow or withhold any benefit for an individual graduate student. Alternatively, my role does not permit me to penalize any graduate student, nor influence learning or degree outcomes for an individual student. I reiterated my limited administrative role throughout the recruitment and interview phase of this study. I identified myself as a doctoral student interested in the graduate student experience. I explained my research questions in depth during the recruitment phase, reminded participants that they can opt out of the study at any time, and explained steps taken to ensure interview data is confidential. Finally, my role as a university administrator notwithstanding, is secondary to my role as an effective and consistent researcher through the multiple phases of this study. Yin (2003) argues that a good researcher must ask good questions, be a good listener, be adaptive and flexible, have a solid understanding of the issue and background, and be unbiased or without preconceived notions. Yin's propositions inform my stance as a researcher.

### **Researcher Positionality**

I am a white male, hold an associate dean position in graduate education administration, conducting race and gender conscious research in the context of homogenous male-dominated academic and professional spheres. Awareness of this positionality and its potential influence on qualitative data collection and analysis was paramount to mediating potential misinterpretation of study participant experiences. My positionality and role of researcher in this dissertation study required a deliberate reflexive and self-reflective approach throughout participant recruitment, interview, and data analysis phases of this study (Creswell & Creswell, 2017; Yin, 2003). This

reflexive lens was informed by the work of Yosso (2005) and Posselt et al. (2017). Yosso (2005) challenges educators to see beyond a deficit lens, while Posselt et al. (2017) encourages educators to abandon preconceived notions of student attributes or determinative norms in academic achievement. As a university administrator, I had to deconstruct academic traditions in interpretations of qualitative data and conduct myself with cultural humility in relation to the uniqueness of each participant experience. Reflexivity and self-reflection became part of the data collection and analysis processes in this study (Creswell & Creswell, 2017; Yin, 2003).

This race and gender conscious qualitative inquiry is guided by Critical Theory and an asset based interpretive stance. Graduate education is not neutral, and academic disciplinary norms and tradition are constructed by the dominant culture and include distinct interpretations of qualifications required for membership that privilege that status quo. As a white male researcher, I cannot fully understand the lived experiences of participants in this study, and my analysis is neither neutral or objective. Nevertheless, my own higher education leadership epistemology is rooted in my membership in the LGBTQ community, and experiences of marginalization and invisibility throughout my own academic and professional trajectories. My academic and professional trajectory manifests as a responsibility to equity and inclusion. Study participant experiences may inform equity and inclusion work in higher education. Participants in this study are authorities in their academic disciplines and professional roles, and I positioned myself as a fellow graduate student, active learner, and ally throughout recruitment and interview phases of this study. Positioning my participants as active and authoritative partners in this study, and centering my role as researcher on our shared graduate student identity allowed for genuine rapport to emerge. This positioning helped build trustworthiness. In deference to participants, I became an active learner. My stance as an ally and advocate, aimed to preserve authenticity of

participant voice. I practiced critical reflexivity toward this research and remained aware of my positionality as a possible influence on study participants and in interpretations of the qualitative data.

I am a first-generation student, and advocate for minoritized graduate students on my campus. I operationalize Critical Theory in my professional role in assessments of the division's service to students. I try to open the gate wider. While my role as associate dean may have posed challenges in attempts to collect reliable data for this qualitative research project, I grounded myself in the current research. Cousin (2010) states, "if we are the research tool, we need to be intellectually sharp and emotionally open" (p.15). In his argument, immersing oneself in the research is part of the process. I discussed the potential for the benefits of this research as I aim to establish honest rapport at the onset. Furthermore, I defined the methodology as a partnership between me and the participants. I cannot hide my professional or personal academic identities and maintain a "reflexive" stance. Cousin (2010) argues against entering research from a fixed position, suggesting we use, "our malleable 'gray' elements to support the negotiation of what we might share" (p. 17). Through the analysis phase of this study, I remained open to unforeseen insights that emerged. I approach this research study as a graduate student first, alongside my fellow graduate student participants; practitioner second, to ensure validity and reliability of the research.

### **Research Setting**

The research setting is the California State University (CSU) in the Bay Area region, specifically San José State University, California State University East Bay, or San Francisco State University. The San Francisco Bay Area and Silicon Valley is a dynamic global region characterized by entrepreneurship, emergent technology and innovation; the technology industry is integrated and engaged in diverse ways with colleges and universities that comprise this

landscape (Scott & Kirst, 2017). Silicon Valley and its technology industry add a layer of context to the research setting.

The three prominent CSU campuses are situated in the Bay Area region. California State University East Bay in the city of Hayward, awards bachelor's degrees in 49 majors and master's degrees in 35 disciplines. CSU East Bay served 14,705 students in fall 2019, 12607 undergraduate and 2098 graduate students (Cal State East Bay, 2021). San Francisco State University resides in the city of San Francisco, awards bachelor's degrees in 72 majors and master's degrees in 62 disciplines. San Francisco State University served 28,880 students, 25,839 undergraduate and 3041 graduate students in fall 2019 (Strategic Marketing and Communications, 2021). San José State University in San José, California, offers 90 bachelor's degrees and awards master's degrees in 70 disciplines, serving a total of 33,027 students, 28135 undergraduate and 4892 graduate students in fall 2020 (SJSU Institutional Research, 2021). The CSU is a mission driven public university system guided by values of equity and social justice.

This study was conducted through the virtual video conferencing Zoom platform across the three large, urban public Bay Area California State University campuses. The Zoom video conferencing platform is necessary for this research due to the coronavirus pandemic impact on in-person instruction and on campus events across the California State University system.

### **Participants in the Study**

The study participants were purposefully selected; they self-identified as an underrepresented minority (URM) or female graduate student enrolled in, or alum of, a Master of Science degree program in academic disciplines of computer science or engineering at one of the three Bay Area California State university campuses. The graduate students in this study are residents of the state of California and reside in the Bay Area region. Study participants were recruited for this study from October 2021 to January 2022, through direct referrals from faculty members in

computer science or engineering departments, or who responded by email to announcements circulated in the academic department of computer science or engineering at one of the three Bay Area CSU campuses, or by peer recommendation. Recent alumni participants were recruited through the LinkedIn social media platform using a paid search feature and in-app messaging. The LinkedIn paid search included the Bay Area CSU campuses and master's degree specializations of computer science, information technologies, software engineering, computer engineering, and engineering. The study announcement was shared through the in-app messaging feature. After an exhaustive recruitment phase, obtaining informed consent and commitment, eight participants were selected.

Participants in this study were selected after a pre-interview stage conducted by email to determine one's reflexivity on their experience with graduate education in computer science and engineering. Study participants identify as Black, Hispanic/Mexican, female, immigrant, transnational, entrepreneurial, and professionals in the field. Participant ages range from mid-20s to mid-50s. Participants in this study hold a range of professional experience, from internship only, entry level technical positions, to senior software engineering positions. They identify as members of the Silicon Valley technology workforce and are actively engaged in this culture.

Pseudonyms are used to maintain anonymity. Each individual semi-structured Zoom recorded interview and subsequent transcription were assigned a case number and pseudonym. Participants are identified by pseudonyms throughout this study. Upon recommendation of the San Jose State University Institutional Review Board (IRB), the study participant specific CSU campuses are also masked. The three universities, California State University East Bay, San Jose State University, or San Francisco State University, are referred to as Bay Area CSU campuses

throughout this analysis to add an additional layer of anonymity, due to the small URM and female population in CSE disciplines.

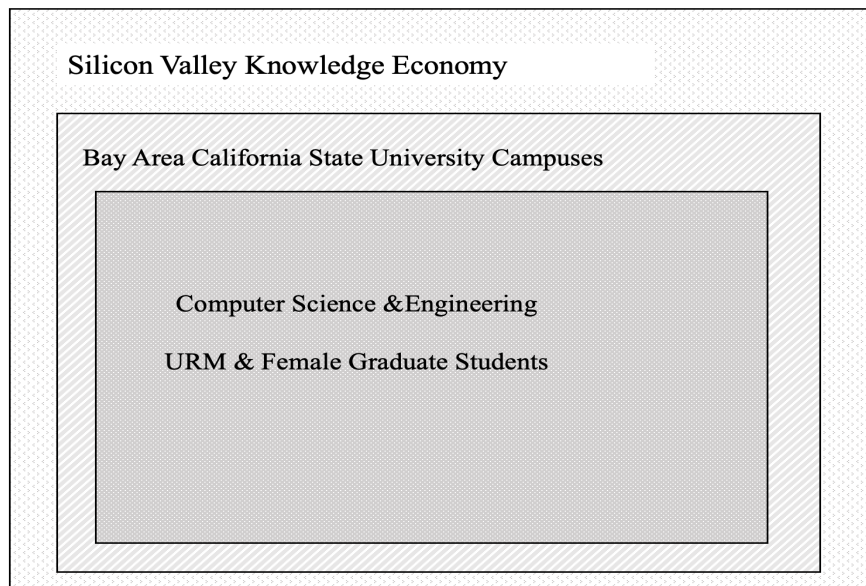
The URM and female graduate student experience in computer science or engineering disciplines uncovered in this research study, likely differs from dominant student groups. The URM and female graduate student interview data indicates a majority of participants were impacted by institutional barriers that may not impact their non-minority peers. The interview data and qualitative analysis presented in this dissertation may aid in higher education institutional reform directed toward inclusion and equity in graduate education. The rates of participation in graduate education, particularly in the CSE disciplines at the CSU across race, ethnicity, and gender suggest that institutional and systemic barriers exist and influence who is likely to enroll in graduate study and attain a graduate degree. The narratives of historically underrepresented minority and female students pursuing graduate research and scholarship, forming an identity as an academic, do reveal structures and agendas that perpetuate the status quo in academia. This data is important to institutional reform, particularly within the California State University system.

### **Research Design**

This dissertation uses a case study design. The case study design and cross-unit analysis is well suited for inquiry into the graduate student experience at the three Bay Area California State University campuses. Yin (2003) argues for the case study approach to research where empirical inquiry investigates phenomena bound by context. The purpose of this study is to uncover the experiences of URM and female graduate students in CSE disciplines at the three Bay Area CSU campuses, contextualized by a region dominated by technology professions that impact the global knowledge economy. The case study is illustrated in Figure 2. This is a very specific context. Yin (2003) argues case studies include goals to “expand and generalize theories” (p.11).

Yin analogies the single case study to a single experiment and justification for either is the same. Yin (2003) advocates for the use of case study research for extreme or unique cases.

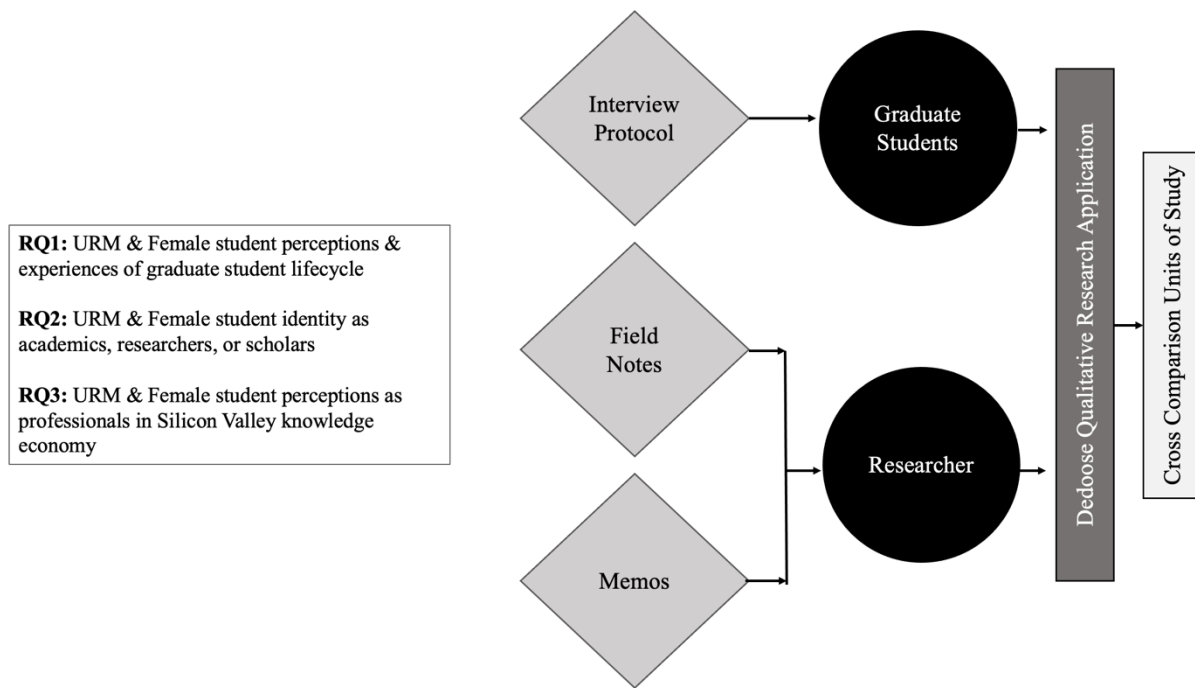
**Figure 2**  
*Case Study Design*



The significantly low representation of URM and female graduate students in CSE disciplines at a mission driven public university system in a region dominated by a prosperous knowledge economy with a parallel lack of URM and female representation in the workforce is “unique.’ Pattern matching is key to understanding the characteristics that comprise the case of the URM and female graduate student experience at the Bay Area CSU campuses. The analysis of URM and female graduate student experiences in CSE disciplines elicited patterns, both positive and negative, at the Bay Area CSU campuses. These patterns, and “analytical generalization” (Yin, 2003, p. 32), derived through comparison to the extant literature in this study, construct an exploratory analysis. This analysis may aid institutional understandings of why URM and female participation rates in CSE graduate programs are lower than those at the undergraduate level.

This study consists of qualitative data collection and analysis of semi-structured interviews of current or recent graduate students; the research design is summarized in Figure 3.

**Figure 3**  
*Illustration of the Research Design*



The case study was analyzed through this research focuses primarily on uncovering the URM and female graduate student experience, attitudes and perceptions that develop while navigating a graduate program in the disciplines of computer science or engineering, and the meaning that students give to these experiences.

### **Instruments & Sources of Information**

The researcher as an instrument for data collection is primary to the design of this study. Fraenkel et al. (2015) states, “in most qualitative studies, however, the researcher serves as the primary data collection instrument” (p. 118). Fraenkel et al. (2015) establish the role of the researcher in qualitative studies as one who is involved directly at the site of research, the observer, the data collector, concerned with context, process as well as product. In my role as a



university administrator, I hold expertise in graduate enrollment management and student services, and the shared governance processes that guide programmatic development. I am fluent in state and federal policies that relate to graduate education and have an interest in reliable research that can impact reform. Furthermore, the researcher as an instrument is one who analyzes data inductively to understand how individuals make meaning out of their lived experience (Fraenkel et al., 2015). Expanding the definition of this role, Yin (2003) proposes an effective researcher is one who asks good questions, is a good listener, is adaptive and flexible, holds a solid understanding of the issue and background, and is unbiased. Yin's propositions guided my reflexive stance as a researcher and instrument in this study. As a researcher, I view the participant as an active partner, and respect their cultural background and aspiration for graduate education. I worked to develop rapport with the participant and an appropriate comfort level through our shared identity as graduate students (Creswell & Creswell, 2017; Fraenkel et al., 2015; Yin, 2003).

The student interview protocol was designed to answer the three research questions. The interview protocol was developed using a four-phase interview protocol refinement (IPR) framework. Castillo-Montoya (2016) presents an IPR framework for qualitative research that: 1) ensures the protocol aligns with research questions, 2) guides an inquiry-based conversation, 3) incorporates feedback in refinement, and 4) is piloted ahead of interview research. The interview protocol consists of a series of demographic questions and open-ended questions informed by the review of literature, that guided interview conversations. While demographic and general background questions add detail to the case study, experience, perception, and behavior questions elicit deeper information about the graduate education experiences. Questions on opinions and perceptions about the experience of graduate education are used in the protocol. As

the researcher, I took extensive notes and used probes “expand on that,” “tell me about that,” and “what do you recall?” to refer back to prior statements to encourage participants to expand in order to prevent a break in a stream of conscious statements. The interview protocol used open ended questions to avoid “yes” or “no” answers. The interview protocol was piloted in advance of the study with graduate student assistants in my division and peers to ensure validity and reliability. The protocol was revised based on feedback obtained through the pilot.

An *a priori or* deductive code book is used in the primary phase of qualitative coding of interview transcriptions. The code book was developed from significant concepts presented in the review of literature. The purpose of a preliminary code book was to establish a level of coherence among deductive codes that arose across interview data collected (Creswell & Creswell, 2017). The deductive phase of qualitative analysis allowed for initial organization of interview transcript data into categories or themes that were later expanded through a cross-unit analysis. Field notes taken throughout the recorded semi-structured participant interviews were analyzed alongside corresponding interview transcripts and augmented the coding of significant points throughout individual interviews. These field notes provided a secondary check on the researcher. These notes captured on the spot analysis and interpretations that provide evidentiary insight into the role of the research.

### **Data Collection**

The recruitment of study participants and semi-structured interviews commenced in October 2021 and concluded in January 2022. The semi-structured interviews were scheduled after pre-screening at times convenient to the study participants. The study participants submitted a signed “informed consent” through the DocuSign platform and an intake sheet designed to collect demographic and graduate program information prior to the interview. The semi-structured interviews occurred virtually through the Zoom video conferencing platform. Interviews

averaged sixty minutes in length. Each interview was initially transcribed using the Otter AI software Zoom plug in application. Transcription accuracy was validated manually by the researcher through a deliberate reading against the original Zoom audio recording. Field notes taken during the interview augmented this manual validation process.

The CSU graduate student interview protocol used in this research study was designed to elicit rich conversation and collect narrative data from study participants. The interview protocol development was informed by the review of literature, and a critical theory framework scaffolded by concepts of social and cultural capital, and campus sense of belonging. This interview protocol was piloted in advance at my educational site on non-participant graduate students and peers to ensure clarity and to establish validity. The protocol was revised according to feedback. Protocol questions were revised to include “describe” or “tell me” and reordered to allow for a more natural progression through the conversation. The interview protocol used in semi-structured interviews was structured to encourage rich conversation. Field notes were recorded in a journal during each of the semi-structured interviews. These field notes guided the transcription validation phase and the initial deductive coding phase of interview data. A summary of each interview experience was drafted immediately following each interview to record researcher impressions and more lively topics of discussion. These summaries directed the researcher to significant moments in each interview and aided cross-unit of study analysis in the inductive coding phase. Finally, analytical memos were created and stored in a Dedoose database during the deductive coding phase of this study. These memos were created when no deductive code existed, and often referenced a comparison to other participant experiences. These memos also guided cross-unit comparative analysis in the initial phase of the inductive coding process.

## **Data Analysis**

A critical theory framework and review of literature guided deductive and inductive coding and subsequent analysis of the interview transcripts from eight semi-structured interviews. The primary data was collected from semi-structured interview data from graduate student participants; interviews were conducted and recorded with the Zoom video conference platform. The secondary data was obtained through researcher field notes taken during each of the eight interviews, analytical memos developed after each interview, and memos drafted during the deductive coding phase of the analysis. The data analysis process included building a study specific database in the Dedoose web-based qualitative research analysis application and consisted of a three-phase approach: 1) application of deductive codes to interview transcripts, 2) development and application of inductive codes to transcripts, and 3) cross-unit comparative analysis for the development of emergent themes.

The initial data analysis consisted of application of deductive codes to interview transcripts in close readings. The validated semi-structured interview transcripts were labeled with a participant identification number that corresponded a pseudonym and uploaded to the Dedoose web-based qualitative research analysis application. The Dedoose platform allows users to construct a database from qualitative sources. Interview transcripts represented raw data uploaded to the Dedoose platform. The deductive code book developed from the review of literature was recreated digitally in the Dedoose platform, and represents one component of this research study database. Significant and meaningful narratives from each transcript were initially coded using the digitized version of the deductive code book. The exported data, coded narratives, sorted by code allowed for pattern matching and a close reading of study participant statements that held similar meaning. This process allowed for axial coding that situated the interview data within the critical theory framework that guided this study (Creswell & Creswell

2017). The reading of study participant quotes or narratives across each unit of analysis, the individual interview, not only established patterns that converged with the theoretical framework, but identified outlier experiences that were meaningful to the interpretation of the data.

The development and application of inductive codes comprised the second phase of data analysis in this study. Post initial phase coding, the deductive codes applied to quotes were exported from the Dedoose database across individual cases, or units of analysis. The Dedoose tool includes a memo feature that was used to draft memos and attaches these memos to instances of unique or surprising statements or quotes made by participants when no deductive code could be applied.

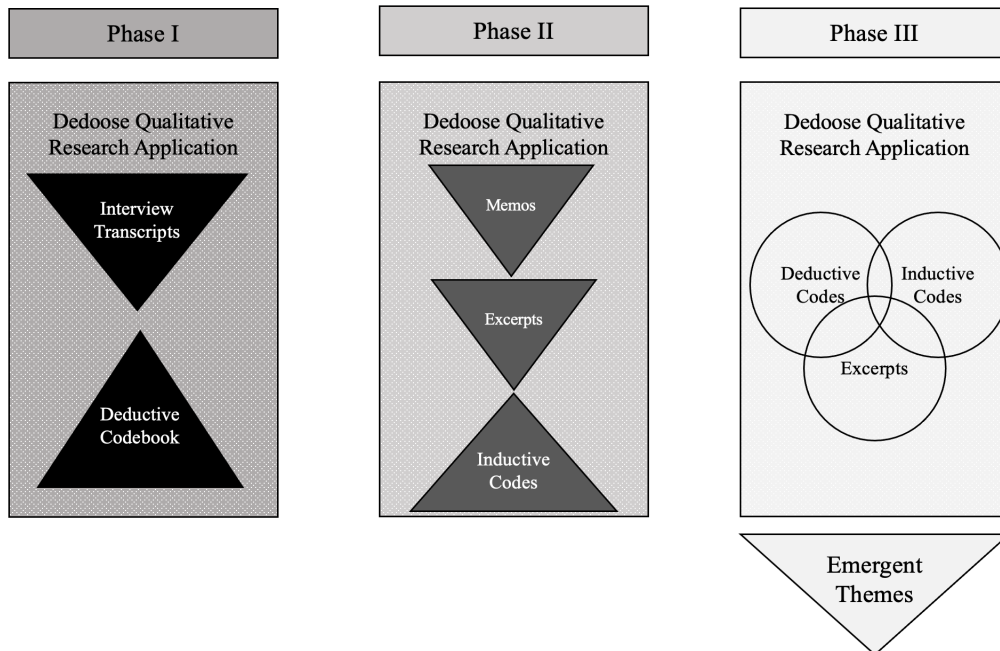
The analysis of the deductive codes comprised the first phase of qualitative analysis of interview transcript data, while analysis of initial memos bridged the second phase of analysis. Subsequently, memos drafted as data points in the Dedoose database in response to significant or unique statements where no deductive code could be applied, were exported along tagged narratives. Close readings of narratives, quotes, and memos across each corresponding unit of analysis guided the inductive coding of interview transcript data. Memos and quotes were grouped by similar topics and read comparatively across each individual instance. This process broadened the critical lens beyond the constraints of deductive codes. This process facilitated the creation of inductive codes and new pattern matching across individual units of analysis. Similar to the organization of deductive coded data, the inductive codes applied to excerpts were exported from the Dedoose database across individual cases. The exported data, coded excerpts, sorted by code allowed for pattern matching and a close reading of study participant statements. This process resulted in emergent themes relevant to the research questions.

Finally, both deductive and inductive codes and attached experts were organized according to the emergent themes. Cross-unit analysis and readings influenced the development of the data analysis report. The deductive coding phase of the data analysis in study aligned the data analysis with the current research presented in the literature review. The inductive coding phase of the data analysis allowed for emergent themes and development of broad generalizations across study participant perceptions and experiences of graduate education in CSE disciplines at Bay Area CSU campuses in the context of the Silicon Valley knowledge economy. The data analysis methodology conducted in the Dedoose Qualitative Research Application is summarized in Figure 4.

This study is contextualized by lack of ethnic, racial and gender diversity in the Silicon Valley knowledge economy, destination professions for students in computer science and engineering. Therefore, Fairclough's (2013) critical methodology for policy analysis is adapted to the third phase of data analysis. In Fairclough's (2013) critical methodology, the researcher interprets text through a normative evaluation of graduate student life, through an evaluation of the problems that exist and a practical engagement of such a problem in a social context. Fairclough's methodology guided the analysis of interview texts in the development of emergent themes in the context of computer science and engineering graduate programs and the regional significance of Silicon Valley. The actors in this scenario include the student, researcher, and university administrator. The interview transcript data was critiqued through a political economy lens and normative social processes, using theory and subsequent analysis to reveal meaning (Fairclough, 2013).

**Figure 4**

*Data Analysis Methodology in Dedoose Qualitative Research Application*



The thematic analysis approach in this study is concerned with the participant and the process. The purpose was to extract meanings that URM and female graduate students give to their experience in academia. The qualitative analysis attempts to understand words, utterances, and attitudes; how attitudes translate to actions, how students are affected by faculty and peers, and external forces of their chosen profession.

The extant literature on URM and female graduate student experiences in STEM disciplines inform the deductive analysis through concepts of social and cultural capital, campus climate, and sense of belonging within the academy. Inductive coding identifies indigenous meanings in the shared experience across the three Bay Area CSU campuses. Subsequent inductive coding and analysis aimed to develop thematic propositions of how study participants make sense of their experience and to find patterns of student experiences across the three Bay Area CSU campuses.

The open-ended interview questions captured rich descriptions and new dimensions of the URM and female graduate student experience. The inductive codes such as early exposure to technology through play, experiential learning opportunities, adaptability, resilience, self-efficacy, self-directed learning, computer campus climate as analogous to the impact of COVID-19 on graduate education, critique of curriculum, critical consciousness, and a moral obligation toward social impact emerged through second phase analysis. There may be an interrelation between advocacy on the admission side, whereas grant aid procurement results in advocacy. Intentionality in a faculty mentor's approach offers an angle from which to answer the research questions. These interpretations relate to anti-bureaucracy actions, actions aimed at breaking barriers. Identical data collection and analysis strategies were used in each unit of analysis. Finally, participant check was used to preserve an authentic participant voice, while researcher generated documents aid triangulation of interview protocol.

This case study data analysis methodology is anchored to a theoretical framework of capitals proposed by Bourdieu (1984) and expanded by Yosso (2005), with concepts of habitus, or campus climate, and a sense of belonging. Theoretical propositions these capitals aid in interpretations of student persistence, coping, resistance, or ability to thrive in a new academic department culture or habitus. The cross-case study, or cross-unit analysis, Khan and VanWynsberghe (2008) argue, allows the researcher to identify new dimensions to participant experiences. The analytical strategies used in the third phase of data analysis consisted of pattern matching to develop broader themes contextualized by the California State University system and the Bay Area at this moment in time (Khan and VanWynsberghe, 2008; Yin, 2003).

### **Reliability**

The URM and female graduate student experience in CSE graduate programs at three Bay Area CSU campuses, contextualized by Silicon Valley, is the aim of this study. Study



participants hold unique personal views. These views influence motivations and persistence in academia. These personal views were uncovered in this study through semi-structured interviews and qualitative analysis. The primary method of collecting qualitative data in this study was the semi-structured interviews. Establishing trust and building rapport with the students over a short period of time was key in obtaining rich conversational data. Weiss (1995) advises, “a good interviewer requires knowing what kind of information the study needs and being able to help the respondent provide it” (p. 66). Anchoring the research study in the limited, extant literature on the experiences of historically underrepresented minority and female graduate students in STEM sharpened the data collection and analysis processes. A degree of flexibility from the protocol was necessary to obtain rich conversational interview data without deviation from the intent of the protocol. Each participant shared a unique experience, during the course of the interview, statements were made that answered upcoming questions, or prompts became irrelevant (e.g. campus clubs). Participants were provided time and space to think and speak in the moment and digress from main topics. The researcher took notes and great care to not ask repetitive questions when such instances provided answers for other protocol questions.

Public universities are a unique social sphere with a responsibility to expand opportunities in the communities and regions in which they are situated. Raply (2004) suggests researchers attempt to “understand the biographical, contextual, historical, and institutional elements that are brought to the interview” (p. 16). This proposition is critical in guiding data collection and analysis because the URM and female graduate student experience resides in these significant intersections. Furthermore, the graduate student lifecycle is a ubiquitous framework for discussions of institutional approaches to recruitment, admission, retention, and graduation (Denecke, 2004; NAGAP Association for Graduate Enrollment Management, 2019b). This

framework and the review of literature guides participant interviews to uncover themes of institutional habitus and provide comparative evidence across three Bay Area CSU campuses.

I accommodated participants in these interviews to minimize inconveniences; scheduled interviews at the convenience of study participants. I established that this is a research partnership with each participant, and defined areas of exploration ahead of time. Rapport was established at the onset of the interview process through a shared affinity as graduate students. Study participants understood my role as a fellow graduate student and commented on shared struggles with research. The interview protocol focused on a range of questions related to the graduate student experience, from recruitment, admission, faculty mentorship, institutional support, degree progress, and entrance into the profession. Moreover, use of linguistic moves and non-leading questions were used to create spaces for “reciprocity” and opportunities for rich conversation to take place. I intentionally paused at intervals throughout the interviews for reflection, and asked participants to “expand on that,” “talk about that,” “tell me more about that,” “what have you observed?” as a strategy to generate rich details (Raply, 2004; Weiss, 1995). Raply (2004) argues, “interviewers, whatever prescriptions they follow, must work to establish a suitably relaxed and encouraging relationship” (p. 19). I worked to earn trust and “likeability” through the recruitment and interview processes. Furthermore, I worked to build rapport, trust, and respect with each of the participants and asked that they review draft analysis through a member check process. The Zoom video and voice recording devices minimized intrusive nature of data collection and note-taking.

### **Trustworthiness**

The aim of this study was to produce a qualitative case study, through analysis using techniques that minimize threats to internal validity and establish reliability. Educational scholars advise qualitative researchers to utilize a number of different techniques to establish

credibility and to check researcher bias (Creswell & Creswell, 2017; Fraenkel et al., 2015). The narrative data collected during semi-structured interviews of study participants across each of the three CSU campuses was triangulated with field notes, analytical memos, and memos created in the Dedoose platform. Qualitative data was collected by email, handwritten notes, and audio obtained from Zoom video conferencing recordings. The researcher engaged with study participants throughout the data collection process and enlisted individuals to “member check” a draft of the subsequent analysis.

The analysis of the qualitative data was informed by the literature, and through deductive and inductive processes. The coding of qualitative data was done with careful attention to the mundane details, and as Silverman (2007) suggests, conducted “in favor of elegant analyses that make a lot out of a little” (p. 29). Strategies to qualitative coding are documented in this study to mediate potential threats to internal validity and reliability, and researcher bias. Furthermore, researcher reflexivity was integrated throughout the data collection processes and subsequent analyses. Due to my position as a university administrator, my past experience with the research problem, and one research site characterized as a “backyard,” Creswell and Creswell (2017) recommend caution in interpretive approaches that bend toward expected themes or outcomes. The approach to the inductive coding phase of interview transcripts was to broaden interpretations beyond the limits of the review of literature. A reflexive approach to note taking on data collection and observation was incorporated in this study.

### **Ethical Considerations for this Study**

There is significant interest in understanding how URM and female graduate students experience the cultural dynamics, collaboration on research and scholarships, relationships with faculty mentors, of academic departments within a university around issues of equity and inclusion, campus climate, campus sense of belonging. How graduate students make sense of

individual experience and develop as computer scientists or engineers are important narrative data that may inform institutional reform and change in practice. The historically underrepresented minority and female graduate students in disciplines of computer science and engineering are not well represented across the three Bay Area California State University campuses and experiential data in this area is sparse. More research on URM and female graduate students is needed; and this is a study of significance intended to broaden current literature. Thoughtful consideration of URM and female CSE graduate students, personal experience or narratives, at the intersections of race, culture, and academia is of utmost importance to this study. Participants in this study were protected from any physical or psychological harm, all qualitative data obtained through semi-structured interviews is anonymized and secured to protect confidentiality, and no deception or deceptive tactics was used in the interview processes.

As a researcher, I adhered to the conduct and professional standards required of higher education and the researcher, and scholarship standards as a doctoral student. Study Participants were protected from harm throughout the study. A detailed description of the purpose of the study, the data collection and analysis process, the study's significance to educational and institutional practices, and potential use of results to inform institutional reform was shared with each participant ahead of engagement. I disclosed my positionality as a university administrator at the onset of participant recruitment. I established a clear agreement with each participant on the interview process prior to obtaining informed consent. I established the individual's right to withdraw from the study at any time and without consequence. As the researcher, I honored this right and provided participants with multiple ways in which to contact me or the dissertation chair should they wish to withdraw.

Institutional Review Board (IRB) approval was obtained at San José State University and California State University East Bay, and permission to conduct this research was obtained by the computer science and engineer department chairs, and dean of the Division of Graduate Studies at San Francisco State University. Interview data was collected in a uniform manner across campuses and all participant interviews. The confidentiality of each participant is maintained through anonymizing the data. Individual semi-structured interview transcripts and Zoom video conferencing data was assigned a case number. Participants were later identified through pseudonyms. Video recorded interview data is labeled with a case number and pseudonym.

The interview transcripts and subsequent qualitative data analysis were labeled with the case number and term for relevant procedural steps. A signed consent form, interview video and audio data, transcripts, and analysis was stored on a cloud-based server that is only accessible using institutional login credentials and Duo two-factor authentication. Duo verifies user identities with two-factor authentication and confirms security health of devices used in authentication before granting access to the cloud-based storage applications and intranet (Cisco, 2021). The qualitative data generated in this study will be secured for one year after the study and then permanently deleted. The signed consent forms will be destroyed as early as is permissible.

Disclosure of researcher positionality occurred before each interview commenced, including an overview of my administrative role in order to demystify any perceived authority that I may have on an individual's academic career or success. I provided details on my role in graduate education and the boundaries that exist between the administrative office in which I serve, and the academic departments in which they study. This full disclosure was an opportunity to develop rapport and trust. Semi-structured interviews were conducted in consideration for ethical

best practices in student services, counseling, and academic advising. Student privacy and wellbeing are central to this stance. A reflexive stance is maintained throughout the study to ensure potential power imbalances or perceptions of such imbalances are mediated.

### **Limitations**

This case-study of URM and female graduate students in CSE disciplines at the three Bay Area California State University campuses is specific to the context of the CSU system and Bay Area region. The study is limited by the sample, and the small number of URM and female graduate students who did pursue graduate education in CSE disciplines. The impact of the coronavirus pandemic on this study is noted; social and physical interactions that occur in an academic department on campus have been transferred to a digital space of email, Zoom videos, learning management platforms, and online modules. The cross-unit of study comparative of interview data collected at the three CSU campuses aimed to establish reliability and trustworthiness.

### ***Generalizability***

The case study conducted at the Bay Area CSU campuses provide a degree of generalizability; however, transferability is a more likely outcome. Each interview is viewed as a case or unit of study. Yin (2003) states, “analytic conclusions independently arising from two cases, as with two experiments, will be more powerful than those coming from a single case” (p. 53). The multiple units of analysis analyzed in this research may be more likely interpreted as transferable than a single instance. Readers of this research may transfer findings to understand graduate student experience in STEM fields.

### **Summary**

A transformative worldview and qualitative case study methodology was used to collect and analyze semi-structured interview transcript data of graduate students in CSE disciplines. A

cross-unit comparative analysis created a broader view of the CSU campuses in the context of the Bay Area region and its ties to the technology professions. This exploratory study attempts to uncover meanings underrepresented minority and female students construct as they navigate the graduate student lifecycle in Computer Science and Engineering disciplines at one of the three Bay Area California State University campuses.

The research study uncovers the URM and female graduate student experience in the CSE disciplines at three Bay Area CSU campuses. The dramatic decrease in UR and female participation in graduate education from undergraduate education in Computer Science and Engineering disciplines at the three Bay Area universities is of interest to change agents in higher education. The individual URM graduate student experience in, and perception of the academic department climate, specific to access, inclusion, and equity anchors this research. The Cross case-study analysis provides a larger picture of student perspectives and attitudes on campus climate specific to CSE disciplines in the Bay Area.

## **Chapter 4 Findings**

### **Introduction**

This chapter presents an analysis of qualitative data derived from in-depth semi structured interviews of computer science and engineering graduate students at three Bay Area California State University (CSU) campuses. The recruitment of eight study participants took place from October 2021 to January 2022. In-depth semi structured interviews were conducted over the fall 2021 semester by Zoom with current students at San Jose State University, California State University East Bay, and San Francisco State University, or recent alumnus. A semi structured interview approach was used to encourage participants to speak candidly about experiences in their specific program of study. Participants were often asked to expand on their thoughts or stories, which resulted in detailed interview transcripts. Participants expanded on motivations and aspirations for graduate school that formed early in academics, experiences overcoming obstacles or barriers to admission, experiences with peers and faculty, and finally participants shared perceptions and experiences as minorities in academia and in their professions. This analysis offers answers to the study's questions.

The purpose of this qualitative research study was to explore the experiences and perceptions of URM and female graduate students in the computer science and engineering disciplines. The participants earned or will earn a Master of Science degree from California State University East Bay, San José State University, or San Francisco State University. The low rates of URM student participation and gender imbalance at the graduate level in CSE disciplines across Bay Area CSU campuses viewed in the context of lack of diversity in Silicon Valley technology professions frame this study. The current political and popular discourse on lack of ethnic, racial, and gender diversity in the regional workforce is twofold: 1) recent legislative debate to increase



diversity in Silicon Valley technology professions and 2) popular news or public research that compels technology firms to act in socially responsible ways. This dissertation study is situated within this context.

This chapter introduces eight participants whose narratives reveal early interest in and aspirations for CSE disciplines and professions, the challenges and successes of graduate student life, the impact of the coronavirus pandemic on the graduate education experience, and individual perceptions of Silicon Valley technology professions. These introductory narratives share a commonality in student experiences in the graduate programs across the three Bay Area CSU campuses. Furthermore, interview transcripts were analyzed in conjunction with the extant literature presented in chapter two of this study and in comparative and contrast cross-unit of study analysis. Emergent themes were identified in order to answer the research questions.

This study is conducted from an asset centered lens (Yosso, 2005), a perspective that participants possess individual qualities that are assets to understanding the graduate education experience in computer science and engineering disciplines at Bay Area CSU campuses. The study findings establish congruence with the current literature on historically marginalized and female graduate students in STEM disciplines.

The themes that emerged through qualitative analysis of in-depth interviews revealed participants' assets as they navigate graduate education. Each participant shared narratives characteristic of familial capital and community cultural wealth, rooted in parental and extended family and friend support networks, motivating academic trajectories. Moreover, each participant possesses aspirational capital, a motivation to advance in intellectual and professional ambitions. The study participants demonstrated self-efficacy evinced by narratives of self-directed learning and seeking out support outside graduate school. A majority of participants, six who were

enrolled at some point during the coronavirus pandemic, demonstrated resilience and adaptability throughout their studies. Finally, all participants held a critical consciousness of their minority status in academia and in their profession, yet pursued these endeavors undeterred. They are hopeful to make a social impact in their profession. These assets are attributes that motivated and influenced graduate education and technology profession ambition.

### **Research Questions**

The following research questions guide this study and aim to uncover characteristics of historically marginalized and female graduate student experiences in academic disciplines related to Silicon Valley technology professions:

RQ1: How do historically underrepresented and female students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities? The resulting analysis answers this question through concepts of identity development; aspirations for graduate school; gaining an offer of admission, and adapting to disciplinary norms and graduate student culture. The qualitative themes developed around this question emerged through a deductive and inductive coding process of interview transcripts, field notes, participant comments, coding memos, and analytical memos. Initial deductive coding of interview transcripts was grounded by the concepts of social, familial, and aspirational capital, significance of peer and faculty mentorships, campus climate and sense of belonging; codes reflective of the current research presented in chapter two. However, an inductive coding approach through a cross unit of study comparison allowed for additional themes of early exposure, community cultural wealth, adaptability and resilience to emerge as sources of motivation.

RQ2: How do historically underrepresented and female graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science

and Engineering (CSE) graduate education in three Bay Area California State Universities? Self-efficacy, and critical consciousness emerge as salient features of participant identity. The cross unit of study comparative analytical approach substantiated emerging themes and a data saturation was realized in inductive codes. Participants in this study were critically engaged with their curriculum, held positive and critical perspectives of theory and elective courses, and were self-directed in the absence of strong peer and faculty engagement. The congruence of responses to interview protocol is interpreted as similar across participants and CSU campuses.

RQ3: How do historically marginalized and female graduate CSE students view themselves as Silicon Valley knowledge economy professionals? This research question is answered in the context of student identity development, participant perspectives on diversity and the current state of diversity in Silicon Valley technology professions. Each study participant holds a strong sense of self and critical awareness of their minority status in the academy and in their profession; they are aware that their participation in these endeavors is important for change. Their presence and participation are acts of resistance to the status quo. They recognize their own potential to contribute to technology fields. Study participants are undeterred by their minority status and hold future aspirations to solve social problems through technology.

The qualitative analysis presented in this chapter follows an introduction of the graduate student participants. The analysis is organized according to the conventional graduate student lifecycle of outreach, recruitment, admission, enrollment, progress to degree, graduation, and transition to an occupation. The emergent themes uncovered in the qualitative analysis of semi-structured interview data overlap three research questions that guide this study. A discussion of findings as emergent themes follows the participant introductions; a summary of emergent themes is presented in Table 7.

**Table 7.**  
*Research Focus and Emergent Themes*

Research Focus	Emergent Themes
RQ1: URM and female student perceptions & experiences of graduate student lifecycle	<ul style="list-style-type: none"> <li>Early identity development in STEM</li> <li>Negative academic experiences as barriers</li> <li>Aspirational capital and social mobility</li> <li>Graduate school aspirations</li> <li>Familial capital</li> <li>Boundary and barriers to graduate study</li> <li>Funding opportunities</li> <li>Peers, faculty and academic socialization</li> <li>Impact of COVID-19</li> <li>Self-efficacy</li> </ul>
RQ2: URM and female student identity as academics, researchers, or scholars	<ul style="list-style-type: none"> <li>Critical Consciousness</li> <li>Self-efficacy</li> </ul>
RQ3: URM and female student perceptions as Silicon Valley knowledge economy professionals	<ul style="list-style-type: none"> <li>Sense of self</li> <li>Social and moral obligations in the field</li> </ul>

The discussion herein is organized around significant milestones of scientist (STEM) identity development, graduate admissions, graduate school experience, and post-graduation aspirations to contribute to technology and the public good.

Diversity and inclusion in CSU Bay Area campus STEM fields of Computer Science and Engineering (CSE) is a subject of interest to academics and educational scholars in these disciplines (Burt & Johnson, 2018; Charleston et al., 2014; Eagan et al., 2014; Posselt et al., 2017). Diversity in destination professions for graduate students in these disciplines, in the

context of the Silicon Valley Workforce, is at the center of legislative action, and of interest to the California State legislature. It should also be of interest to the California State University. The California State University is a broad access institution that serves a diverse student body. The CSU campuses in the Bay Area region have made progress in inclusion and diversity at the undergraduate level, the graduate student body is less diverse, even less in the computer science and engineering disciplines. Nonetheless, the CSU is a potential mediator of the lack of diversity in academia and technology.

A more diverse CSE graduate student body may result in a more robust pipeline to Silicon Valley technology professions, specifically in senior roles or leadership positions (John & Carnoy, 2017). Furthermore, an increase of Black, Latinx, and women professional representation in leadership roles may then influence cultural change in these professions, the professoriate, and CSE in the region. Higher educational researchers argue: 1) “graduate school is an increasingly critical part of the American opportunity structure” (Posselt et al., 2017 p. 2), and 2) graduate education is one way to diversify STEM fields (John & Carnoy 2017). The two propositions together with current political and popular debate on Silicon Valley diversity efforts, or lack thereof, and social implications of a homogenous male-dominated workforce is cause for the California State University to flex its mission and values. Operationalizing mission and values will ensure the CSU educational pipeline is functioning through all stages of lifelong learning, including graduate school.

### **Participant Introductions**

The graduate student participants in this study comprise a purposeful sample, recruited through a network of graduate faculty in Computer Science or Engineering departments at California State University East Bay, San Jose State University, and San Francisco State University. Additionally, recent graduates were recruited through a paid LinkedIn search

service. Specifically, they were invited to participate in this study through in-app messaging. Participants were current and recent graduates of a Computer Science or Engineering Master of Science degree program at California State University East Bay, San José State University, and San Francisco State University.

These participants identified as Black, Hispanic/Mexican, Asian, female, immigrant, transnational, entrepreneurial, and professionals in the field. The eight participants in this study are critically aware minority and women underrepresentation in academic and professional arenas of these fields. Participant ages range from mid-20s to mid-50s. Participants in this study hold a range of professional experience, from internship only, entry level technical positions, to senior software engineering positions. They are members of the Silicon Valley technology workforce and actively engaged with its culture. Pseudonyms are used to maintain anonymity. The three universities, California State University East Bay, San Jose State University, or San Francisco State University, are referred to as Bay Area CSU campuses, at the recommendation of the SJSU Internal Review Board, throughout this analysis to add an additional layer of anonymity.

**Table 8.**  
*Participant Summary*

Pseudonym	Program	Graduation	Age	Gender	Ethnicity
Ayesha	Electrical Engineering	2021	22 - 26	Female	Asian Indian
Kaleb	Computer Science	2023	22 - 26	Male	Black
Robert	Computer Science	2020	40 - 48	Male	Black
Dewayne	Computer Science	2023	50 - 56	Male	Black
Mia	Computer Science	2022	26 - 32	Female	Asian Indian
Kirana	Computer Science	2021	40 - 44	Female	Asian
Alex	Computer Science	2017	30 - 36	Male	Hispanic/Mexican
Miguel	Civil Engineering	2018	38 - 32	Male	Hispanic/Mexican

## *Ayesha*

Ayesha was interested in a career in journalism, but was heavily influenced by her father who wanted her to become a doctor or engineer. She said, “he said, finish your engineering degree, first. Get your bachelor's and then go and pursue journalism. It's like, fine.” Ayesha’s father had nine siblings and grew up with modest means. He had an associate degree level education, starting from “very basic ground,” a hard worker and now, a general manager overseeing about two hundred people. Ayesha’s father modeled a strong work ethic and an entrepreneurial approach to life. He was instrumental in her academic trajectory and supported her through undergraduate and graduate study. Ayesha enrolled in a computer networking course and a hardware design course in her senior year, enjoyed both, which solidified her academic trajectory.

Post-baccalaureate, Ayesha abandoned her interest in journalism and decided to pursue an engineering master’s degree program. Ayesha described her undergraduate experience as easy, she “sailed through” with good grades; wanted to get out of her “comfort zone” in her pursuit of her master’s degree. She earned her Bachelor of Science in 2018, and began her Master of Science in fall 2019. Ayesha enrolled at her Bay Area CSU graduate program in engineering during the fall 2019. She enjoyed the on-campus experience for a semester and a half before the coronavirus pandemic forced universities to remote learning modalities. She lamented the loss of in-person instruction and peer discussion in study rooms in the library. Ayesha felt she was able to recreate some peer engagement through Zoom, but wished for more opportunity to develop deeper connections with her peers. Nonetheless, she demonstrated adaptability and resilience during the pandemic transition spring semester 2020.

Ayesha is a highly motivated, self-directed learner; described her graduate advisor and various professors in positive ways. She served as a Graduate Teaching Assistant (GTA). She

taught lab courses to groups of 25 undergraduate students on Zoom like her teachers. However, Ayesha characterized her graduate school experience as an “on her own” endeavor. Ayesha had an opportunity to pursue interdisciplinary studies outside of her engineering degree and enrolled in computer science networking courses; she pursued a related internship. She described her internship site with “no actual network person there. The only network person they got was me. and I was an intern.” She described her approach to configuring a network for her internship site as relying on Cisco documents and self-directed training. She said, “it's not been easy so far; it's been challenging, and it's been good. I've been learning so many things in the process.” She held a critical lens to the current engineering graduate program curriculum, and perceived it to “need updating.” She felt challenged by the program nonetheless.

She embraced these challenges, and at the time of the interview was working to complete her final thesis course. Like many students and workers forced into a remote environment during the coronavirus pandemic, Ayesha left the Bay Area for upstate New York to be near family. She had a strong desire for the campus experience, and would go to the public university in her town for the scenery and campus feel. She said, “I would take my laptop, and you know, they have a huge, huge campus that's beautiful...” “You know, many isolated places where there are no people. So, I'm like, okay, COVID safe.” Ayesha’s on campus experience was disrupted by the pandemic, yet she found surrogate surroundings on an upstate New York public university campus while working through her program remotely.

Ayesha understood, as a woman in engineering, her minority status. She was the only woman at her internship site. She shared, “the fact that I was the only woman on the team was weird. My manager also pointed out to me that you see the stream of men and there's just one woman, you, and you're an intern.” She is fluent in the public and political discourse on the lack of ethnic,



racial, and gender diversity in Silicon Valley technology professions. She perceived women in these professions as holding human resources or marketing roles. She said, "I think all the executives are men, you don't see many executives who are women." She believes that some companies are proactively working toward inclusion and diversity, while other companies only promote such an image without investment in strategy. She perceived a misalignment of values and action, said, they "want more women, but actually, I don't think they put in all their efforts." The gender pay gap is an issue that is frustrating and surprising for Ayesha. She remained self-directed at the intersection of her profession and gender. She follows the Grace Hopper foundation. She said, "I don't know if you've heard about that or not. It's, it's like, it's a huge conference, which is designed mostly for women in tech, you know, to support women in tech..." "...It's a great event."

Ayesha is a motivated individual who embraces the challenges of graduate school and professional life. She has a rich source of familial capital in her father as a role model and her family in New York. She understood there are resources at the margins of graduate school, such as Cisco training materials that helped her complete her network design project or a women's organization that mediates a male-dominated profession. Ayesha, nearing graduation, had already set her sights on pursuing a Master of Business Administration degree.

### ***Kaleb***

Kaleb is a confident, enthusiastic, and intellectual Black man who grew up in Southern California. His mother bought him a computer at a young age and he developed an interest in gaming, spending time specifically playing Minesweeper. He had an interest in computers at an early age. He characterized himself as proficient in math, successful in two years of calculus and "coasted on that all through high school." He was self-reflective on his ability and academic performance, shared positive and negative experiences. At fourteen, Kaleb participated in and

struggled through a computer programming course at Brown University, an experience that impacted his undergraduate choice at the University of California. Kaleb said, “I literally, you know, I didn't even consider CS because that one experience made me think I was too stupid to do it.”

Kaleb, confident in his calculus background in high school, had difficulty adjusting to university life. He shared that he took calculus in college and “failed it.” He “got a D.” He reflected, “why? Because, I think I had two years of calculus already. Why would I need to try at this class, you know?” He had to leave the University of California to attend a community college in order to raise his GPA. Kaleb, eager to get back to the University of California, said “so, I didn't get accepted anywhere for computer science, but I was in a rush to get back into a UC”. His grades prevented his qualifying for the UC transfer admission guarantee (TAG) program to a computer science major. Policy prevented Kaleb from pursuing computer science in his undergraduate career at the University of California. Instead, he pursued math and statistics. and earned his undergraduate degree in statistics.

Kaleb entered the workforce post-graduation in a technical account management role for a real estate software company. Unsatisfied, he shared, his job “made me feel like I was just, you know, losing IQ points every day.” He lamented not pursuing computer science in his undergraduate program; his professional role made him realize computer science, “it's not that hard.” He reflected back to his experience at Brown University, “when I was 14, I just didn't try,” and characterized that experience as an “obstacle for me doing what I wanted to do.” He wanted employment in a challenging profession. He shared opinions of his previous employers, “they weren't asking me to solve, like, I wanted to solve problems.” His mundane experience at the real estate company influenced his graduate school aspirations.

Kaleb believed he could do better for himself. He had a family network in the Bay Area and wanted to be in the center of the current technology profession phenomenon. Kaleb applied to computer science programs at public universities in the Bay Area intentionally to be in the region. “I said I’ll take any state school in a tech hub focus area that has a program, that’s not, you know, terrible. It just needs to be average or better.” Kaleb, holds an outlier opinion of the Graduate Record Exam (GRE). For him, the test was “very fun.” He said, “I like the math. The tricks that you have to learn; it’s all simple math. It’s all about, can you do it fast?” Kaleb’s undergraduate GPA prevented him from his first-choice graduate program, and his second-choice program admitted him only on the condition that he completed a series of prerequisite courses. He described his current grades as excellent. His study habits are improved. He experienced support from an accessible and responsive group of professors in the computer science graduate program.

### ***Robert***

Robert grew up in the Bay Area, pursued a career in information technology after he graduated with a Bachelor of Science from the University of California for many years before returning to graduate school at a Bay Area CSU. He pursued informatics and big data in his graduate program. Robert developed an interest in computers and computer science at an early age through play. Family friends worked for IBM in the 1970s and 1980s, lived in San Jose, had a son near his age, and they played with computers. He was exposed to the culture of Silicon Valley technology early in life. Robert said, “I was really exposed to, you know, to PCs and computer technology, a lot of that.” He valued this early exposure and role models. These friends had an impact on his identity. Robert shared, “parent’s, friends, they’re, they’re, you know, they’re Black, like, at an early age. That’s, that’s what I saw. I saw, like, these Black people with

this technology and doing things.” Robert tinkered with computers at a young age, built his own computers, something he still does today.

Robert pursued mathematics in his undergraduate degree at the University of California. He reflected on the lack of representation of Black students during his time at the university. He said, “I was the only black person in my class, and at a graduation event, I think I was one in five.” He perceived Black student enrollment at his University of California as low. He said, “I think it was 2% Black or 3%, yeah, out of some thousands of students.” Robert was reflective on the lack of diversity in his academic and professional life and mentorship is an important recurring theme. Robert attributed his aspiration to graduate school to his mother, who earned her master’s degree. He said, “you know, I always, you know, always aspired to go to graduate school, and my mom went to graduate school. I kind of saw her as a role model, if you will.”

Robert began his graduate program in 2019 and earned his Master of Science degree in December 2020. He viewed his Bay Area CSU as prestigious and the low tuition and fees, flexible course structures influenced his choice to apply and attend. He shared that he could pay as he progressed through his program because tuition was affordable. He shared that he is still paying off his undergraduate student loans. Robert experienced graduate school life pre-pandemic and through the academic and workforce shift to remote modalities. He worked fulltime in an information technology division at a private Bay Area university. Robert simultaneously pursued his profession and his graduate education from Zoom in a two-bedroom apartment, where his wife and daughter also worked and attended school remotely. Robert characterized this moment of his life as extreme burnout; joked with his wife that it was his “mid-life crisis.” However, he created authentic learning opportunities in the context of the pandemic. He shared details of his big data management class, and said, “I was able to create a

time series analysis of COVID deaths and show a correlation between that and the economy...”  
“...and that's, that's kind of like a real-world use right there.”

Robert completed his graduate degree and moved his family out of state for new professional opportunities and reduced cost of living. Robert believed his graduate curriculum was relevant to his professional aspirations and that his graduate degree increased his competitiveness within technology professions. He is interested in mentorship at an early age in computer sciences. He is a current education facilitator and a software engineer at a grade school that Robert characterized as “kind of like a boot camp, but it's a more intensive CS program or computer programming curriculum. And I teach students programming skills, the higher-level skills, like machine learning.” He is a mentor to these students and ties this role back to his early exposure to computers and technology.

Robert considered his early exposure to technology as one way to positively influence diversity and inclusion in the Bay Area. On diversity Robert said, “I lived in Silicon Valley, so yeah, it's a tough one. I feel that we could do better at the K through 12, and especially in certain areas, like certain schools, school districts. Yeah. It's tough, because, uh, you know, we aren't really graduating too many professionals in California as much as we need.” Robert is considering going back to school for education in order to pursue a teaching career. He reiterated his perception and experience that early exposure to technologies are meaningful influencers for academics and professions in computer sciences.

### ***Dewayne***

Dewayne is returning to graduate school in his early fifties with decades of professional experience in software engineering. A family man with four children, decided to take a leave from the workforce during the pandemic to finally pursue a graduate degree. He perceived his professional experience as an asset as he progressed through his degree program. Dewayne has

always aspired to earn his Master of Science in Computer Science, but his economic circumstances long delayed this goal. Dewayne said, “graduate studies it's not something I made a decision to get into right now, or there is something special that put me into it now, I had always wanted to do it, but then economic situations wouldn't permit it.” Dewayne began his graduate program in Computer Science in spring 2021, mid-pandemic.

Dewayne earned an undergraduate degree in computer science. He made this decision at the start of his undergraduate career because he wanted to pursue an area of study that would lead to “immediate employment”. He believed computer sciences would allow “gainful employment as soon as you get out of school”. Dewayne has been a software engineer all his life and does not view a graduate degree as necessary for professional advancement, but is an unfinished lifelong goal.

The pandemic shifted his focus to academics. The pandemic impacted Dewayne’s graduate school experience. He balanced his family obligations with graduate studies in a remote learning environment. He recalled that as an undergraduate student, he enrolled in seven or eight courses a semester, but now, he said, “now I’m struggling to do two”. For Dewayne, time management was more critical. He said of COVID-19, “I think the impact is really, it's profound.” Dewayne regretted the lost opportunity for discussions with classmates and faculty. The Zoom space flattened his experience. Dewayne said, “you want to think of graduate schools to be where you could rub minds with peers, but right now, you only get to see peers when it is that two hours of instruction.” The two hours of instruction over Zoom does not allow for the space to connect and develop an understanding of the concepts and theory of the curriculum. Dewayne said, “yeah, you don't get that exchange of ideas, so you're not getting your peers' impact on you, and neither are you impacting on them, so the pandemic is having a profound impact on the graduate

experience.” Even in these circumstances, Dewayne believed he and his peers should push forward and do with “what we got.” He attempted to build connections with his classmates through the Discord and WhatsApp messaging platforms.

Dewayne was self-directed in his approach to degree progress. He researched degree roadmaps in the university bulletin and on the department website. He has a goal of completing his degree in four or five semesters. When he was not driving his kids to school or running errands for the house, he studied. He acknowledged he could not get through graduate school without the support of his wife. He said, “if she wasn't there supporting me, I don't think I'd be able to pull it off.” Returning to the university after a significant time away in pursuit of his software engineering career, Dewayne reflected on the challenges. He said, “some decades of having not been sitting here in the classroom, yeah, it becomes a bit challenging ramping up...” “...the homework.” Dewayne had yet to settle into an area of specialization within the computer science degree program, but is interested in security and artificial intelligence.

Dewayne is critical of the curriculum and technology profession trends in general. He perceived “the hype of the day” has an impact on the curriculum. He posited, “maybe there isn't enough emphasis on the underlying principles or the reason why things are done the way they are, and it's all about this is what the market is now.” Dewayne viewed some courses and curriculum as bending toward market forces and is critical in his view, even as it pertains to his interest in security and artificial intelligence.

Dewayne holds a view, “the technology is so fleeting.” He argued in favor of solid theory over “the hype” of industry trends. He is critical of current technology and the impact on our lives, he believes much of the social media technology influence is a waste of time and is an impediment to real and meaningful social interactions. He is proud of being in technology for

such a long time. It has positioned him to have a critical view of technology and how it impacts society. Although not a necessity for professional advancement, Dewayne said, “I do hope the graduate program will open up new opportunities.” He considers pursuing a doctorate in computer science after he earns his Master of Science degree.

### ***Mia***

Mia is an immigrant to the United States in her late twenties who chose to pursue a master’s degree in computer science at a Bay Area CSU campus because of its proximity to Silicon Valley and the prospects for job and professional opportunities in the region. She began her computer science graduate degree in fall 2020. She gained offers of admission at several Bay Area universities, including private universities, but chose her campus because of the affordable tuition. Mia earned her undergraduate degree in computer science from New York Institute of Technology in New York City, solidifying early exposure and identity in the profession. She commented on the diverse student body to which she was exposed. She points out the homogeneity of students in her current graduate program here in the Bay Area. She said, “here I see just one ethnicity or one nation.” Her graduate program is dominated by international students from India.

Aspiration, self-efficacy, and the influence of her husband on her academics established her trajectory toward graduate education. Mia engaged in self-directed learning after finding options for online courses in a Reddit forum. These courses enabled Mia to explore the computer programming world and develop her skills in programming. In these digital spaces, Mia developed her understanding of data science and Python programming language. These courses, she said, provided “the basic level of understanding that I can build upon.”

Mia characterized her views of the mentorship of her husband and her own minority status as a woman as somewhat contradictory. On one hand, she viewed her husband as her biggest



advocate, experienced in computer programming and current technologies. On the other hand, as a woman computer scientist, desires to succeed on her own. She is unsettled by the lack of female representation in online “do it yourself” programming forums. Mia said, “I feel like there are not many women YouTubers, or like these famous people on the platforms that are female...” “...whenever I Google, anything like how to do this, how to do that, a man comes up, and he is like teaching us. There are no women.” Nevertheless, she spoke affectionately about her husband. She characterized her husband as a source of inspiration, “we're standing in this coding world together, and I never thought that I would be doing a computer science master's.” Mia shared how her husband mentored her and shared his knowledge as she progressed through her degree. “My husband helped me a lot to learn more about coding and programming; I took many courses on my own, like some Harvard courses, and some Coursera courses, where I actually learned how to build things. I built many projects; I built some portfolios and small apps. So that's how I got started.”

Mia shared positive experiences with the curriculum at her Bay Area CSU campus. She compared it to her undergraduate degree program which focused on the Java programming language. She characterized Java as, “like really old school.” In her current program, she is exposed to multiple and current programming language offshoots based on Java and Python such as React and Django. She perceived her computer science department as keeping pace with the evolution of technology.

The coronavirus pandemic impacted her graduate education in similar ways to other participants in this study. Mia missed out on an internship and meaningful peer interactions. She expressed disappointment with co-curricular programs that support professional networking. Mia said, “when I entered, I thought that because the proximity is really close to Silicon Valley, it's

not even like, it is kind of in Silicon Valley. But I felt like all the job fairs and anything related to the jobs or these events are concentrated towards the business side, like Management Sciences, nothing on the tech side.” She had hoped the academic department and university was more engaged in the region.

Mia’s father is also a source of inspiration in her pursuit of graduate education. She shared details of her emerging thesis project that will fulfill her degree requirements. Mia shared her childhood background of growing up in farming; she shared that her father is a farmer. She perceived that he, like many other farmers, is not technologically savvy and cannot access government established grain prices with ease and efficiency. She is developing a user-friendly predictive app that will forecast for farmers the going price of grain or crops. She said, “I will be doing it using AI RNN neural networks” and believes it may help her father be more successful in farming.

### ***Kirana***

Kirana grew up in San Francisco and Jakarta, she is an early forties transnational professional pursuing graduate education to advance professionally with hopes to directly impact gender diversity in the profession. She said, “I’m also really into diversifying the computer science student body. So, my focus was, how can we do that through, you know, modifying the program or creating an application so that students could feel more included in the classroom.” She holds social justice stance in both her academics and professional roles. In academics Kirana actively worked with her faculty mentors on ways to encourage more women in technology disciplines and professions, in her role as a GTA or through mentorship. In her profession, Kirana viewed technology as a useful tool in solving community problems, and argued an ethnic and racially diverse technology workforce is better able to solve community problems. She aspires to write about women in technology. Kirana pursued her undergraduate and graduate degree at the same

Bay Area CSU campus, benefited from undergraduate research opportunities, and a network of women professors who mentored her through graduate studies.

Kirana has a stop and start academic trajectory because of financial issues. She began her studies in the mid-1990s in engineering, but had to drop out because she was laid off from a job and could not afford her education. However, Kirana always had an interest in engineering, math, chemistry, and computer science. She continued to pursue her education at her own pace. She shared her interest in computer science and motivation for pursuing a Computer Science degree specializing in software engineering. She said, “obviously, living in the Bay Area, you hear about, you know, software engineers getting paid more. But I also felt that I was pretty good at it. So, um, you know, seems like the best way for me to, you know, earn an income and also have fun.” Kirana wants to stay in the Bay Area, experienced turbulent economic circumstances, and views her graduate degree as an opportunity to advance in a prosperous profession, while enjoying the work she does.

Kirana described a foundational network of women professors who included her in undergraduate research projects and eventually in curriculum review and revision processes while in a Graduate Teaching Assistantship (GTA) role in graduate school. She found mentorship at the undergraduate level where she used her mathematics and research skills to “map health effects from smoking, geographically in the San Francisco Bay Area, basically highlighting the areas in the San Francisco Bay that are underrepresented and hurting because of the smoking health issues”. She described this opportunity as a chance to use her technical skills and solve community problems. This experience, Kirana said, “kind of inspired me to also go into this computer science education.” Faculty mentors on this project guided Kirana through the graduate admissions application, but more importantly provided a strong female role model.

Kirana said, “I saw her as an, you know, she is an Indian person, and she's, she has her PhD., and I think it helps knowing that she was kind of like me. Yeah. And she had an advanced degree that I thought that okay, I could see myself doing that, too.”

Kirana’s professors included her in the curricular review process for undergraduate courses. She held her GTA position and taught students, but inclusion in these discussions were meaningful and created a real community of inclusion. On course revisions, Kirana said, “I was part of a committee with two other professors to brainstorm on how we would do that.” Her experience as a Graduate Teaching Associate informed her views on the project and she describes true inclusivity. She said, “I felt that they always wanted me to be included in meetings...” “...so yeah, I felt that, you know, I mattered there.” Kirana elaborated on the cultural climate in her graduate program and in the academic department. She shared positive remarks, “I’ve just been really lucky with the group there.”

Although she shared positive experiences with faculty mentors, Kirana is critical of the co-curricular programs on campus that support career and professional development. She perceived her university of not really investing in these areas. Kirana said, “I mean, they have, you know, career stops and career support, you know, for resumes and stuff. But this is beyond that, like, once you get the resume, once you get the interview, what do you do? You know, how do you speak?” For her, the question, “how do you speak?” resides in the language of the profession, the discourse of computer programmers or software engineers.

Kirana aspires to make a social impact in the area of computer science education for youth. At the moment of the interview, she was finishing her thesis project, the creation of an application to aid teachers providing instruction through remote modalities. Informed by the pandemic and her own experience at a GTA, Kirana developed and tested an application to

improve instruction. She explained, “this application was created to kind of make the responses, the communication between students and teachers more visible... So, instructors can actually see when students are not understanding something.” Throughout the testing phase of her application, she highlighted some negative responses, “I have to say there's some pushback. Yeah, because some instructors don't want to see it, or they also don't want it recorded anywhere.” Kirana wondered if the application “doesn't follow their kind of philosophy, or what learning should be.” She understood there is more work to be done in this area for educators.

Kirana is also highly aware of the lack of women representation in her profession. She follows the public and political discourse of the lack of diversity in the Silicon Valley Technology professions. She shared the fact that men comprise the majority of her workplace. Kirana said, “I'm happy with the two or three women engineers that I have, not happy for now. I mean, I wish it would be fifty-fifty.” She views herself as an important part of change in her profession, dominated by men. She is optimistic.

### *Alex*

Alex is a mid-career professional software engineer in his early thirties. He identified as Mexican, pursued his undergraduate degree in economics and his graduate degree in computer science with a specialization in video compression at the same CSU Bay Area campus. One of his key video compression projects is still referenced on GitHub by a community of self-taught experimental computer programmers. Alex holds a full-time software engineering position in the Bay Area. He also serves as an adjunct lecturer at his CSU Bay Area campus.

Alex was interested in computers from an early age. He did not receive adequate academic advising early in his undergraduate studies. He characterized his early academic experience as lacking an understanding of university policy and limited access to academic advising that matched his interests. Alex said, “I was interested in computers for a long time, but never really

took a class until my senior year of undergrad. It just wasn't something I even had any idea how to research before. I would have taken classes way before if I knew where to start." He regrets that he did not major in computer science as an undergraduate student, said, "I wish I would have majored in computer science." He attempted to pursue computer science as a senior but was prevented from course exploration because of a university unit cap on the undergraduate degree. He had earned enough units for his baccalaureate degree in economics and was forced out of studying computer science at that point.

Alex did make connections with key faculty in the computer science department at his Bay Area CSU campus, enough to gain a conditional offer of admission with prerequisites in the first semester of graduate study. He described his graduate admissions process as straightforward, he said, "I talked to some of the faculty and they were pretty helpful." Alex is critical of the Graduate Record Exam (GRE) as a component of the application for graduate school. He believes more relevant alternatives exist. Alex said, "the GRE is not relevant, it should be LeetCode style questions." LeetCode questions are computer program problems specific to the profession that may, in Alex's opinion, be more predictive of success in the computer science program at his campus, where he is an adjunct lecturer.

Alex suggested he would have benefitted from an early and more hands-on relationship with a faculty advisor in his program. He eventually developed productive relationships but thought, "it's easy to fall through the cracks. Some more guidance at the beginning would be helpful as well as help getting linked up with an advisor. I still managed to graduate on time though. It's just tricky figuring out which class to fit in, and where to get done on time."

Alex brings his current professional and lecturer lens to his experience. He is critical of the co-curricular programs and opportunities for professional network and the curriculum offered in

his computer science department. Alex wished he would have more opportunities in this area and understands the value of such programming. He said, “In my opinion, the connections you make are very, very valuable. I understand there are some hurdles because my [ Bay Area CSU] is a commuter school, but I still wish I would have had more group work and interaction with other students and faculty.” Alex described his graduate program as challenging and commends the strength of the theory taught. He said, “the theory classes were good, theory never changes. The software engineering classes were a bit antiquated though, and could use some updating.” His perceptions on the curriculum needing updating align with other participants in this study.

Alex holds positive views about the company for which he works as a software engineer. He shared his perceptions that the company is engaged in diversity efforts. He said, “I feel they are actively trying to hire a more diverse workforce. My team is diverse and they value my opinion.” However, Alex acknowledged the larger context of Silicon Valley and said, “I do know that in general though there needs to be more diversity.” Alex views Silicon Valley as full of opportunities. He gives back to his community through his adjunct lecturer role at his CSU Bay Area campus, and he supports aspiring computer scientists through the graduate admissions application processes in the Bay Area, even writing letters of recommendation for his students.

Alex understands a graduate degree in computer science is not enough to land a competitive job in the region. However, he agreed that higher education in general plays a key role in developing interest in this field at an early age. Alex said, “we do need to get more young engineers truly interested in engineering; just joining a cs program to get a job isn’t enough.” Alex shared the view, informed by his own experience in his undergraduate program, that early exposure and early interest are important features of increasing diversity in Silicon Valley technology professions.

## *Miguel*

Miguel is a socially conscious civil engineer who works for a Bay Area city public works agency. He is an immigrant from Mexico, English his second language, and has a strong family network in the San José area. Miguel developed an interest in engineering as a child by building with Legos. He would build highways for his Hot Wheels cars, and tracks for his trains. He aspired to the design aspects of engineering. He gravitated to math, calculus and geometry and algebra in high school. He excelled and was encouraged in this area. He said, “from high school, you start to get more and more and more like, you know, math courses oriented towards engineering.” His early exposure, ability and interest in building and design solidified his academic trajectory in undergraduate studies. He pursued civil engineering in his undergraduate degree and narrowed his specialization in the same field at the graduate level. He aspired to specialize as a civil engineer. He said, “So, I felt like, okay, I think I need, like a little more study just in one particular area” to develop his expertise as an engineer. He chose his Bay Area CSU campus because of its proximity to Silicon Valley and the dynamism of the region’s knowledge economy in general. He understood his institution was not comparable to Stanford University or University of California, but that he could make his own experience meaningful. He is self-directed and motivated. Miguel said, “I mean, you make, like, your own degree if you study and you put your effort Yeah.” He understood that he would get out of his degree program what he put into it.

Miguel described his graduate school experience in positive terms. He perceived his graduate program as mostly international students from India and China. The commuter campus aspect of his Bay Area CSU impacted opportunities to engage with classmates in meaningful ways. He was; however, able to develop a community of peers, about ten students, who over time began to meet up before or after class to study or solve problems together. Some of these peers are now



co-workers in his profession. Miguel had an assigned faculty advisor, who was mostly “absent” in the role. Nonetheless, Miguel described a strong network of faculty throughout his program, many adjunct lecturers with current and relevant professional experience. He described meaningful interactions with these faculty that oriented him to the professional world. A self-described introvert, one faculty member included leadership curriculum into a course and helped develop Miguel’s soft skills in presentations and writing, preparing competitive bids for public works contracts. Miguel described the graduate degree program as challenging and relevant to professional advancement, but attributed meaningful and authentic learning experiences to adjunct lecturers who brought current industry knowledge into the classroom and helped develop professional skills.

Miguel aspires to the public good. He chose to be in the Bay Area for its progressive culture and the opportunities available in the Silicon Valley knowledge economy. He views the intersections of the region’s scientific communities, dynamic technology firms, as informing the evolution of engineering. He uses such technologies in his profession. He is committed to the public good and works to preserve the San Francisco Bay Area watershed. In his current role, he uses his expertise to manage climate change, sea level rise, water recycling and plastic waste. He holds a critical awareness of diversity issues in his academic discipline and profession. He perceived a strong gender imbalance throughout his undergraduate studies in engineering, less of an imbalance in his graduate program, and perceived a bifurcation of roles in his profession. Miguel characterizes the women at his workplace as focused on the environmental engineering areas, while men work in the design and construction aspects. He is hopeful this will change in the future and emphasized the Bay Area progressive ideals and dynamic economy are reasons for his optimism.

## Participant Summary

Yosso (2005) proposes familial capital, an asset rooted in one's ethnic and cultural background, and community cultural wealth as cultural and community experience rooted within related communities, as counter to Bourdieu's social capital. Yosso (2005) argues these concepts hold cultural power. Familial capital and community cultural wealth assets (Yosso, 2005) emerge as a recurring theme across participant experiences and are critical motivators and influences in the academic and professional trajectories.

The participants' narratives capture how parents, relatives, and spouses served as sources of motivation, mentorship, and ambition for the participants. Family influence begins at an early age, through exposure to technologies, and continues through computer science or engineering graduate education experiences for participants in this study. Participants shared qualities of resilience and adaptability; they actively pursue challenges. These participants found opportunities for authentic learning experiences relevant to their professional ambitions. They hold similar critical views of graduate program curriculum relevance to rapidly evolving technology and related professions. They are reflective of the lack of minority and female representation in Silicon Valley technology professions, and understand their identity in this context. The participants in this study are undeterred by the real and perceived obstacles to professional advancement and aspire to future goals post-graduation.

Each Participant in this study demonstrated *conscientização* or critical consciousness (Freire, 1970), a reflexive awareness of their minoritized status in both the academy and workforce, coupled with aspiration toward making impact for the public good. That they are minorities in these spheres, is described by all in similar ways as both critical to social change and an instance of resistance to the status quo. Critical consciousness is a dominant recurrence over the eight in-depth interviews, viewed through all phases of study participant's graduate student experience.

These graduate students are successful in their academic and professional pursuits and represent role models for others who may follow them. They evinced qualities that substantiate Yosso's (2005) reconceptualization of Bourdieu's (1984) assumptions of social and cultural capital from the White, middle-class culture as the standard from which to measure the URM student experience; toward community cultural wealth or an asset-based lens. Posselt et al. (2017), attempt to move "the conversation about educational equity forward by learning from the positive examples that exist" (p. 3). Similarly, Burt and Johnson (2018) present an "anti-deficit depiction" (p.258) of Black graduate engineering student role models who possess an early interest "advantage" in scientist identity development that led to graduate school pursuits.

### **Perceptions and Experiences of the Graduate Student Lifecycle**

The leading research question to this study attempts to uncover the perceptions and experiences of URM and female students in CSE graduate programs at Bay Area CSU campuses. Specifically, RQ1 asks: How do historically marginalized and female students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities? This qualitative analysis encompasses the concepts of identity development, aspirations for graduate school, gaining an offer of admission to graduate school, and adapting to academic disciplinary norms and graduate student culture. This analysis is organized through concepts of early influences, motivations for graduate education, barriers to gaining admission to a graduate program, funding issues, peer networks and academic socialization, and faculty mentors. These concepts are common features of the ways in which the participants experience the graduate student lifecycle at a Bay Area CSU Campus. The qualitative themes developed around this question emerged through a deductive and inductive coding process of interview transcripts, research notes, participant comments, and analytical memos. Interview transcripts were coded deductively, with codes derived from current relevant

scholarship, and coded inductively with codes derived from a cross unit of study comparative and contrast methodology (Yin, 2003).

The qualitative analysis presented here is organized by shared overarching asset-based themes that emerge through in-depth interviews consistent with current scholarship. These themes include: identity development in STEM, aspirational capital, social mobility, familial capital, community cultural wealth, navigating barriers to graduate study, funding graduate education, peer networks and academic socialization, faculty mentors, and for some participants the impact of the coronavirus pandemic on the graduate education experience. Identity development in STEM, specifically computer science and engineering field, begins with early exposure to technology, often through play, for participants in this study. Pivotal courses in high school or in an undergraduate degree, including opportunities for undergraduate research are prominent milestones in the academic trajectories of the participants. The impact of these experiences, both positive and negative, is shared among this group of Bay Area CSU graduate students. Similarly, students share aspirations for engaging careers in prosperous Silicon Valley technology professions. Family and community are sources of inspiration and motivation, a phenomenon aligned with recent scholarship in this area (Burt & Johnson, 2018; Charleston et al., 2014; Yosso, 2005).

Many of the participants in this study overcame barriers to admission, to cross “the boundary” into the academic discipline at the graduate level. Funding graduate education delayed academic trajectories for several participants. Graduate student experiences with peers or faculty mentors in the graduate programs are uneven, but impactful nonetheless. The impact of the coronavirus pandemic on graduate student life is significant, isolating, and altering the ways in which students engage with peers and faculty mentors.

## **Identity in STEM, Early Exposure, Pivotal Courses, and Undergraduate Research**

The experiences of the graduate student participants in this study suggest that early interest in the computer science and engineering fields resulted from access to technology, play, pivotal undergraduate courses and opportunities for undergraduate research. The findings presented here align with findings of prior scholars on historically underrepresented minority and women graduate students in STEM disciplines. Recent scholarship in these areas offer evidence that early academic identity formation in STEM remains an indicator that one will pursue and persist in STEM graduate programs (Burt & Johnson, 2018; Charleston et al., 2014; Eagan, 2014; Griffith, 2010; Singer, 2020). Alternatively, students who have negative experiences early on may face barriers to graduate degree attainment. Two participants in this study had to reconcile negative early experiences as they began graduate study.

### ***Early Exposure through Play***

Enjoyment and play in the context of science, technology, math and engineering (STEM), early in academic life is a recurring theme in recent scholarship and attributed to graduate school aspirations (Burt & Johnson, 2018; Charleston et al., 2014; Griffith, 2010). Burt and Johnson (2018) present findings that confirm early enjoyment in math and science fosters interest in STEM. Participants in the Burt and Johnson (2018) study, “mentioned how their enjoyment of math further drove them to pursue doctoral degrees in engineering” (p. 264). The importance of play also emerges in his study. “Several participants recalled moments when they engaged in play, and how learning from those experiences encouraged their growing interest in STEM” (Burt and Johnson, 2018, p. 264).

The five male graduate student participants in this study, share early experiences that involve play and enjoyment with computers. The narratives presented here are examples of early

exposure to technology through play. Kaleb Shared his early interest with computers and recounted, "My mom bought me a computer from Costco" ... " Maybe like 2000, 2001...because, everyone is saying go buy a computer. So, I just started playing, you know, Minesweeper and stuff on the computer." Computer games were influential in Kaleb's early interest in computer science. Similarly, Robert shared his childhood experience with family friends and early exposure to technology through play. He recalls his experience with family friends and a parent:

One individual had a job at IBM; worked at IBM very early on in the 70s, and lived in San Jose. They have a son who, he was older than me, I'd go and I'd play over at their house with them. And they have a lot of technology back in like the late 80s, early 90s. And that's where I was really exposed to, you know, PCs and computer technology, a lot of that.

Early exposure to technology through a friend and through play developed Robert's interest in computers during childhood. Robert experimented on his own and built his own personal computer (PC). He Shared that building computers was part of growing up exposed to technology. He said he, "did a lot of that; still do it." Robert attributes his childhood experiences with technology as shaping his ambitions to pursue computer sciences in higher education and his career.

When I was a child, I was exposed to computers and computer technology at a very early age. And I had an inclination towards electronics and that kind of thing. I was tinkering with things at an early age. So, I just kind of knew that's where I was heading. Yeah.

Similarly, Miguel located his interest in engineering to play as a child. He attributed his interest in engineering and design to play. He shared:

I like to build like, you know, these highways with the Hot Wheels cars and you know, move them around or have these little trains and our Lego blocks. So, I think it would be kind of typical for me since I was a kid, and then I really like airplanes as well. So, I felt, like, okay, like, what the gray you know, it's like very, very broad that I can then choose just one field within that big umbrella.

For Miguel, engineering is a big umbrella for his academic trajectory and career aspirations. His creative experiences as a child impacted his academic trajectory early in high school, focusing on engineering then, through his graduate program.

### ***Pivotal Courses***

In addition to early exposure to technology, significant undergraduate experiences are motivating factors in higher education aspirations; the experiences of five study participants align with recent scholarship. Pivotal undergraduate courses and opportunities for research are identified in educational research as milestones that shape student identity in STEM (Burt & Johnson, 2018; Charleston et al., 2014; Griffith, 2010; Posselt et al., 2017). Ayesha identified two key courses that solidified her academic trajectory in engineering and motivated her to continue on in a related graduate program. Similarly, Mia explored online courses through an online community on Reddit.com. She found online courses through Coursera and Harvard and explored her interest through these educational opportunities. Although she explored these courses post-baccalaureate degree attainment, these courses helped develop her confidence in computer programming basics and fostered an identity in computer sciences. She attributes these online courses as inspiration for graduate study.

I was not prepared for this tech world. So, I thought that I would take some courses, and I developed some projects on my own. I searched around for courses, which can give me, like, you know, the basic level of understanding and I can build upon that. On Reddit, I found out about this course that is for beginners. but it's not really for the beginners that they are not ready to do, like, around 40 to 50 hours a week. So, I started with that, and it was really, really hands on.

Miguel was exposed to “a lot of math and calculus and geometry and algebra” early in high school. He had the opportunity to focus his mathematics background toward engineering, which he characterized as an advantage when he began his undergraduate studies. This opportunity provided a path toward engineering in high school. He shared:

I chose the math and engineering one. So, from high school, you start to get more and more and more like, you know, math courses, oriented towards engineering. And that really helped me in college, because I was already ahead of more, you know, people, especially at the beginning.

Miguel developed an interest in mathematics in high school, where he excelled, and his progress in his studies developed his confidence as an undergraduate student. He translated this to engineering and design at a very early stage in his academic trajectory. For Miguel, these courses were pivotal.

### ***Undergraduate Opportunities for Research***

Similarly, undergraduate student opportunity for research also influences identity as a scientist and research suggests such opportunities have lasting impact on academic pursuits. Eagan et. al, (2014) present findings suggesting undergraduate research is a critical formative opportunity. Eagan et. al, (2014) state, “undergraduate research programs socialize students by connecting them with faculty and advanced peers who provide undergraduates with access to professional networks and new sources of information, and broader access to institutional resources” (p. 689). Robert and Kirana described undergraduate research opportunities as important milestones and influential on graduate school aspirations. Kirana’s experience aligns with recent scholarship. She Shared an experience that parallels these findings. Kirana developed relationships with faculty advisors in her undergraduate studies and was invited to engage in authentic research opportunities. She recounted a research opportunity that had a lasting impact on her academic trajectory. As an undergraduate student, Kirana had the opportunity to:

map health effects from smoking, geographically in the San Francisco Bay Area, basically highlighting the areas in the San Francisco Bay that are underrepresented and hurting because of the smoking health issues. So, that was kind of interesting. In that, it was an opportunity to use my technical skills to solve community problems. And that kind of inspired me to also go into this computer science education focus.



Research opportunities at the undergraduate level shape a student's social capital, academic socialization, and aspirations for further academics. Such experiences provide opportunity to develop relationships with faculty mentors who may play roles in gaining admission to graduate programs, through recommendations, securing funding opportunities (Kim, 2012), or further mentoring through a graduate degree. Such opportunities influenced Kirana's decision to pursue a graduate program in Computer Science.

### ***Negative Experiences as Barriers***

Negative experiences in courses early on may become deterrents or barriers to graduate study. Kaleb, Mia, and Alex share negative experiences that made them question their abilities in computer science and delay study in this discipline. Alex Shared that he had been "interested in computers for a long time" but was unable to access effective undergraduate advising early on. He did not have access to an undergraduate road map for computer science. He Shared, "I would have taken classes way before If I knew where to start. I wish I would have majored in cs." Alex majored in economics. This choice delayed his aspiration for a computer science education. He had to reconcile his undergraduate major and lack of computer science courses through prerequisites upon entry into his graduate program, lengthening his time to graduate degree attainment, increasing the cost. Alex lacked access to appropriate advising that aligned with his passion for computers. He did pursue and earn a graduate degree in computer science later on, but delayed pursuing his education due to lack of institutional support services that acknowledged his passion for computers.

Negative or lack of early experience may become a deterrent or additional barrier needed to overcome. Mia experienced early computer science courses with little or no context and in classrooms with a noticeable gender imbalance.

I had no idea in eighth or ninth grade what computer science was? I thought of it as just Microsoft Word and Excel; these are computer science things. But when I was studying in school, there was a mandatory thing after eighth grade...so, I took it and they were teaching us Java courses, like how to write hi... hello...some computation... that's all. At that time, I had no interest. I was not able to understand how, why, do we have to write, you know the syntax, like systems in and outs... ..For me, I was like, why am I doing this, why this? And I have no interest.

Mia describes the gender imbalance she experienced in these computer science courses available to her. She said, “Those were like courses that boys used to take”. However, Mia benefitted from teachers who advised her into other related courses. Kaleb Shared a negative experience. He participated in a summer course at Brown University and experienced an imposter syndrome that impacted his undergraduate major decision. Kaleb recounted:

I was 14; I took, over the summer, a course at Brown University for computer science which heavily discouraged me from doing computer science... If that makes sense. I didn't, I didn't know how to study through difficulty. I didn't get it immediately. So, when I was 14.” .... I’m like, you know, I’m good at computers. I’m gonna go to Brown, take this CS course, and I’m not good at it. First thing on my mind is that it means I’m not good at computers...” ...”so when I was applying for school, I literally, you know, I didn't even consider CS because that one experience made me think I was too stupid to do it.

Kaleb eventually pursued computer science in graduate school, but his real interest was diverted by a negative experience in early computer science courses. Alex, Mia, and Kaleb demonstrate resilience in the aftermath of negative experiences and self-efficacy in finding their path to graduate education in the computer sciences.

Education research suggests a low sense of belonging is correlated with low academic achievement, and compounds into possible deterrents to further academic pursuits (Stachl & Baranger, 2020). Nevertheless, this research suggests nurturing self-efficacy and programmatic interventions (Stachl & Baranger, 2020) may act as mediators. Early exposure is only beneficial when the experience is positive and nurtures one’s aspirations for STEM. Alex, Mia, and Kaleb

possess degrees of aspirational capital and self-efficacy that enabled them to move beyond these experiences and negate the possibility of deterrent.

### **Aspirational Capital and Social Mobility**

Aspirations for social mobility in Silicon Valley technology professions mediated through graduate education, is a recurring theme among participants in this study. These aspirations are understood as motivating factors to pursue an advanced degree. The group of participants in this study share a similar rationale for pursuing a graduate degree in computer sciences or engineering, and for choosing a CSU Bay Area campus. Participants pursued computer sciences or engineering in the Bay Area precisely because of the location and perceived opportunities offered in the Silicon Valley technology professions.

The computer science and engineering professions offer opportunity for social mobility in a region dominated by technology and graduate education offers a point of entry (John and Carnoy, 2019). Understanding motivations to pursue graduate education in these fields as aspirations for social mobility or economic security may inform university response to diversity and inclusion at the graduate level. John and Carnoy (2019) argue lack of opportunity for high wage software developer or programmer positions is a valid research endeavor in the context of the Silicon Valley region. Student motivations are one area of research to consider.

Furthermore, graduate education may enhance professional advancement, and provides opportunity to access Silicon Valley knowledge economy professions. Posselt and Grodsky (2017) present data that suggests increased earning potential for graduate degree holders over bachelor's degree holders. The participants in this study hold similar views on the potential for professional opportunities available to them in the region, access to high wage professions, and they aspire to such opportunities. While participant views diverge on the potential of a graduate degree to increase their competitiveness in the Silicon Valley workforce, data suggests that

graduate degree holders gain social mobility with an increased earning power (Posselt and Grodsky, 2017), and opportunities for professional advancement. Graduate degree holders may be better positioned to influence workforce culture. Several participants in this study aspire to make an impact and found opportunities in their graduate programs for authentic learning experiences that solved a social problem.

Participants in this study possess degrees of aspirational capital in relation to their chosen professions, and understand higher education as a route to social mobility in the context of the Bay Area professional landscape. Aspirational capital is an emergent recurring theme throughout in-depth semi-structured interview data analysis. Yosso (2005) establishes aspirational capital as the ability to hope and dream for a better future for oneself, coupled with resiliency when faced with societal barriers. Graduate student participants in this study aspire to social mobility through careers in high wage software developer or programmer positions. In analysis that follows, they demonstrate resilience and persistence in the face of a professional landscape understood as competitive, lacking diversity, and gender imbalanced. These students hold a critical view of the regional professional landscape, are highly aware of their minority status within graduate education and the professions, yet they remain undeterred.

### ***Graduate School Aspirations***

After earning a bachelor's degree in statistics, Kaleb gained employment at a software company in a technical position. He grew frustrated with the mundanity of his day-to-day role. He viewed the work as routine and simplistic and his company as lacking opportunity. Unsatisfied with opportunities for professional growth, Kaleb considered his next move. He recounted his time at a real estate software company.

Yeah, it was a technical account management job; and like the most technical thing I did was write SQL (Structured Query Language) queries, which made me feel like I was, just you know, losing IQ points every day.

Kaleb aspires for challenges. He is confident in his intellect and ability as an emerging computer scientist. He seeks a professional role where he can solve problems and build something. He envisions a future where he can go beyond entry level technical work and create.

I quit the last job because it was so mind numbing; I needed work that makes my brain, you know, spin... I need something that really, like I need to look at my job as something complicated that requires me to think...I wanted a real problem...I want to build a tool that does a thing you know, a module that passes data to something else, not finagle with all the functions until we can get the right profit number, which is the most complicated thing you're doing there.

Kaleb understood the opportunities afforded by Silicon Valley technology professions, and the knowledge economy in the region and viewed his own professional advancement and social mobility as contingent on earning a graduate degree in computer science. Lack of fulfillment and perceptions of limited professional opportunity in his technical account position at the software company became motivating factors for graduate school ambition. Contemplating his future, Kaleb thought, “Grad school and the GRE is like my path to a better future.” While graduate school may open doors for Kaleb, he is also conscientious of competition within Silicon Valley professions and lack of diversity therein. He is skeptical of public proclamations of Silicon Valley technology firms’ diversity and inclusion initiatives. He views these statements as insincere.

My specific field is so competitive I don't think it matters, it does not make a difference if you're Black, White, Asian you're not getting any help, and sorry, but I feel like White people think that, you know, affirmative action is so much more prevalent than it is.

Kaleb continues to pursue his graduate degree and remains hopeful that he will attain a job in Silicon Valley that will challenge him, even in the context of competition and perceived insincerity of Silicon Valley firms’ diversity and inclusion efforts.

Dewayne perceived the study of computer sciences as a route to social mobility. He pursued computer science as an undergraduate student and worked in Silicon Valley technology firms for

several years before he decided to pursue graduate school in Computer Science. He aspired to the computer science profession early on at the start of his undergraduate career. He believed his education in computer science would lead to gainful employment. Dewayne recounted how he searched for undergraduate majors before choosing computer science. Dewayne wanted “immediate employment”. On his early decision, he said, “Okay, so it was purely economic, find a profession, where you could get gainful employment as soon as you get out of school...so I made that decision, right from the get go.” Dewayne aspired early on to pursue a career that would benefit him economically. He understood the labor market in general, that finding a good job after graduation was not a guarantee, and pursued computer science to better position himself for the workforce.

Mia aspired to computer science (CS) as an opportunity for a high wage profession and pursued graduate education in this field for its potential for economic and social mobility. Mia considered engineering early in her academic career and viewed the potential for a stable profession as an engineer in a governmental agency; however, she chose to pursue computer science because she perceives the field as an opportunity for prosperity. Mia said:

CS is lucrative. You can go for CS, and it's not even that hard... ..electrical engineering was the thing, because there are government jobs involved in that and stuff. I went for CS, because I found it more lucrative.

Kirana shared the perspectives of participants in this study, viewed computer sciences as potential for social mobility and a high wage profession. Kirana contextualized her perspective within the realities of the cost of living in the Bay Area. Furthermore, as a current professional in the field, Kirana is confident in her ability in the field and finds enjoyment in this work.

Well, I think, you know, obviously, living in the Bay Area, you hear about, you know, software engineers getting paid more. But I also felt that I was pretty good at it. So, um, you know, seems like the best way for me to, you know, earn an income and also have fun.

Each of the graduate students in this study view Silicon Valley technology professions as opportunities to advance in life. The participants possess aspirational capital in their pursuit of a graduate degree and advancement in their chosen professions. They demonstrate a similar understanding that their graduate education experience may be a route to social mobility in the context of the Bay Area professional landscape. Aspirations and motivations to pursue graduate education in computer sciences or engineering are important features of the graduate student lifecycle. Universities are better positioned for nuanced outreach and recruitment efforts with an understanding of aspirations and motivations to pursue these disciplines.

### **Familial Capital and Graduate School Aspiration**

The eight participants in this study share similar experiences, often early in life, of family influence on their academic trajectories. Family support and influence shaped early interest in computer science and engineering through play and exposure to technology. The narratives presented here are evidence of this aspect of the graduate school experience. Robert, Ayesha, Mia, and Kaleb viewed their parents as role models who nurtured academic and professional trajectories. Ayesha and Robert provided detailed insight into their view of parental role models that broaden an understanding of familial capital. Ayesha attributes her academic trajectory to her father; he was insistent and supportive of her pursuit of engineering and supported her financially throughout her graduate degree. Similarly, Robert attributes his academic pursuits to his mother; he witnessed her pursuit of a master's degree as a child, which sharpened his belief in the value of education. Extended family influence impacted experiences of Kaleb, Mia, Miguel, and Robert. Moreover, spousal support is a common feature of familial capital among married participants, Mia, Dewayne, and Robert. Family networks emerge as critical to persistence through a graduate degree program. Yosso (2005) advances the concept of "community cultural wealth" as a challenge to deficit thinking, an aspect of dominant cultural

reproduction of the status quo in education institutions. Yosso argues for understanding “the empowering potential of the cultures of Communities of Color” (2005, p. 76). Historically marginalized students bring a wealth of assets to higher education and it is incumbent on higher education institutions to expand views of qualities and attributes of students who are the “right fit” for a graduate program. Familial capital is a central tenet of this concept; delegitimizing deficit-based assumptions of historically marginalized minority students. Familial capital is an asset that all the participants in this study possess. Yosso’s (2005) definition of familial capital encompasses familial and community bonds that shape one’s critical consciousness and moral commitments to society.

### ***Family as Sources of Aspiration and Motivation***

Influenced by Yosso, recent scholarship in this area focuses on assets communities of color possess in the form of familial capital and moves away from a deficit lens. Posselt et al. (2017) and Burt and Johnson (2018) situate their research within this anti-deficit lens and argue successful URM and female graduate students become role models. This research offers evidence of the impact strong family support has on URM and female graduate students as they persist in STEM graduate programs (Burt & Johnson, 2018; Charleston et al., 2014; Posselt et al., 2017). Familial capital is an asset. Furthermore, Burt and Johnson (2018) find families cultivated an early interest in STEM, and a “majority of participants in this study attributed their current progress in engineering to family members’ cultivating and maintaining their interest in STEM at early ages” (p. 262). Similarly, Charleston et al. (2014) found parental and familial support influenced decision-making toward the computing sciences among participants. Familial capital is an emergent theme across eight instances of participant interview data. Spousal support emerges as a more intimate form of this capital. Each of the eight participants in this study are



reflective on their family's role in academic pursuits and identify family as a source of inspiration and motivation.

Ayesha described her choice to pursue engineering as an undergraduate major as a choice heavily influenced by her father. This influence continued through both her undergraduate and graduate degree programs. Initially, they debated the usefulness of her first-choice undergraduate major. Ayesha wanted to pursue journalism, but her father was insistent on engineering. Ayesha Shared this story of her father.

'He said, finish your engineering first. Get your bachelor's and then go and pursue journalism.' My father had nine siblings; my grandfather was the only one earning in the family. They had resources, but not many... My father had a diploma, an associate degree. So, he started from like, you know, very basic ground. Not a very wealthy family, and he, you know, now he's a general manager. He has like, 200 people working for him. I mean, for him, it was not easy to get to that point. And he was not privileged enough.

Ayesha has strong positive male influence on her academic pursuits; this influence later translated to Ayesha pursuing a master's degree in Electrical and Computer Engineering instead of journalism. In an industry and academy that is male-dominated, this strong familial influence ensured Ayesha persisted through her degree programs. Her father understood the benefits of education in an engineering discipline and perceived its pragmatic route to a stable and potentially prosperous profession.

Mia, similarly, possesses strong familial capital and attributes a significant degree of her inspiration and motivation to persist in computer sciences to her husband. She tried to articulate what she perceives to be a contradiction of wanting to be part of change, to change the lack of women representation in computer science professions in the Bay Area and her leaning on her husband. Mia's husband is also in the field of computer science and provided an incredible amount of support and mentorship. Mia is both conflicted and inspired by her husband's influence on her computer science education. Mia shared:

So, I wanted to pursue a master's because I had an undergraduate computer science degree. Why not do more than this? ... So, like, then I wanted to get into it. My husband helped me a lot to learn more about coding and programming. I'm going to put my female only thing here, but before I dive into it, what really inspires me is my husband. We're standing in this coding world and I never thought that I would be doing a computer science masters. He actually sits with me to explain things to me.

Mia shared that her husband is a role model. On this point, she elaborated on her internal contradictions.

I feel like there are not many women, YouTubers, or like these famous people on the platform that females can actually learn from. Whenever I Google anything, like how to do this, how to do that, a man comes up and he is like teaching us. There are no women. We are lacking a lot on that side.

Kaleb's mother was instrumental in his early interest in computers. He shared that his mother bought him a computer at Costco at an early age, which he attributed to influencing his early interest through play in computer science. In addition, Kaleb acknowledged his family in the Bay Area is an important network. Not only did he pursue his graduate program in the Bay Area because he wanted to be in the middle of a prominent technology hub, but also his cousins work and live in the Bay Area. For Kaleb, his cousins form a meaningful network and inspire his academic and professional pursuits. Kaleb shared:

I have cousins you know; I've moved there, I have two cousins, one works, he worked at Apple for eight years and now he's at a startup. I have another one that works at Credit Karma. But I feel like I got to take advantage of my you know my family and the situation and everything you know that's there. There's just too much for me to ignore in that area. My network, I guess, is my family and it's pretty small, but it would count, you know.

Kaleb viewed members of his family as role models and individuals who will help him navigate the post-graduate degree professional landscape. These role models are important in his choice of his Bay Area CSU graduate program, and looks to them for support and networking potential.

These role model relationships have also influenced Kaleb to act in similar ways to younger

members of his family. For Alex, this mentorship is paid forward. He shared his stance toward encouraging a younger family member to pursue computer science:

Yeah, so... I tell my little cousin you just have to be half decent at math. Literally, can you do one plus one, one times two, one divided by two. Yes, you're smart enough in math to do computer science. That's it.

Kaleb attempted to demystify computer science professions and to encourage one young family member to develop interest in Computer Science. In Kaleb's narrative, the familial influence circulates from mentors to him and from him to mentees. Kaleb's family is a source of motivation to persist in his graduate program.

Robert shared his perceptions of how family friends helped develop an early interest in computers, similar to Kaleb, through play. Robert benefitted from his parent's community network. A close family friend worked at IBM in the 1970s and 1980s, and Robert was exposed to Silicon Valley professional culture early in life. He recounted:

My parents had friends, family friends, and one individual that had a job at IBM and worked at IBM very early on in the 70s, and lived in San Jose. They have a son who I was friends with, older than me, I'd go and I'd play over at their house with them...  
...And they had a lot of technology back in the late 80s, early 90s. And that's where I was really exposed to, you know, PCs and computer technology, a lot of that.

Robert understood early on that seeing Black people in the Silicon Valley technology arena was rare, and this had a profound impact. He could see himself in the Silicon Valley technology culture.

My parent's friends, they're, Black. Like at an early age, that's what I saw, these black people with this technology and doing things and I think I think that image could be presented more. Yeah. We don't really see that too often.

Moreover, Robert benefitted from second generation status and drew inspiration from his mother, who pursued graduate study. He said, "I always, you know, always aspired to go to graduate school. And my mom went to graduate school. You know, I kind of saw her as a role model, if

you will. Additionally, Robert benefited from role models in his extended community. He shared his opinions of his friend who is also a source of motivation and inspiration:

He's a PhD student at UC Davis right now in computer science. And whatever way, he makes it look easy. He's, he's just, he's just brilliant. And, every time he just, he touches something, or even does something. I'm like, oh, man, like, if I could, like, try to work to get somewhere near there. That's, that's, that's the, that's the pinnacle. Yeah, he just inspires me to really work harder and, and really push myself.

The narratives presented here are in accordance with findings presented by Burt and Johnson (2018), where, a “majority of participants in this study attributed their current progress in engineering to family members’ cultivating and maintaining their interest in STEM at early ages” (p. 262). Familial capital, a participant asset, is an important feature of their graduate education experience.

The role a participant’s spouse plays in one’s persistence through graduate school is a feature of familial capital that should be emphasized. Graduate students in this study who are married attribute their inspiration, motivation and source of support directly to their spouse. Mia characterized her husband as a teacher and mentor who helped develop her confidence in computer programming. Robert acknowledged that his wife played a significant role in helping him balance his professional and academic roles with family life, especially in the final semesters of his graduate program when the coronavirus pandemic forced workers and students into remote confines of home. Robert shared:

You know, my wife and I were stuck at home in our two-bedroom. Then we have our daughter too. And she's there. I'm trying to work and her room is my office. And I'm doing school too. That was difficult... You know, I'll be honest, I burned out. I burned out really bad, and, you know, I joke with my wife. I say, ‘you know what, I think I think I had a midlife crisis.’

Robert’s wife encouraged him to find balance and practice self-care. He explained that he no longer logs into his computer on Saturdays. He forced himself to break away from the computer to rest and refresh from the demands of his academics and profession. Similarly, Dewayne

attributed his support structures to his wife. Dewayne balanced graduate school and family life, including taking care of his four children. He said, "I have support from my family. My wife is a huge support. If she wasn't there supporting me, I don't think I'd be able to pull it off." The three married graduate students in this study lean on their spouses for a level of support that is not seen in the extant literature. Spouses are characterized as critical sources of support, directly and indirectly contributing to persistence and academic success.

Posselt et al. (2017) presents a case study on an Applied Physics program that instituted a "family like atmosphere" (p. 20). This family-like atmosphere developed to ensure the success of the historically underrepresented minority and female students intentionally recruited into the graduate program. Family viewed as an asset to the graduate education experience is an overlooked network, a source of support and motivation for participants in this study, and an essential characteristic of the Bay Area CSU computer science and engineering student participant experience of the graduate student lifecycle.

### **Boundary and Barriers to Graduate Study**

The traditional graduate admissions experience is bounded by academic disciplinary norms and cultures, selective in admission, embracing a competitiveness toward best fit candidates (Posselt et al., 2017). In the United States, students must prepare a discipline specific portfolio of achievement that includes undergraduate academic records, personal statements or letters of recommendation, resumes, and standardized tests such as the Graduate Record Exam (GRE) (Denecke, 2004). The graduate study application process across the Bay Area CSU campuses is similar to the process described by the Council of Graduate Schools (Denecke, 2004). The application process requires significant preparation time, tapping a network of faculty or professionals to comment on one's academic preparation, presenting oneself as a "good fit" for the graduate program or academic department, and competitive standardized test scores.

Selectivity is determined by graduate faculty in the discipline. Gaining admission to a graduate program is a significant milestone in one's academic trajectory.

Overcoming barriers that delayed graduate school pursuits is a common experience among six of this study participants. Graduate programs that did not recognize the value of interdisciplinarity imposed a barrier, and several students experienced rejection by their first-choice university. Resilience, self-efficacy and determination are shared characteristics revealed through cross case qualitative analysis. Participants hold various, yet critical views of the Graduate Record Exam (GRE). They identified key faculty mentors who ensured entry into graduate school, and several students received conditional admission offers resulting from a holistic approach to application review.

Education research on URM and female students in STEM graduate programs present a case study that calls for rethinking the traditional selection methods (Posselt et al., 2017). Posselt et al. (2017) offer evidence that alternative approaches with intention to diversity STEM graduate programs, can be successful. This research suggests a broader lens is needed to achieve diversity, a lens inclusive of values, professional experience, research experience, or a multidisciplinary focus (Posselt et al., 2017). The traditional graduate admission selection process may be a barrier or deterrent for minoritized and female students in STEM fields. In Posselt et al. (2017 study, faculty "observed a record of success among students whose profiles differed markedly from the conventional achievers privileged in graduate admissions (Posselt et al., 2017). This recognition helped broaden faculty members' conception of the ideal applicant's profile."

Other barriers are identified in parallel research. Burt and Johnson (2018) identify deterrent effect of "weed out" courses aspiring students must overcome at the undergraduate level. Weeding out, "creates deterrents that are realized early in one's academic career. Graduate

student participants in this study identified pivotal courses that influenced decisions to pursue graduate school; amplifying these courses while minimizing the “weed out” effect is critical when adopting a comprehensive long view for diversifying STEM graduate programs.

Kaleb and Mia were rejected from the first choice Bay Area CSU campus, and expressed regret. Nevertheless, they were resilient and both did gain admission to another Bay Area CSU graduate program. Both participants were critical of their own academics throughout their undergraduate programs and experienced courses that became barriers to computer science graduate program aspiration. Experience with weed out courses is an emerging theme in this study; consistent with prior scholarship on historically marginalized and female graduate students in STEM disciplines. The “weed out” course experience presented here became more of a hurdle, rather than a barrier for Kaleb. Kaleb Shared:

I think actually the number one barrier for programming is the first class. I think that's the big thing; the difference between your first programming class to your second is gigantic and you just gotta push through it, no matter how bad you did on that first class.

Kaleb enrolled in a “weed out” class during his time at the University of California before leaving for a community college. He was unsuccessful at this first attempt, but persisted through the second attempt and subsequent sequenced courses while at the community college. His level of determination, rooted in aspirational capital, self-efficacy and resilience, is evidenced by his return to the University of California to complete his undergraduate degree. Burt and Johnson (2018) pose a counter argument for weeding out; that such courses could be restructured to build “foundational knowledge” (p 259), rather than play such a determinant role in one’s academic trajectory. Kaleb may have had an early route into computer sciences with courses structured in a manner suggested by Burt and Johnson (Burt & Johnson, 2018).

Participant experience suggests graduate faculty did not embrace interdisciplinarity of their undergraduate academic preparation in relation to the graduate program. Alex was prevented

from exploring computer science courses in his senior year of study due to a university policy of undergraduate unit caps for degree requirements. Lack of access to undergraduate computer science courses became a barrier to graduate school and delayed his eventual degree attainment. Nonetheless, Alex received an offer of admission that included a series of prerequisite courses because faculty did not recognize the interdisciplinarity of his undergraduate major to computer science. He persisted through prerequisite courses at the graduate level because that was his only option to transition into the field. These prerequisites extended his time to a graduate degree and increased the cost of the program. Alex remained resilient in his pursuit of his computer science degree.

The concept of interdisciplinarity in the Computer Science field became a topic of conversation with Mia in the in-depth interview. Mia mentors her brother on his attempts to gain admission to the same degree program. Mia understands how computer science intersects in multidimensional ways with the economy and society. She Shared:

My brother, he did his undergrad in law and management, yeah, a lawyer and now he wants to pursue computer science. So, I went to a few of the meetings with him and I understood that for CS people, this is a very good thing because they are coming with their own knowledge of that domain. That's the whole point of Tech. Tech is like helping people solve things that take too much time. But you know, what's the bad thing about it? He wanted to but he doesn't have a degree related to CS. Yeah. He wants to apply to this university, and they won't accept him. Universities don't accept applicants who are from nontraditional backgrounds.

Mia sees opportunity in the field of computer sciences at intersections of all academic disciplines. Moreover, Mia viewed computer sciences and technology as influencing all facets of society, holding creative potential to solve problems. The lack of recognition of the value of interdisciplinarity of the computer science field is of concern for Mia. She interpreted this as a lost opportunity for the university.



Participants in this study faced barriers to admission when academic departments overlooked interdisciplinary potential in the recognition of undergraduate preparation in disciplines outside computer science or engineering. Kaleb struggled early on in his undergraduate career at the University of California. He did gain admission to a Bay Area California State University computer science graduate program, but was required to do pre-requisite courses, extending the duration of his 30-unit degree program. Kaleb recounted:

So, I had to go to community college after failing at the University of California. I said, I'll be a CS major; I'll transfer and do computer science. I didn't get a high enough GPA to do the TAG [Transfer admission guarantee (TAG)] the transfer guarantee. So, I didn't get accepted anywhere for computer science, but I was in a rush to get back into a UC. So, I just, I just said; take me for math. Fine, I'll do math. I didn't like math, but they don't let you transfer to computer science, so I said I'll do stats.

Kaleb was prevented from pursuing computer science at the undergraduate level at the University of California due to the GPA requirement for transfer students into a computer science major. His undergraduate degree became a barrier to graduate study; however, the admitting Computer Science department offered a path to admission through a series of pre-requisite courses.

The Graduate Record Exam (GRE) is a traditional feature of the graduate school application. However, recent critique of the GRE as a barrier or deterrent and correlative studies suggest it may no longer be beneficial to the graduate admissions process. Scholars argue the test is a barrier or deterrent (Posselt et al., 2017). Moreover, educators committed to diversity in graduate education, particularly in science and technology, present evidence of limited correlation between high GRE scores and academic success of graduate students in health care and science and technology disciplines (Sealy et al., 2019). All three Bay Area CSU university CSE graduate programs require the GRE exam at the point of application submission. The GRE exam component of the graduate admissions process was experienced differently across participants in

this study. Mia, Kirana, and Ayesha had to take the exam multiple times, and bought Educational Testing Services (ETS) study materials, a costly endeavor.

Ayesha recounted costly test preparation and the need for retaking the GRE to present a competitive application. “I took the GRE exam twice. The test was good. My first one was not good.” Mia Shared a similar experience, she said, “I took the GRE multiple times.” Her GRE score resulted in her rejection from her first choice Bay Area CSU campus. The time restrictions for each component of the GRE exam were problematic and the entire experience was stressful.

Mia Shared:

It was really confusing for me, because I think at that time, I realized I know I'm not a really good test taker, because it takes my brain time to adjust from one domain to another. So yeah, it was tough for me, like with the time instruction, it was really, really tough for me” ... “...I was living in Pittsburgh, and I was sure I'd be coming to the Silicon Valley area. So, I applied to many universities where my score, like my score was 310. So, I tried to filter out the university that accepts a 310 score in computer science.

Miguel shared his struggle with the verbal and writing components of the GRE exam.

Miguel, an immigrant from Mexico, identifies as a non-native English speaker, which impacted his test performance. Miguel shared:

The writing part. I think it's one I have a little more issues with, and I guess, just because English is not my first language and you have to structure your ideas in a certain way that some natives have and sometimes people, not natives, maybe we don't have it. Yeah. So, I think I had more difficulty.

Miguel had a strong mathematics and engineering background from high school through his undergraduate degree. His story is unique amongst study participants, but is evidence that the GRE exam is not relevant or useful in predicting one's ability to succeed in a graduate degree. Furthermore, the GRE exam is not designed for non-native speakers and in this instance poses significant barriers for students in similar circumstances. Miguel excelled in his graduate program, arguably the GRE test was irrelevant in demonstrating an academic profile acceptable to a graduate program admission committee.

Alex shared his critique of the GRE test. After graduating with a master's degree in computer science, he joined his campus computer science department as a part-time lecturer simultaneously pursuing a career in software development. Alex is in a unique position as a lecturer in the graduate program and as a professional in the industry. This position shapes his opinion of the GRE. He said, "The GRE is not relevant, it should be LeetCode style questions." LeetCode is an industry specific platform for programmers to develop related skills (LeetCode, 2022). Alex believes this method of assessment is more relevant to contemporary computer science in academia than the traditional GRE.

Many universities suspended the GRE exam for use in graduate school admissions at the start of the coronavirus pandemic, and Dewayne used that as an opportunity to move forward. Dewayne did not want to go through the time to study and the expenses associated with taking the GRE. He had taken the GRE once in 2003, scores since expired. Dewayne said, "When the pandemic set in, I felt, okay, I have to take the leap right now. I had been procrastinating on it." Dewayne benefitted from a computer science department's willingness to consider his years of professional experience and expired GRE score instead of requiring a new test.

One huge thing was the GRE. I had done the GRE sometimes in 2003 and when you look at the admission criteria, every school said, 'oh, we need the GRE'; you will need the general; the GRE criteria, it wasn't upfront. I put in the application and if the GRE becomes a stumbling block; dang you know, you now have some fire under your feet, and so I put it in. I guess my years of experience probably was a factor. The need to take the GRE was sort of laid back a little bit.

The computer science program at Dewayne's Bay Area CSU campus opted for a more holistic approach to graduate admissions, which resulted in his offer of admission without a current GRE exam.

Kaleb is the outlier in the study. A confident Black man who characterized himself as one who did not put effort that matched his capabilities into undergraduate studies. He had no fear of

the GRE exam. On the GRE, he said, “I’m conflicted because on the one hand, studying for the GRE was almost, one of the most fun things that ever done for school.” But he was conflicted over the GRE because it was a significant determining factor for his future ambitions. He understood the GRE to be a significant factor in his graduate school application. He said, “I was stressed about the GRE but the reason I was so stressed about the GRE was because I so badly wanted to escape my current situation.” Kaleb was employed in an unfulfilling technology role at a software engineering company. Kaleb had low undergraduate grades and viewed a high GRE score as a mediating factor in graduate school admission. Other participants in the study did not share Kaleb’s confidence. The test was costly after multiple attempts and they did not receive admission from their first choice Bay Area CSU.

Faculty mentors at the undergraduate level play a significant role in aspirations of historically underrepresented minority student pursuits for advanced degrees. The positive faculty mentor-mentee relationship in the success of historically marginalized and female graduate students in STEM disciplines is critical to gaining admission to graduate programs. Furthermore, faculty mentors have significant influence in one’s identity as an emerging scientist directly influencing decisions for graduate education (Charleston et al., 2014; Eagan, 2014; Singer et al., 2020; Stachl and Baranger, 2020).

Alex shared he was able to develop relationships with key faculty mentors who helped him navigate the graduate admissions process in the computer science department at his Bay Area CSU campus. He said, “some of the faculty and they were pretty helpful.” Alex is now able to write recommendation letters for undergraduate students in his role as a lecturer in the department. Kaleb Shared his experience with a professor at his University of California campus who wrote a letter of recommendation for him. He developed a relationship with her by showing

up to office hours repeatedly. He indicates that his grade for the class was average, but the relationship was meaningful. The professor became his advocate.

Faculty mentors helped facilitate the graduate admission process for Alex, Kaleb and Kirana, paving the way to submitting a competitive application for graduate school. Kirana benefitted from a solid network of faculty that developed from her undergraduate research experience at the same campus as her graduate program. She recounted:

I think it was very easy for me, because I had a lot of professors, most of the professors know me. So, it was pretty easy to get them to be willing to write a letter of recommendation, and then, once they did that, it was pretty easy. And it was pretty quick that I got the announcement. So, I stopped applying everywhere else because I got the admission.

Faculty mentors directly influenced access to graduate education for Alex, Kaleb, and Kirana in significant ways. The faculty are characterized as advocates and important to gaining admission.

Posselt et al. (2017) critique traditional graduate school admission selection and offer evidence of successful alternative approaches established specifically to diversity STEM graduate programs. Successful approaches include flexibility admissions requirements, a holistic assessment, and a reflexive stance toward academic department norms and culture. These researchers argue in favor of rethinking the graduate admissions process. Dewayne, Alex, and Kaleb, did benefit from graduate program flexibility with admission requirements. Dewayne's Bay Area CSU campus accepted an expired GRE score and his significant professional experience in software engineering as an alternative to a current GRE score. Alex and Kaleb gained offers of conditional admission because their undergraduate preparation did not align with department admissions criteria. Although they had to successfully complete prerequisite courses, they were able to pursue a graduate degree in computer science. Kaleb Shared that his GPA at the University of California was not as competitive as it could have been, his GRE score was very high and likely influenced the department decision to admit him. Kaleb recounted his desire

to pursue graduate study at a Bay Area CSU, disclosed he was denied by his first-choice campus.

Kaleb Shared:

My GPA was terrible in college, my GPA is great now. It's cool, it's great, you know I actually try. Every single class I try, but I just wanted to get into a school. I said I'll take any state school in a tech hub focus area that has a program that's not, you know, terrible; it just needs to be average or better.

Kaleb enrolled in prerequisite courses and continues to push through his coursework. He possessed high GRE scores and was willing to prove himself to the admitting computer science department by enrolling and successfully completing prerequisite courses. He demonstrated reflexivity in his approach to undergraduate studies, and acknowledged that he did not push himself the way he should have. He is a more determined graduate student.

The eight graduate student participants in this study recounted their experiences and perceptions of the graduate admissions process. The experiences shared here align with the current scholarship. Students in this study faced barriers when interdisciplinarity was not valued or recognized at the point of graduate admission selection, they struggled with “weed out” courses early in their undergraduate career, held mixed experiences with the GRE exam and question its’ value, identify significant faculty mentors who encouraged them to pursue graduate school, hold a critical lens toward graduate admission in that academic departments must demystify the profession moving forward. The GRE remains an impactful milestone in the admissions process, but is contested by students who succeed in the program. Faculty mentors paved the way for participants through direct advocacy and advising. Noteworthy here is the critical awareness several students hold of themselves and the process as they were inducted into their respective academic departments. Students in this study demonstrate resilience, self-efficacy and determination.

## **Funding Opportunities for Graduate School**

Funding graduate education is a significant factor in degree attainment. Robert is still in the process of repaying his undergraduate student loans, a factor that motivated him to choose a CSU campus for graduate school rather than a UC. Dewayne and Kirana had to delay graduate school due to economic circumstances. Kirana experienced a stop and start progression through her degree program due to her financial circumstances. Mia explored the scholarship application process, a source of frustration, and gave up. Ayesha and Kirana were offered the opportunity to teach undergraduate courses as a Graduate Teaching Associate (GTA), which mediated some cost for the tuition and fees, and informed their graduate research focus. Alex benefited from a committed faculty mentor who helped him find a critical internship.

Research on historically underrepresented minority and women graduate students in STEM disciplines focuses on limited funding opportunities as barriers to graduate education. Funding opportunities for graduate school increase participation, persistence, and completion rates, particularly for historically marginalized students, and grant aid specifically increases the odds of degree attainment (Goldrick-Rab et al., 2016; Kim, 2012). Stockard et al. (2021) student survey data suggests women and URM graduate students are not afforded funding opportunities at parity with male non-minority peers. Kim (2012) minority and female students may not likely pursue graduate education without such aid. Furthermore, graduate programs that secure funding or assistantship opportunities are better positioned to attract and retain URM graduate students. Eagan et al. (2013) underscore the importance of faculty mentors securing funding opportunities through federal agencies, such as the National Institutes of Health (NIH) and the National Science Foundation (NSF) in order to increase the representation of American Indian, Black, and Latino students in STEM graduate programs.

Dewayne wanted to pursue graduate school sooner than the present moment, but funding became a barrier that delayed his start. He said, "Graduate Studies it's not something I made a decision to get into right now, I had always wanted to do it, but then economic situations wouldn't permit it." Kirana experienced economic situations that delayed her degree attainment as well. Kirana returned to her graduate program after several years. She had to leave her program and delayed restarting because she was laid off work and could not find alternative funding opportunities.

In 2017, when I was laid off, I had dropped out. Then when I got laid off, I was thinking, okay, you know, and just before I got laid off, I was managing a website. So, I got curious about that. And then I had all of my engineering and math and chemistry background, because when I first started college, you know, engineering was my major, but I never finished because of, you know, economic issues.

Mia expressed frustration with the lack of scholarships on offer and the process for which one would have to go through to obtain a scholarship. Scholarships supplement a student's means to pay for graduate education. This aid mediates the anxiety students face when moving through their graduate program. Mia spoke about the lack of scholarships within her computer science program, and expressed astonishment in the context of the prosperous Silicon Valley, that there is such a lack of supplemental funding opportunities. Mia shared:

As a tech graduate student who wants to apply to scholarships that are in the department, to my surprise, there are none. Like none, in terms like out of 1000, There are just three for tech students and for those scholarships you have to write so many essays and stuff like that. Like, I don't really have time for essays, because that's not my domain, either give me a scholarship based on some project, or based on how I did in my courses or anything tangibly related to my work.

Mia identified a misalignment in the scholarship awarding process. Rather than scholarship award issuance conducted in a manner related to current project work or grades, the writing of essays presented a challenge, a barrier, a process viewed as outside the scope of disciplinary norms. This represented a hurdle she could not overcome because she did not have the



confidence to write in a manner that would successfully help her score a scholarship. She did believe other factors would make her case, project work and grades.

Fernandez et al. (2019) indicate graduate students who held research and teaching assistants were more productive in their academic discipline than other students. These students persisted. These assistantships offer URM students access to funding opportunities and may shape the scientist identity in significant ways as they progress through a graduate degree program. Ayesha and Kirana speak about their experiences as a GTA. This role amplified their graduate education experience and influenced their final research projects. Both students had to move to remote teaching during the coronavirus pandemic, as universities around the country move to remote teaching modalities. They struggled initially, as did their professors, but describe success in adapting to this new way of teaching after the spring 2020 semester. Charleston et al. (2014) identifies successes “in computer science when academic departments provide apprenticeship opportunities” (Charleston et al., 2014, p. 236). Ayesha and Kirana share a perception that their role as a GTA amplified the quality and opportunity of the graduate program.

### **Peer Networks and Academic Socialization**

Supportive and collaborative peer networks amplify potential for success in graduate school and adapting to academic disciplinary norms (Charleston et al., 2014; Fernandez et al., 2019; Stockard et al., 2021). Positive peer networks and academic socialization in higher education evince a surrogate manifestation of community cultural wealth, an extension of family and community. Participants in this study acknowledged the commuter school characteristics of each of the three Bay Area CSU campuses as a limiting factor for engaging with peers and faculty in meaningful ways.

With the exception of two participants, the coronavirus pandemic impacted academic socialization, opportunity to build peer networks and develop in-person relationships. The

graduate school experience became an isolating experience because of the pandemic. The impact of the coronavirus pandemic is analyzed in sharper focus in forthcoming discussion. However limited, the resiliency and adaptability of the graduate students in this study nonetheless, provide a snapshot of the state of academic departments and peer networks in computer science and engineering disciplines at Bay Area CSU campuses.

The qualitative analysis of in-depth interview data suggests that, in general, peer networks were not strong throughout the participants' graduate program and academic socialization was secondary to other aspects of their graduate school experience. Kaleb shared frustration with the state of academic socialization and peer networks in his computer science department. Group work is a feature of many of the assignments, and he characterized these experiences as lacking a cooperative approach and shared responsibility. On programming assignments, Kaleb shared frustration in explaining how cooperation is necessary:

That's not how programming works... ..It's incredibly interdependent. You know, if your part doesn't work, and I asked you to do that, then that guy doesn't... ..Nothing works, so I got to do everything. So, we're done with milestone one; I've done everything now; milestone two... You don't understand what we did, for the first milestone, because I did it yeah so, the only way to make progress would be for me to explain everything, right, so I'm spending my time, you know, trying to catch other people up when I could just be working.

Kaleb is resilient and highly motivated to succeed in his graduate program. In group work, he led project work, but often carried the weight of his peers. His negative experience is a burden, but he persisted nonetheless. He remained confident in his intellectual ability and was self-reliant when others did not fulfill group obligations. He did not enjoy the group work project. He said, "It's just so drastic here. I mean, how different your experience can be based on your group, how stressful to my mental health. I was depressed as hell last week because I wasn't making progress."

Peer networks reinforce identity formation processes and pose challenges for individual students in STEM graduate programs. Fernandez et al. (2019) argue graduate students “must learn not only to cope with academic demands but also to recognize the values, attitudes, and subtle nuances reflected by faculty and peers to succeed in their new environment” (p. 1). In Kaleb’s scenario, he recognized values and attitudes that do not align with his approach to academics. These peers are disruptive to his performance in the course. He coped by doing extra work or spending time explaining things to classmates. This added pressure and responsibility impacted his mental health.

Kaleb, Dewayne, Robert, Mia, and Kirana described the effective usage of social media platforms that mediated peer networks within their respective academic departments. These platforms provide a space to engage outside the classroom. These platforms became more important for some during the pivot to remote instruction on the onset of the coronavirus pandemic. Participants in this study used Discord, Slack, Twitter, and WhatsApp to engage with classmates and faculty in their various graduate programs. Kirana explained Discord:

It's kind of like Slack. Yeah, each group can open a channel. And it's by invitation only. So, it's private to the group in that link. Okay. Yeah. But it's just another slack...  
...Discord. Not just our department, I think, I think the university uses it, but like, yeah, computer science kids. Yeah, they use it a lot. I think it's popular for people who play games. Yeah. So that's, that's how it started? I think.

Kaleb shared opinions of his friend who he interacts with on Discord, a classmate who he looks up to in his graduate program:

I have friends, you know, on discord groups that I, you know, people that are doing great. I try to follow their lead. There's another guy in my program doing his master's in CS. Yeah, and I see how hard he works with the code and basically like he's programming 10 hours a day.

Kaleb, similar to other participants in this study, integrated the use of communication platforms and social media to replicate the peer engagement throughout the degree program.

Both Alex and Miguel had on-campus opportunities for peer networking and academic socialization; however, the commuter school characteristics of their CSU campuses prevented deep engagement. Alex described the commuter school characteristics of his Bay Area CSU campus and said:

I wish I would have gotten more. In my opinion, the connections you make are very, very valuable. I understand there are some hurdles because [Bay Area CSU Campus] is a commuter school, but I still wish I would have had more group work and interactions with other students and faculty.

Similarly, Miguel recounted his experience with peers as impacted by the commuter campus characteristic. He understood his graduate degree program and course schedule was designed to accommodate working adults, and did not translate to strong peer engagement. He perceived his classmates as disinterested in academic socialization opportunities. He said:

People that I saw in my program that were really, really, isolated. Yeah, they just came to class and would leave. We wouldn't know who they were, what they were doing. They weren't just like sitting, leaving, not talking to pretty much anyone.

Over the course of his graduate degree program; however, Miguel did find a small network of peers in his academic department. This group formed organically because fellow students enrolled in the same courses; Miguel's peers intentionally sought out relationships and support without direct influence of graduate faculty or through spaces provided by the academic department. Nevertheless, Miguel perceived this informal group formation as positive and lasting beyond his graduate education. He said, "actually, in my previous employment, I realized I was working with like three of them." Miguel's experience, similar to Alex, is indicative of a commuter campus culture, and represents opportunity for academic departments to reimagine social spheres for students.

The use of digital spaces and social media communication platforms may be an asset to the commuter school campuses post-pandemic. Alex would have liked more peer interactions and

the ability for deeper engagement, but the nature of the commuter school campus, his experience as a commuter student, prevented deeper engagement. As the pandemic has shown, there is potential to enhance student engagement opportunities through the use of digital spaces and social media communication platforms.

The graduate students in this study share similar perceptions of academic department climate that reveal how they experience graduate education at the three Bay Area CSU campuses. Stockard et al. (2021) acknowledge a lack of research focused on the URM graduate school experience in STEM disciplines. They analyzed peer network impact on graduate school and found that URM students, particularly women, reported fewer positive interactions among peers and faculty (Stockard et al., 2021). The students in this study, in general, do not attribute interactions with peers as impactful on their graduate education. The interactions are not described as overtly positive or negative by participants. They share perceptions that the social media communication platforms are effective channels for student engagement, in terms of group work, and such peer engagement is not defined in positive or negative terminology. The students in this study present experiences that suggest graduate programs at Bay Area CSU campuses have opportunity for improvement. Although these experiences have been impacted by the coronavirus pandemic and the move to remote study, there may be opportunities through digital platforms to recreate a robust space for academic socialization, cooperative group work, and new forms for engagement in graduate education. Use of technology to enhance the graduate program academic socialization is an area for future research.

### **Faculty Mentors**

Faculty mentors often mediate acclimation to academic discipline norms and department cultures (Fernandez, 2019; Posselt et al., 2017; Stachl & Baranger, 2020). Faculty mentors who are advocates, are key actors in retention, persistence, and achievement of graduate student

mentees (Fernandez, 2019; Posselt et al., 2017; Stachl & Baranger, 2020). Participants in this study shared experiences with key faculty mentors who were instrumental in inspiring them to pursue graduate school, who advocated for them during the admissions process, and guided them through challenging coursework and thesis projects. “Because graduate students spend most of their time within their department and laboratory” Stachl and Baranger (2020) state, “their sense of belonging is more connected to the few faculty mentors” (p. 28). This statement resonated across participant experiences in this study, particularly in the context of a commuter campus environment and the isolating impact of the coronavirus pandemic.

Ayesha, Alex, Kaleb, Kirana, and Robert shared experiences of faculty mentors who influenced their decision to pursue graduate education, guided them through the selective admissions process, and who have shaped their graduate student experience overall. Ayesha recalled her relationship with a professor who was not her main advisor, but an advocate nonetheless. This professor did not assume the worst when Ayesha accidentally uploaded the test questionnaire without answers, instead of her actual document with the test answers. She shared:

One professor, I know, in our department, I took two classes under him. He's very generous, you know, very polite, very humble. And, you know, I remember once there was a midterm and what I did, instead of the answers, I just submitted the question paper. Any other professor, I think, would have given me a zero grade. But he said ‘Did you submit a wrong paper?’ I mean, I'm a Graduate Teaching Assistant (GTA) myself, right. So, the people who submit the question papers just like that, I mock up zero because that's how I've been instructed, but that professor is like, you know, we're gonna assume a mistake and then he gave me an extra hour or two, if you need it. I said no, no, I have the answers.

Ayesha spoke of this professor as an advocate through two courses in her graduate program. The professor was a key advisor and did not engage in punitive grading practices, but allowed second chances to fix mistakes.

Kaleb shared his experience with pivotal faculty mentors who not only advocated for his graduate school admission, but who are now readily accessible to him throughout his degree program. On support for graduate school admission, Kaleb shared:

Yeah, this is an interesting one, because when I was in person at the University of California; I developed relationships with professors that I needed to. You know, if I was struggling, especially when I go into class, and I remember one of my math classes, I didn't even do that great, but that professor wrote me a shining recommendation letter because, regardless of the grade, I was going to office hours; she knew me I taken three classes with her.

He characterized his experience with faculty mentors in his current graduate program as responsive and accessible. Kaleb's professors use the same social media technology platforms that students in the program use to collaborate and socialize Kaleb shared:

Now, my professors are much more accessible on a minute-to-minute basis because they're on Discord and they're expected to be able to reply. I mean, one of my professors said, if I don't reply to you within an hour, it means that the question you asked is already available in the syllabus or I've already answered it in the Discord. I mean that's, that's literally it. If I can ask him any question, and if, as long as it's a good question he'll get right back to me; one professor is a little bit slower, but the point is like I've never felt so connected.

That Kaleb experienced a high degree of connectedness with his faculty mentors indicates areas of potential in the digital spaces that mediate graduate education advising and activity. The professors in this scenario embraced the social media technologies used by the students to collaborate and connect to do the same in building positive mentor mentee relationships.

Kirana's relationships with her professors are perceived as nurturing and welcoming. She saw her female professors as role models and is inspired by these women computer scientists. Kirana experiences a level of comfort in a male-dominated area because the department faculty is more gender balanced. Faculty mentors played critical roles in inviting her to undergraduate research opportunities, gaining admission to graduate study and mentoring her through her degree program. On her experience in her undergraduate major and applying to graduate school,

Kirana said, “I had done a little bit of research with one of my professors in the undergraduate major, who's also teaching in the graduate program. So that's how I got interested in it.”

When I first started into my graduate program, you know, you're supposed to get a research advisor. So, I did that and my research advisor was always working on projects hand in hand with my undergraduate research advisor that I had worked with. So, I had one, two and three advisors co-advising me. So, I always felt that I had support. I felt pretty good in terms of support.

Kirana's experience is remarkable in that she experienced strong mentorship from women professors. She sees herself, not as an imposter, but as able to do what these professors do. She acknowledged that these professors cleared her path to admission and mentored her through the program.

I think it was just an opportunity that they made. And then, you know, I applied for it. And that in itself kind of, you know, helped me. I think it helped because I saw her as an, you know, she is an Indian person, and she's, she has her PhD. And I think it helps knowing that she was kind of like me. Yeah. And she had an advanced degree that I thought that okay, I could see myself doing that, too.

Kirana perceived her campus computer science department as gender diverse. This feature of the computer science department climate has been a motivating influence.

I think they [the Computer Science Department] have a pretty good diverse selection of women professors; so, I think I, we at least have six or seven or eight, you know, out of all the professors that would advise a research graduate. So, the three that I had; two from the computer science department, one from the psychology department, they're, Asian, and they both had advanced degrees. So, I felt that there was a pretty good makeup. And that was also one of the reasons why I felt comfortable, you know, continuing my graduate program here.

Kirana did not see the same representation amongst her classmates. She is in a male-dominated graduate program. This reality was the same for Kirana in her undergraduate program and in her place of employment as a software engineer. Kirana said, “I left college back in 2000, and there were two women in my engineering class. Then I came back in 2017, and then there were two women in my engineering class.



The faculty mentor is an important influencer of inclusive and diverse graduate education reform. Figueroa and Hurtado (2013) describe a graduate faculty mentor as an advocate, role model, mentor, and resource. Figueroa and Hurtado state, “faculty represent a wonderful vehicle of change when they model appropriate interactional behavior between members of the academic community” (2013, p. 27). From this view, faculty who work closely with historically marginalized and women students, hold potential to reform departmental cultures toward real inclusion.

Miguel’s experience suggests the use of adjunct lecturers in his field of study is beneficial. He shared positive experiences with faculty who also held current professional roles in the field, while he struggled with theory. He characterized his adjunct faculty mentors as committed educators, mentoring students outside the margins of syllabi. Miguel shared:

I always preferred professors that were already in the field because they were, I mean, nothing against people doing research. But sometimes when I had professors that were researchers, they really were like, focusing on one topic like very, very deep. Yeah. And it was kind of difficult to follow them. And then the other ones that were like working in the field were very easy to follow because they were also sharing their experiences. And you know, history, anecdotes, etc. And I felt that was very engaging.

Miguel shared stories of adjunct faculty who integrated leadership discussions into engineering project management courses, who invited industry representatives as guest speakers to seminars. Furthermore, Miguel benefitted from critical and direct feedback from adjunct lecturers on presentation skills, resume and cover letter writing. He said, “they were willing to review your resume, connect you with people that you wanted, like, to talk to, sending, you know, job posts from their companies or their employers”. Faculty mentors engaged in these efforts are committed to student success beyond the course and play a critical role in persistence and success.

The faculty mentor relationship is a significant attribute of the graduate school experience. This relationship, when positive, fosters academic success. This relationship may be even more critical in the intersectionality women computer science and engineering students may experience in a male-dominated discipline. Female representation in the professoriate not only mediates male-dominated cultures, but offers inspiration for further academic achievement. Male professors who are advocates for female students, as Ayesha describes, can also mediate a male-dominated culture by modeling inclusive mentorship.

### **Impact of COVID-19 on the Graduate Student Experience**

The impact of the coronavirus pandemic and COVID-19 on the graduate student experience for those participants in the study who were just beginning, mid-program, or nearing completion of a graduate degree in Computer Science or Engineering is profound. This impact permeates every facet of their graduate student experience. Participants spoke about this impact at points of admission, and after pivoting from in-person instruction to fully remote learning during the early days of the “shelter in place” ordinances invoked by mayors across the Bay Area. Students in this study experienced the biggest impact on academic socialization within the academic department or graduate program, their ability to be fully engaged with their peers and develop meaningful relationships with faculty mentors. The pivot to remote learning in March 2020 flattened the academic department culture into digital spaces of Zoom, online learning platforms, and social media communication channels. The experience isolates students from general engagement with peers, in-person seminars, and group work.

The participants in this study demonstrate resilience and adaptability with the pressures of graduate school in the middle of a global pandemic. These students embraced remote and online instruction. They pivoted to social media channels such as Discord, Slack, LinkedIn, and email. They engaged in Zoom faculty advisor office hours; and conducted group work via video

conferencing. Those participants who held Graduate Teaching Assistant (GTA) positions struggled alongside faculty mentors in adapting to remote and online instructions. Students in this study continued to progress in their degree programs, several of them successfully defended a thesis and recently graduated.

Ayesha began her graduate program in fall 2019; reflects that she was lucky she was able to develop friendships and have group interactions before March 2020. She noted one impact of COVID-19 on graduate education, the, “decreased the social interaction among students.”

Ayesha elaborated on her experience:

I remember previously in my first semester, whenever we used to do these project meetings, it was you know, the, you know, in a room in the library. Booking the room, talking about other stuff. And, you know, not just talking about projects, but in general life as well. But now it is, it's like a Zoom meeting and we just talk about projects and you know, goodbye. No conversation at all, and just having a conversation inside your house [by Zoom] is just not enough.

Ayesha recounted the early days of her pivot to remote instruction and eventual learning to adapt and be successful. She said:

Look, initially, it was really frustrating. Yeah. And I'll tell you, but then when the [pandemic] went on, then, you know, I got in the habit of doing online classes, then it became a comfort...” ...I think it affected everybody's education. But I'll say the impact was not that bad back, I was still able to maintain my grades. I was able to get an internship, so I wouldn't say it affected me in a negative way.

Ayesha is resilient and adaptable. She is a self-directed learner who was able to adjust to remote instruction and the isolating experience in a relatively short amount of time. However, Ayesha did long for campus life. She temporarily moved to Buffalo, NY to be closer to family while she continued through her engineering program. She would walk the public university campus. She staked out less popular places on campus to study by herself. She shared:

COVID impacted our lives. I'm telling you a little bit. I'm living in Buffalo right now. So, we have this University of Buffalo campus. So, sometimes I take my laptop, and you know, when it's, they have a huge, huge campus like, yeah, that's beautiful. So, they have

like, you know, many isolated places where there are no people. So, I'm like, okay, COVID safe. Yeah. That's good there and do some stuff so that I get that campus feel.

Ayesha saw the positive in her position as a GTA in the COVID-19 higher education context and recognizes her fortune compared to other classmates who lost on-campus jobs in the food court due to campus-wide closures.

So, I've been working as a GTA for a long time: you can say like, you know, two years now. So, again, I was fortunate to land this job because COVID had many people who were working on campus and restaurants and cafes lost their jobs. I was working as a GTA and you know, I get the flexibility from working on my computer. And from anywhere I want to, so yeah, so my experience is like, you know, I've been fortunate.

For Ayesha, the GTA position mediated the cost of her program, providing an additional challenge in her degree. She pivoted to remote teaching simultaneously to her professors, an impactful experience for which she felt fortunate.

Dewayne Shared similar opinions with Ayesha over the loss of the social component of graduate student life. He sees value in the instances of conversation over theory or related problems and figuring those problems through with like minds.

I think the impact is really' it's profound..." "You would want to think graduate schools will be where you could rub minds with peers, but right now, you only get to see peers when it is in that two hours of instruction and that is basically so you really don't get to know ups you don't get to have that exchange yeah you don't get that exchange of ideas, so you probably do not get the impact you you're not getting your peers impact on you, and neither are you impacting on them, so it is the pandemic is having a profound impact on the graduate experience.

Dewayne adapted to his circumstance because he believed, "we have to do with what we have." He began connecting with peers and faculty through Discord and WhatsApp. He characterized these social media channels as a "fine in between."

Kaleb expressed mixed feelings about the impact of COVID-19 on his graduate education experience. There was a convenience to remote learning, savings from delaying city living and

high rents, chose his university for its proximity to Silicon Valley, his family network in the Bay Area, and is currently unable to engage as he initially intended. Kaleb shared:

I think there's positives and negatives. I know I want in-person for parts of my master's... "yeah, but I would like to keep the convenience that's come with..." "...with online, not necessarily like the class has to be online, but the expectations for a professor, to have in an online class, If those are implemented in an offline classes well, then I think I'd be I'd be just as happy.

Kaleb was satisfied with the expectations his professors set for him and his classmates throughout his coursework thus far. The convenience factor was notable.

Robert shared his experience working full time as an IT professional for another Bay Area university and simultaneously pursuing graduate school full-time Working in a professional capacity at home intersected with his academic life and caused "burnout" and Zoom fatigue.

Yeah, it was insane and that I'd say, that portion. I want to say that until the program was done it was very challenging because, you know, the job was like, the responsibilities of the job ramped up. And then, you know, my wife and I were stuck at home and our two bedroom; then we have our daughter here too. And she's there. I'm trying to work and her room is my office. And I'm doing school too. That was difficult. I'll be honest, I burned out. I burned out really bad.

Robert decided to work on some self-care, take time off of work and really limit his weekend hours on the computer. He indicated that he does not login on Saturday. He showed resilience and adaptability in his graduate degree program. He incorporated the COVID-19 pandemic into a school project.

We had a big data management class, and I was able to create a time series analysis of COVID deaths and show a correlation between that and the economy. And it was the, at the time in a class, I mean, that everybody was talking about COVID, because that's what's going on. Yeah. So, there's a lot of projects with COVID data. So, I was able to pull the COVID data, and do some analysis and have a dashboard and really present that. And that's, that's kind of like a real-world use right there.

Robert graduated from his master's degree program in December 2020. He demonstrated resilience balancing school, family, and work obligations. He adapted and was highly motivated to succeed.

Mia shared her experience with professors in the remote instruction environment. She has mixed experiences, both positive and negative. Some of her professors were really comfortable with the Zoom approach to course delivery, while others had difficulty which impacted her experience.

I think I had mixed experience with a professor who was really comfortable with Zoom settings and they were giving more than one hundred percent so that people don't miss out because they actually knew that their, their courses, one of the 'cores' in graduate degrees, so they made sure that people don't miss out on this one because if we are taking it with them, even though they are a very hard grader, they want you want to learn something

Mia's experiences with other professors were not as successful. She shared:

For a few it was even a struggle to catch them during their hours. Plus, you have to email them, then they will come and I felt like that was no help to be very honest. ... We were on our own. Like we were just paying the University for her giving us credit. That was it.

Mia expressed regret over her opportunity for an internship as part of her degree program. She said, "psychologically, it also gives you that, oh, I'm not that confident whenever I give interviews now for the entry level of full-time position." Mia believes that an opportunity for an internship would have benefited her post-graduation, but she believes that her ability to discuss coursework and her thesis project in an interview setting may be as meaningful in the job search.

Kirana is a full time professional in software development as well as a full-time graduate student. She shared positive opinions of the pivot to remote learning and actually preferred this approach.

I don't know if you'll get a lot of these responses, but I loved it. I Yeah. I wish this was the norm. Like because it made it possible for me to work full time, and then swivel over and go to school. And I didn't have to hop on three buses to get anywhere. Yeah, I didn't have to tell my manager that I needed to disappear for three hours. Risking you know, how much they like me. So, it just removed all of the stress out of it. I just loved it.

The remote instruction environment and COVID-19 pandemic influenced Kirana's research interest, similar to Robert and his projects in the graduate program. Kirana developed an app as

a component of her final thesis project for elementary teachers to gauge inclusion, engagement, and understanding of course content by the students in the classroom. This app is developed for a remote learning environment student across the country experienced through the coronavirus pandemic.

The coronavirus pandemic will undoubtedly inspire future research on its higher education impact and the challenges and successes of remote learning modalities. The participants in this study were resilient and adapted. They were motivated to succeed and several graduated mid-pandemic.

### **Self-Efficacy and Authentic Learning in Graduate School**

Each of the participants in this study view their graduate education as challenging. From these challenges, a shared theme that emerges from participant experience is self-efficacy. Students in this study are ambitious, and aspire to do something meaningful after graduate school. Participants reflected on the differences between undergraduate and graduate school, expressed enjoyment of the narrow focus of their academic discipline and the rigor of the curriculum. However, participants in this study shared an experience of self-directed learning, not always by choice. Alex, Ayesha, Robert, Dewayne, and Kirana shared examples indicative of self-efficacy as a recurring theme across participant experiences.

Ayesha recounted her undergraduate education experience; said, “my undergraduate engineering degree was very smooth to get, trust me.” She elaborated on her graduate school experience, “But here, I'll say that, you know, I really have to get things done on my own, mostly. And that gives me a clear perspective of the things that I've learned so far in my degree.” Self-reliance is an attribute that Ayesha is proud of and Shared scenarios throughout her degree program where she had to solve problems on her own.

Robert expressed similar sentiments, and compares his undergraduate institution with his current graduate program.

You know, coming from a research institution, I know that the graduate school experience isn't a traditional graduate experience. Like I was in a class. I didn't really have an advisor or anything. I talked to my professors during office hours, and wrote, did a lot of research and papers, but it wasn't a traditional on campus graduate school experience.

Dewayne shared his approach to loading his semester with courses while pursuing his undergraduate degree, things changed for him in the graduate program. He said, “now I’m struggling to do two. So, the time management gets more, a lot more critical, yeah; time management gets a lot more critical.” Dewayne demonstrated self-efficacy in determining a planned course of study in the absence of an advisor. He developed his road map on his own. He shared:

I had the roadmap to say I need to be able to see myself good through this in four semesters four to five semesters yeah. And I went through the college bulletin and things like to expect what and how many credits are required, what courses are required, what electives you could do in order to meet those requirements.

Alex spoke positively of the focused nature of the graduate program and enjoyed that he did not have to experience “Less distractions from other non-CS classes.” Alex, similar to the other participants in the study, demonstrated self-efficacy throughout the program, and would have benefited from more guidance, he shared:

It was a bit confusing at first, and it's easy to fall through the cracks. Some more guidance at the beginning would be helpful as well as help getting linked up with an advisor. I still managed to graduate on time though. It's just tricky figuring out which class to fit in, and where to get done on time.

Kirana described her program as evenly split between coursework and prepping for her final research. She said, “I think, for the majority of probably 50% of my graduate program, was taking classes and doing homework, and then 50% of it was getting ready for my research project.” She Shared a different experience, a supportive network of mentors who mentored her



in her GTA position and included her in academic department curriculum revisions for undergraduate courses. The GTA role prepared her for her final thesis project. She said, “I think it gave me more confidence in deciphering what kind of questions to ask. You know, what to expect out of it? Also, to relate with them better? I think it definitely helped being a GTA.”

Kirana shared an experience of belongingness that others in this study do not share.

I was included in one of the programs that they had to redesign the core courses. So, I was part of a committee with two other professors to brainstorm on how we would do that. So that was the introduction to the computer science course, Java. And then I think, data structures for computer science minors.

This experience was both an inclusive endeavor that fostered a sense of belonging and an authentic learning experience that influenced her final project and aspiration for a future computer science educator role.

Each participant in this study shared moments of real authentic learning opportunities, of varying impact, that solidified interest and engagement in coursework and motivated them to persist in the graduate program. Singer et al. (2020) focuses on the authentic learning experiences of historically underrepresented and female students in STEM as critical to identify formation as a scientist and to persistence toward degree completion. One example, Kirana’s thesis, linked her software engineering skills to “improving communication and sense of belonging in remote teaching. So, we (she and her advisor) created an application, where if students did not understand something, and then [teacher] will focus on that topic. The next time. So, I think the goal of the app was to, basically, to give the teachers more feedback than they could usually expect in an online classroom”.

Similarly, Robert utilized his data management skills to develop a project on COVID -19 infection rates nearly in real time as the pandemic began in spring 2020. He also completed a digital asset management course that he:

constructed data pipelines and things like that. My undergraduate degree was in statistics, and I work with a lot of data science projects. So, it kind of went hand in hand, how to curate the data, source the data and make it searchable. That was really something that I really fell into. A lot of times, we do projects and we think we need a huge data set. Sometimes we just need the metadata to really find out what, what we're looking for.

Singer et al. (2020) research suggests more successful outcomes when students themselves hold strong science and scientist perceptions of self. Authentic learning experiences of the participants in this study are amplified by their high degrees of self-efficacy and self-directed learning.

Identity development in STEM, aspirational capital and social mobility, familial capital, barriers to graduate study, faculty Mentors, impact of COVID, self-efficacy and authentic learning are emergent themes from the similar experiences and perceptions of participants in this study. These themes reveal how historically marginalized and female students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities. Students in this study are independent, self-directed, self-reliant, they overcame real and perceived barriers to graduate admission through persistence and long held motivations to complete a master's degree in the computer sciences or engineering. The reality of the Bay Area CSU campus as a commuter school influences an isolation and poses a challenge to the graduate students to be more independent, self-reliant, and rely less on peers through graduate study. The impact of the COVID-19 pandemic on the student experience is a corollary to the commuter campus, influencing isolation and less reliance on peers.

### **Experience with Graduate Curriculum and Pragmatics of the Degree**

Understanding participant experiences with the graduate curriculum in computer science and engineering disciplines at the three Bay Area CSU campuses provides an answer to the second research question that guides this study. The second research question attempts to uncover how historically marginalized graduate students in this study perceive themselves and academics,

researchers, in the context of Silicon Valley and the popular and political discourse on diversity in the regional workforce.

RQ2: How do historically marginalized graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities?

Each of the eight students in this study are actively engaged with the evolving nature of their chosen field. They are critically aware of the rapid pace of change in Silicon Valley landscape, and view computer science and engineering academic disciplines in this context. From the view of study participants, CSE disciplines are slow to adapt at pace with rapidly evolving Silicon Valley knowledge economy. A majority of six study participants expressed views of core theory courses as more meaningful in the overall experience of the graduate degree program due to the pace of change in these fields. Evolving computer programming languages, for example, are perceived by these students as outpacing graduate coursework. Students in this study possess degrees of professional expertise and critique the graduate curriculum in the computer sciences and engineering programs at the three Bay Area CSU campuses from an authoritative stance.

### ***Critique of Graduate Program Curriculum***

Each of the eight study participants hold a critical lens at the curriculum in their chosen graduate degree program. Students demonstrate critical consciousness and strong sense of self in discussions about the relevancy and currency of graduate curriculum aligned to Silicon Valley professions. Participants have developed a critical lens directed at courses in their programs in relation to the pace of change within Silicon Valley technology professions. These students understand the rapidly evolving nature of their chosen fields and understand areas of the curriculum that provide a solid foundation and areas that are passing trends. Opinions of curricular currency are revealed in the narrative data.

Participants in this study demonstrate *conscientização* or critical consciousness, a dominant recurring theme that consistently emerges throughout in-depth interviews, in all phases of their graduate student lifecycle, but is prominent in discussions about curriculum, scholarship, and the professions. Study participants were successful in their academic and professional pursuits and represent role models for others who may follow them. They evince qualities that substantiate Yosso's (2005) reconceptualization of Bourdieu's (1984) assumptions of social and cultural capital from the White, middle-class culture as the standard from which to measure the URM student experience; toward community cultural wealth or an asset-based lens. Posselt et al. (2017), attempt to move "the conversation about educational equity forward by learning from the positive examples that exist" (p. 3). Similarly, Burt and Johnson (2018) present an "anti-deficit depiction" (p.258) of Black graduate engineering students who possess an early interest "advantage" in the development of a scientist identity that led to graduate school pursuits.

Freire (1970) describes critical consciousness as one learning to perceive social, political, and economic contradictions, and to act against such contradictions. El-Amin et al. (2017) situates education research within Freire's definition of critical consciousness, when marginalized students act upon social, political, and economic contradictions, academic motivation and achievement may be more fully realized. Students in this study are critically aware of their minority status in higher education and in the profession, they possess a critical consciousness surrounding the inequity in Silicon Valley technology professions and the social consequences that arise from this reality. Nonetheless, the participants in this study are undeterred in the academic and professional pursuits. They bring a critical lens to the graduate curriculum taught in the graduate programs. These students debate the usefulness of the graduate degree as

necessary to advance in their profession or as a lever of social mobility. They demonstrate a strong sense of self, as academics and professionals in the Silicon Valley knowledge economy.

Ayesha is preparing to graduate from a graduate degree program in electrical engineering with a specific focus on information technology network infrastructures. She looked at industry documentation while finishing her thesis and holds an opinion that curriculum should be updated or at least more aligned with industry trends. She said, “There are some classes, which require updating. When it comes to what industry demand is all over the USA. Maybe specifically, I think there are some classes which require upgrades, if not upgrades then, more industry aligned course content.” The perception that courses in her program lag industry cause Ayesha to rank the program as average, or slightly better than average. She expected a bit more currency from the program and believed her professional background and recent internship offer evidence for the need for curriculum revisions to remain current.

Ayesha, spent her final semester on her final thesis project and referenced industry documents to help her finish. She sees a lag between course content and industry through her research. She said:

I have to go through so many resources, so many Cisco documents, so many videos to, you know, make all these pieces come together to make them make sense. But the past three days, I can tell you that I'll be going over a lot of Cisco documentation that to design my own company network, first, you have to brainstorm you know, what is the company requirement? What's the business requirement, then? Okay, their business requirement is like, you know, 200 people are working in that company, in three different areas. And then okay, how many network ports they will be needing, how you have to, you know, design, how do you have to take care of the security. So, all these things I'm putting my effort into at the moment to bring all these pieces together.

Ayesha's use of Cisco documentation on network systems is evidence that she is an active applied and academic scholar both in the program and in the profession. She is confident with her critique of her program's need of updating. She views herself to have authority in this area.

Kaleb too understood the quickly evolving nature of the computer sciences field. The graduate curriculum offered at his Bay Area campus computer science department aligns with his interest. He acknowledged the difficulties this university may have in keeping current with industry trends. Kaleb is in the early stages of his graduate program, he said of the curriculum, “it looks great; has a lot of things that I want to look into. I think the newer things that are coming out like crypto are pretty difficult to come up with a curriculum this quickly.” Kaleb defends his computer science program on curriculum currency. He argued, “so, you know they're doing their best.” Kaleb viewed the elective courses in his computer science program as aligned with his interest. He does not want to linger in the graduate program beyond two years, He said of the curriculum offered, “these are all the topics that I would want to learn about right now, and the only thing that sucks is that you have to only pick and choose a few, you only have two years.” From Kaleb’s perspective, his graduate program is as current as it can be and he, similar to Ayesha, has enough professional exposure and a sense of identity in the profession to be confident with his claims.

Mia Shared positive experiences with the curriculum, but questions the level of engagement her home campus computer science department has with Silicon Valley industry. She wondered whether or not some professors are not actively engaged in the discipline and current trends. “I think some of the professors aren't doing that; there are some that act like they don't care.” Mia chose her Bay Area CSU campus and thought the proximity to Silicon Valley would be a notable departmental asset throughout her degree program. Mia viewed her computer science graduate curriculum in positive terms and compares it to her undergraduate experience. She noted how technology has changed from her undergraduate to graduate degree, specifically the programming languages now taught in graduate school:

One thing I really want to tell you about [my campus], maybe because it's Silicon Valley? I don't know. But my experience with the curriculum is very positive, looking at the computer science side, because when I was doing my undergrad, they taught us everything in Java. And Java is not even a language like you know, if you really want to do your personal project, really contribute to something that's hot, then you need to know Python, right? Java. Java is like, really old school... They have so many courses that are just for like, preparing you for these big companies like you know, they are teaching you React, Django stuff like that, that is so in and everyone is in need so I think they are keeping pace.

Mia had positive experiences with website development coursework, database management, and advanced algorithms. These classes are viewed as more current and aligned with current trends. Her knowledge of the industry and computer programming language trends is remarkable. Her skill in this area influences her confidence as a scholar and professional.

Robert witnessed solid linkages between his graduate degree program and his professional life. He thought curricular revision was necessary after graduation, but also thought the core courses helped build a solid foundation. He said:

I thought the curriculum was very well, very well constructed. The program was still very new. Yeah, so, I believe we were the first cohort to go through and to the program. So, I felt some refinement was needed. A lot of my job was with software, with support, and a lot of software support, and even hardware support. So, a lot of the informatics principles and when it comes to data storage, data retrieval, using software applications, and things like that, and then software programming as well. Yeah, that was pretty much the core of my role and the program as well.

Robert shared opinions of the core courses as offering a solid foundation for the field. Dewayne agreed that his computer science graduate program core courses, consisting of theory, were critical to his understanding of computer science, but foundational and relevant to a rapidly evolving profession. He expressed skepticism of the passing trends in the industry and some of the newer classes on these topical areas. Dewayne referred to his years in the profession as reasoning for negative opinions of the trending computer science courses. Dewayne said of trending elective courses, “they are not necessarily...I wouldn’t call them challenging in that sense. They are new things you have to learn...security, artificial intelligence.”

Dewayne understood the strength of his computer science graduate program resides in its core courses, an introduction to the theory of the discipline and field. He said it is "beneficial to really understand the basics." Dewayne is critical of the fads of the technology professions. He elaborated on faculty who "introduce the fleeting aspect of that technology so that yes, you are current, but you do not know all those ladders that people have gone through in order to get to the flashy stuff." Dewayne, similar to the participants in this study, is an active and engaged scholar with deep perspectives on Silicon Valley technology professions and the role academia must play in graduate education. Theory represents the foundation in his view.

Alex echoed Dewayne's sentiments. He found the curriculum challenging, but his opinions on the curriculum are focused on the theory courses as more beneficial due to the changing nature of the field. Alex said, "theory classes were good, theory never changes." Alex shared Ayesha's view that the curriculum needs updating. He said, "the software engineering classes were a bit antiquated though, could use some updating." Alex is simultaneously a professional software developer and lecturer in his campus computer science department. He tries to bring the current professional perspective to the classroom. He said, "I can't comment on other instructors' curricula but I try to incorporate as much as what I do on a day-to-day basis for my students." Alex is uniquely positioned as an academic and professional, his perspectives on the curriculum at his Bay Area CSU campus align with other participants in the study. Alex is critical in his assessments, and tries to mentor students by bringing real world problems to the classroom for discussion.

Miguel's narrative highlights the critical role adjunct faculty may play in the currency of computer science and engineering graduate programs. From his perspective, they bring applied knowledge and currency to the experience. He said, "they have their own jobs, which was great



because they brought all their experience from working in the field to class.” He viewed the balance between theory, with which he struggled, and practical or applied courses, as having “value.” He said of one faculty mentor:

He would reserve some sessions to talk about, like leadership, and like, public works. You know, engineering, I guess, how the city is run, and how public projects are, you know, planned and then go to bid, and how to bid on projects and all that.

For Miguel, the adjunct faculty teaching elective courses opened space for him to connect theory with his engineering profession.

Students in this study follow the fast-paced changing nature of their chosen fields. They pursued graduate education to gain competitive leverage in the competitive Silicon Valley professional landscape. Their insight into industry developments is an asset to academic disciplines. The critical consciousness shared by participants in this study, about their evolving professions and the currency of their graduate program curriculum is an emergent theme uncovered through cross case comparison and contrasting of in-depth interview transcripts.

### **Pragmatics of Degree**

The students in this study hold contradictory views that their potential graduate degree will give them leverage in the competitive Silicon Valley job market. Nonetheless, each of these participants is highly motivated to complete the graduate degree.

Robert suggested that his degree did help boost his competitiveness. He changed positions post-graduation. Robert said “It did boost my leverage in the job market. I actually transitioned from Stanford to a different company. And I’m looking more at possibly teaching. And I feel that the master's degree and the graduate program did prepare me and sense for that. And I actually even enrolled into another program to try to be a community college teacher.”

Graduate students in this study recognize that there are professionals in the field who have obtained training in coding bootcamps through Google or Amazon. Mia shared her perspective:

even the graduate students who put like, who give more hours to the coding and programming building on their stuff, they are on the same level, I cannot say that degree gives you upper hand, all the things that I learned, I already learned in undergrad, but here, I learned because it's six years of gap. What's in the industry right now. So, I learned those things like React or Django and stuff like that. At that time, there was no React. So yeah, that's the difference. Otherwise, I think there's no difference.

For Mia, the only competitive edge she perceives of her graduate degree is its technology curriculum currency. She self-taught through online courses, enough to learn some basic skills for entry into these professions. She is a self-directed learner who could update future skills through online resources.

Alex said, ““Having a master’s doesn’t guarantee you a job or salary, you still have to grind practice problems really, really hard. It would be interesting to see data about this.”

Kaleb characterized his potential professional peers as “sweat lords” “s term used to describe someone who is a “mega try hard at something (usually in games such as Fortnite) and goes above and beyond to try and show off their "skills" (Urban Dictionary, 2018). These professional actors are his competition, and he perceives them as investing in countless hours of coding and training. He shared:

Gen Z, they’re sweat lords.” ... “So, the kids who literally spend the entire day coding, and sometimes it feels like you literally can't do enough. If I don't get a job with the master's degree, I'll just get a PhD at that point.

If he does not gain meaningful employment post-graduation, he would question his experience, "What was the degree for was that, just like you know, just a stamp that said you tried and now you have to do extra?"

### **Relevance of Co-Curricular Activities and Professional Networking Opportunities**

A thematic recurrence in this study resides in the participant’s in-depth, asset-knowledge of their industry and professions. Students in this study bring professional currency to the discourse of their graduate program. This recurring theme emerges through analysis of participant

experiences and perceptions of co-curricular professional networking opportunities offered on their home campus. These professional networking opportunities may include career fairs, industry speaker series, research conferences, or Bay Area industry networking opportunities. This type of co-curriculum programming at the graduate level provides students linkages to internships and offers of employment or doctoral studies post-graduation.

Charleston et al. (2014) research decisions to pursue education in computing sciences and student achievement in computer science fields. These researchers find faculty and peer networks, including experiential learning, professional networking with the computing industry, are attributes that lead to success of African-American students in their study. Similarly, Dodson et al. (2009) suggest co-curricular programming that introduces the culture of academic and professional conferences are effective tools for socialization into the academic discipline and profession, leading to persistence and success.

Participants in this study reflected on the state of co-curricular academic and professional conferences, and professional networking opportunities. The COVID-19 pandemic disrupted the ways in which universities and academic departments could host traditional conferences, and professional networking opportunities; however, the three Bay Area universities did deliver forms of conferences and professional networking opportunities throughout the pandemic. The student experience is mixed. Students shared opinions and perceptions of the Bay Area CSU campuses in the context of Silicon Valley that include, lack of alignment to the opportunity structures in Silicon Valley, a misalignment of offerings with their graduate degree area of focus, and lack of enthusiasm for the programming on offer.

Kaleb explained why he chose his Bay Area campus in the first place as its proximity to Silicon Valley and the City of San Francisco.

I chose to go to [Bay Area CSU campus], specifically, because it's the [San Francisco Bay Area]. I could have gone to Cal State Fullerton which is 20 minutes away from me. You know Irvine's a tech area, but now I wanted to be in San Francisco. I don't know, I feel like [my CSU campus] should be you know, every week, we should have tons of companies, asking for students but, I'm not too concerned, maybe because I'm a master's student I got a lot of time to worry about it yeah, but I also have no experience and I need to get an internship down.

Mia Shared similar expectations of her CSU campus because of the region and Silicon Valley

Context. Mia expected a higher level of engagement with the Silicon Valley technology professions from her Bay Area CSU campus. She viewed the region as abundant with opportunity. She shared:

I thought that because the proximity is really close to Silicon Valley, it's not even like, it is kind of in Silicon Valley. But I felt like all the job fairs and anything related to the jobs or these events are concentrated towards the business side, like Management Sciences, nothing on the tech side, like, I think there are only one or two companies who come to the campus for the recruitment on the tech side. Otherwise, we are on our own. We are applying on LinkedIn, we are applying here and there, but we are on our own. I was not expecting that. I thought that because of its location; it is such a big thing for the university.

Mia is critical of her university's engagement with Silicon Valley. From her perspective, the university is not doing enough to create meaningful engagement for students with the Bay Area industry. She was surprised at the lack of quality engagement.

Ayesha did attend engineering conferences but did not find them useful. She said:

Engineering conferences... so, I would say, yeah, no. I tried to join one or two via Zoom, via Zoom, sorry, but it was not that great. In fall 2019, I attended two of them on SF State campus, one was from Microsoft. And the other one was from another larger company, I cannot recall the name, unfortunately. So, I have experience of doing both online and offline as well. And I can say there's a huge difference. Like, you know, a huge, huge difference in doing conferences, you know, people say that you have to network with people. I am very bad at networking with people at a Zoom conference when they are like, you know, 40 more people. So, I joined like, once or twice after that, when, when things went online, it did not like I did not find it rewarding.

The opinions expressed by Robert, Dewayne, and Alex agree with the others in this study. These students understood the opportunities available to them, but the networking opportunities offered

as co-curriculum programming were not compelling enough to encourage their involvement. Robert said “There were professional networking opportunities. I didn't personally partake a lot into it. But they're there...networking opportunities. There are happy hours. We even got memberships to professional organizations, I think, I think the big thing is taking advantage of it.” Dewayne also acknowledged the university promotion of professional networking and career fair events. He said, “I get, I get some emails that do come in.” He shared his opinions:

On this career development and leadership development; right now, I'm concentrating on the program...” “...I have personally taken, myself, I've taken a passive attitude to that and not really actively following up or seeking it out.

Kirana shared her perceptions of professional networking opportunities offered by her Bay Area CSU campus. She was aware that her university offers career services “websites, like Handshake or events like that, that they let us know about? Yeah. So, there's definitely a lot of opportunities.” However, she did not engage in these opportunities while in her degree program. She said, “I mean, I don't know why I don't take them.” Kirana did take on the role of the Graduate Teaching Assistant (GTA) and highlighted the amount of work she undertook. Kiran said, “I did enjoy teaching {GTA}. Um, I like the process of teaching people. What? It is a lot of work. Oh, my God.” Kirana Shared opinions of how universities could do better:

So, as a software engineer, you know, it's not just an interview, you have to successfully complete coding within 30...30 minutes or less, and while somebody is watching you. But I don't think, you know, the universities really pay attention to that much. I mean, they have, you know, career stops and career support, you know, for resumes and stuff. But this is beyond that, like, once you get the resume, once you get the interview, what do you do? You know, how do you speak? And, yeah, so anyway, that is the one challenge, I think.

Current educational research underscores the influence relevant co-curriculum programming has on the academic success of historically marginalized and female students in STEM fields, particularly computer sciences Charleston et al. (2014) and engineering Burt and Johnson (2018). The experiences of the graduate student participants in this study suggest that Bay Area CSU

campuses have the opportunity to develop co-curricular programming that is relevant to the professional fluency their students already possess. Programming from this view is more advanced than resume writing and interview preparation currently provided by campus career services. The students in this study are not beginners. They would benefit from intentional professional networking opportunities and industry conferences. The three Bay Area CSU campuses are situated in a dynamic economic region with significant opportunity to elevate co-curricular programs for graduate students.

Charleston et al. (2014) study computer science specific co-curriculum programming that consists of professional networking. This programming led to student success. Similarly, Brunnsma et al. (2017) suggests impactful faculty mentorship is done through nurturing professional networks. Dodson et al. (2009) defines effective mentoring as faculty and student collaboration in scholarship, research, group work, and professional conferences. Academic departments could demonstrate cultural humility by recognizing the professional assets and professional networks their graduate students possess as they begin graduate programs, by offering career and professional networking opportunities that go beyond basics and are at a level of sophistication that matches professional experience students already have. The Bay Area CSU campuses are charged with serving the region; this charge requires meaningful engagement with the stakeholders in Silicon Valley, including technology professionals who will employ the CSU graduates. Integrating co-curriculum programming with stakeholder engagement may enhance the education to profession pipeline for URM and female CSE students.

### **Historically Marginalized and Female Graduate CSE as Silicon Valley Professionals**

The professional experiences of graduate student participants in this study range from entry level internships to decades in professional roles in the Silicon Valley workforce. Participants are

knowledgeable about industry trends and evolving technologies, the competitiveness of the job market. Furthermore, they are aware of what is required of professionals to advance in the fields beyond a graduate degree, such as firm specific coding knowledge and the ability to prove one's skills in the hiring process. The perception of self as a Silicon Valley knowledge economy professional is the focus of the third research question that guides this study. RQ3: How do historically marginalized graduate and female CSE students view themselves as Silicon Valley knowledge economy professionals? These perceptions are important in the context of graduate education, because these students critically reflect on their graduate experience as it relates to the field and reflect on the popular and political discourse on lack of diversity in technology.

### *Sense of Self*

Kaleb understood that as a Black man, he is underrepresented in his academic discipline and in technology professions. He said, "I feel like, you know, the pool is too small. "He witnesses a lack of diversity in his program and attributes it to lack of interest or historically marginalized students simply not pursuing these disciplines and professions. Kaleb said, "first of all there's...there's not...there's not people doing it; and that's not their fault, it's not the university's fault." Kaleb does not lay blame on the students or the university. He believes that the profession needs to be demystified and that assumptions about computer science as math intensive may deter students from pursuing computer science in the first place. He tries to persuade his cousin that computer science is simple math.

Robert, too, experienced lack of representation in his professional life and in his undergraduate degree program at University of California. He shared:

Yeah. It's tough, because, uh, you know, we aren't really graduating too many professionals in California as much as we need. I know. Yeah, yeah. No, at all, even at the undergrad level, I want to say when, when I graduated, I was the only black person in my class. And at a graduation event, I think I was one in five of the Yeah, and yeah, that

was interesting, but it's very low. Even at the [University of California], I think it was 2%.

Robert is reflective on his early exposure to computer technologies and holds opinions on the importance of mentorship early in life.

Mia shared her experiences and perceptions of her emergence into the technology professions. Mia said:

I think even a blind person will understand that the disparity is huge among men and women in the tech world. Like, if I go to any of the events now, like, even if it's on Zoom, I don't see women, even if I see a woman I think like, okay, they are from marketing side, they're from sales side, or they are recruiters, I don't see many women who are coders, like, you know, yeah, that is something that we are lacking on.

Mia is confident in her educational and professional pursuits, even in a culture that is male-dominated.

Kirana shared similar views, she discussed her experience in the male-dominated software development world. She characterized her workplace as, "you know, I mean, it's mostly men. Yeah. Yeah, but you know, I'm happy with the two or three, you know, women engineers that I have. Not happy for now. But I mean, I wish it would be 50-50." Furthermore, Kirana follows the public and political discourse on the lack of diversity in technology professions. She, as is Mia, confident in her ability to navigate a male-dominated profession.

Yeah, I follow [the headlines]. I mean, just because, you know, I'm part of the group that they're fighting for. But, I've put myself into this field; I think it's a great thing that they're starting to talk about it. I don't think it was something that was really talked about back then.

Kirana is interested in pursuing some kind of computer science education in the future where she can directly impact young women in the field. Kirana is pushing forward, paying attention to the public conversation about gender diversity in her profession. She had women mentors in her graduate program, remains in the minority in her profession, yet aspires to impact change.



Alex understands the importance of diversity in Silicon Valley technology professions. He views his professional software engineering team as diverse; however, he understands the need to recruit more. He shared:

At the company I'm at I feel they are actively trying to hire a more diverse workforce. My team is diverse and they value my opinion. I do know that in general though there needs to be more diversity. But we do need to get more young engineers truly interested in engineering, just joining a cs program to get a job isn't enough.

Alex understands a broader scope of the diversity problem. Students need to be interested in engineering beyond a graduate program, and universities have a role to play at the juncture of graduation and employment.

Ayesha said that she did not experience bias or sexism in her graduate program or internship. When asked, she said, "I never, ever experienced anything like that." She did share her experience at her internship site as the only woman on a team of forty men:

My manager was great, and yet, the fact that I was the only woman on the team was weird. One thing my manager also pointed out to me is that you see the stream of men here and there's just one woman, you. You're an intern, right?"

Ayesha is the only woman at her internship site, she experienced a gender imbalance in both her graduate program and internship site. She perceives women in engineering professions as taking on roles other than engineering or software development roles. The few women who Ayesha engaged with prior engineering professional roles held Human Resources or marketing positions. She said, "You know, all the, I think all the executives are men. You don't see many executives, women. They don't exist." For Ayesha, her minority status as a woman in this field is real and ever present. Although she does not perceive any sexism in her graduate program or internship directed specifically at her, she grapples with the gender imbalance in both areas. However, Ayesha is aware of subordination of women in technology professions to less male-dominated engineering roles. Asked if she follows gender diversity issues in technology, Ayesha said, "Of

course I do...” “...I believe that there are some companies, I believe this, I can be wrong, who say that they want more diversity, but do not align to it? I don't think so they put in all their efforts.” Ayesha, is confident in her ability to succeed in a male-dominated profession, she is an emerging engineer, seeks opportunities to network with other women in the field, but may overlook the gender imbalance or marginal professional roles women take as an indication of sexism.

Participants in this study are engaged in the discourse of diversity issues in technology and in Silicon Valley professions. They share opinions about corporate diversity initiatives and why lack of diversity persists. Corporate diversity statements are viewed as hollow.

Ayesha wants to be judged on her merit, not her gender and expressed skepticism for companies with public statements in favor of diversifying their workforce. She said, “if I believe that there are some companies, I believe this, I can be wrong, who say that they want more diversity, but do not align to it? You know?” Ayesha shared:

I don't want to put all the pressure on the companies, because they also want to hire the best people for any job they're filling. But um, I think they should be more open, you know, to give opportunities like, you know, to experiment.

Ayesha follows the Grace Hopper Foundation and intends to participate in this conference in the future in a post-pandemic environment. She said, “It's, it's like, it's a huge conference, which is designed mostly for women, women in tech, you know, to support women in tech. I've been planning to do this event. It's a great event.” Ayesha is searching for opportunities to network with other women in the field as a way to mediate her experience with the lack of gender diversity in her field.

Miguel seeks to make a social impact at the intersections of engineering, technology, and the environment. He wants a more diverse profession and perceives his field as changing along

gender lines, with more women entering environmental engineering areas, but not design aspects. Miguel's observations about women entering certain segments of these fields aligns with the perceptions of Mia, women in user experience or design, and Ayesha, women in human resources or marketing roles at engineering firms. Nevertheless, in his current profession, Miguel is focused on protecting the San Francisco Bay Area watershed. He chose to live and work in the Bay Area because of its progressive politics and because he perceives it to be at the nexus of scientific and technological advancement. At the intersection of engineering and technology, Miguel said:

We kind of start, like digging into more advanced studies for the future things happening in (engineering and technology). We can be like, on the leading edge of that. Yeah. So, I think that's really, really an advantage to me here. Because I feel that Silicon Valley feel from the tech companies also permeates into my sector.

Miguel is optimistic about serving the public good in his role as a public works civil engineer. He views proximity to Silicon Valley as an opportunity to integrate rapidly evolving technologies into public works projects that focus on preserving the Bay Area region.

Kaleb, aware of his own minority status in his chosen profession, is a young Black man who shared his perspectives on women in computer sciences. He said, "I don't think they were purposely trying to exclude women; you know they weren't concerned with, including with them." He perceives his experience as aligned with women in the profession.

Robert revisits his stance on the necessity for early exposure in these fields. He said, "I feel that I feel that we could do better at the K through 12. And especially in certain areas, like certain schools, school districts." Mentorship at an early age, in Robert's opinion, is a critical strategy for diversity in the computer science professions. He shared:

A mentorship relationship or, or just exposure at an early age is as important. Like for instance, like, my, my, my parents' friends, they're, they're, you know, they're black. Like at early age. That's, that's what I saw it I saw like these black people with this technology

and doing things and I think I think that image could be presented more. Yeah. We don't really see that too often.

Mia is engaged with Silicon Valley diversity discourse through social media channels and professional conferences. She characterized a split in the technology professions to occur at the juncture of design and engineering. She perceived women as being guided toward the design side of website development or User Interface (UI) or User Experience (UX) side of technology.

This could be an area of further research. Mia said:

I feel like there are less women in this field. I'm on Twitter, and it feels like women that are there are in some little crowd on the web development side. Because I think it's a more feminine version of tech. The women are there because they are really good with their UI or UX, this kind of work. Yeah. So, in that domain, they have women like every time I see I talk to people in these big tech firms, they say, 'Oh, UI UX, you will find many women in there.'

Mia defines UI or UX as user interface and user experience, the background design elements of computer programming. Mia perceives this to be a sorting of women into feminine aspects of technology, preserving the male dominance in the software engineering and programming aspects.

Kaleb is concerned with recruiting more historically marginalized students into the profession. He argues that the profession and graduate school should be demystified:

You don't even need calculus to do computer science, I did calc because I was a math major and stats, right? So, when I was in math, it was like, 'oh you got to get to calc, so I did calculus and all this stuff. I use so so, so, little of my math knowledge so little, plus, minus, divide, multiply I tell my little cousin just have to half decent at math literally, can you do one plus one; one times two; one divided by two; yes, you're smart enough in math to do computer science that's it. When in reality it's, it's, philosophy when it comes down to it; philosophy, and when I took my philosophy class and they teach you basic logic, you know if this true that...' ...' yeah that's what computer science is.

Kaleb is aware of the anxiety surrounding math for many students. He is confident in his ability at math, and is eager to share how math is related to computer sciences. His argument for enhancing diversity resides in a demystifying of math as it relates to computer science.

### ***Desire for Social Impact***

The participants in this study understand the opportunity for social impact they may have in their professional lives. Robert is a mentor in his new professional role and is considering going into teaching. He said:

So right now, I'm an education facilitator and a software engineer at a [computer programming school] and this school is kind of like a boot camp, but it's a more intensive CS program or computer programming curriculum. And I teach students programming skills, the higher-level skills like machine learning, and there, I'm a software engineer, so I help out and writing different software applications to help maintain operations there, but also, I assist students and helping them with their coursework and making sure that you know, they're, you know, they're doing things good.

Dewayne hopes to make an impact, but doesn't see it. He is critical of the social implications of technology, he said

Here's the thing, so, I've been in technology for quite a while to have an opinion of mine. Yes, and I do think that some technology is unnecessary, yeah. For example, I don't have a Facebook page. Okay, I think, when people get into the train if you're in the Bay Area, who among them is looking at the other person sitting beside him or her. Right? everybody, everybody's glued on to the phone. I don't think that's what technology should be about. Technology has turned into things that are actually wasting our time.

He wonders if he will have the opportunity to make an impact, "I want to see things in a different light? Why should young men and women only think about Instagram? When, when, we could use that technology to make mathematics easier for everyone."

Mia wants to make a social impact. Mia is working on developing an app with social impact. She comes from a farming background. Her father is a farmer. She is working on an application for her final thesis project to aid farmers who she perceived as not fluent in technology.

I come from a farming background; my father is a farmer. I think farmers are very non-tech savvy, they have no idea about what's going on. So, I want to develop an app, very

user friendly for these non-tech savvy farmers in India, which will give them a prediction for the grain or whatever they are selling their brains price for a day to a week into a forecast price for them. I will be doing it using AI and RNN neural networks, so that helps.

Kirana also developed an application for her final thesis project to benefit educators in the remote learning environment. Her stance is one of inclusion in the classroom. She aims at “improving communication and sense of belonging in remote teaching.” She shared that and her advisor:

Developed an application where students could choose between five different emojis and each like emojis, like progressively from I'm happy to I'm sad. And it has a label right next to it like 'I understand' or 'I don't understand, I'm lost' ... So basically, the students will choose those in the classroom as the instructors teaching. And then there's like a bar chart that is updated throughout the class that shows how the students had voted. Then the instructors basically can go back and forth and see how they did in previous classes. And some of them have taken to the chart and looked at the timestamp to see when students did not understand something, and then they'll focus on that topic. The next time.

The scholarship of Posselt et al., (2017) finds potential in URM and female graduate students who hold moral obligations to their communities and who want to have a social impact. These researchers argue that the “boundary” around a STEM graduate department may be erased if decision makers recognize the importance of focusing attention on future aspirations of potential graduate students throughout the graduate student lifecycle.

## **Summary**

The participants in this study are critically aware of their minoritized status in academia and in their chosen technology profession. Nevertheless, study participants advance intellectually and professionally even in academic and professional cultures that are homogenous and perpetuate the dominant status quo. The unique experiences of study participants are presented in this chapter with convergence around ten themes that span graduate education trajectories and answer the guiding research question. Furthermore, four additional sub themes emerge to answer the second and third research questions. The final chapter presents a discussion of findings and

implications for educational practice, recommendations for institutional practice reform, and recommendations for future research.

## **Chapter 5 Conclusion**

### **Introduction**

The purpose of this study was to explore the experiences and perceptions of historically marginalized and female Bay Area CSU graduate students in computer science and engineering programs as they navigate the graduate student lifecycle. Lack of diversity in computer science and engineering graduate programs at California State University East Bay, San Jose State University, and San Francisco State University is a problem of practice for administration and graduate faculty. In general, the undergraduate student body composition at these three Bay Area Universities is diverse and characteristic of the equity and inclusion mission and values espoused by the CSU (Office of Public Affairs, 2020). However, URM enrollment declines at the graduate level at each of the three Bay Area California State University Campuses, specifically in these academic disciplines, and gender imbalance is evident (The California State University, 2022).

The participants in this study are rare across the CSU system in the region. Their unique experiences in and perceptions of CSE graduate programs and professional opportunities in Silicon Valley post-graduation converge around critical themes and asset-based attributes. The qualitative data obtained through in-depth semi structured interviews present a case study that may inform diversity and inclusion reform efforts at the California State University from an asset-based stance. This dissertation study is situated in the context of converging issues of race, gender, equity and inclusion in graduate school CSE programs and lack of such diversity in Silicon Valley Technology professions. Study participant experiences reveal areas of opportunity for the CSU to mediate the educational and professional “pipeline” to Silicon Valley professions.

The California State University system is a mission-driven institution. A public university system, charged to serve students and stakeholders in the region and ensure equitable



opportunity. The CSU system is driven by social justice and offers accessible education. The CSU CSE enrollment data and Silicon Valley workforce gender and ethnicity data (The California State University, 2022; Salesforce, 2020; Tomaskovic-Devey & Han, 2018) are parallel challenges for higher education. Gerth (2010) presents a history of the California State University upholding its mission and values through evolving engagement of students and stakeholders in the state. From this historical perspective, graduate deans, graduate faculty, and directors of admission must investigate potential barriers or deterrents to URM participation in CSE graduate education. Graduate education is often a pathway into Silicon Valley professions (John & Carnoy, 2019). Furthermore, current scholars position the lack of diversity in higher education STEM disciplines, including computer science and engineering, as a matter of national security, a threat to our position in the global knowledge economy, and critical to democratic ideals (Burt & Johnson, 2018; Figueroa & Hurtado, 2013; Griffith, 2010; Stockard et al., 2021).

This dissertation study is a response to the problem of practice seen in graduate enrollment at three Bay Area California State University campuses. The qualitative data analyzed here is both a synthesis with the extant literature presented in chapter two and expansion of the concepts and findings of recent scholarship on underrepresented minority (URM) and female graduate students in STEM fields. The small purposeful sample of participants in this study underscores the lack of ethnic, racial, and gender diversity in CSE disciplines at Bay Area CSU campuses. Although limited by size, the sample of participants provided detailed accounts of motivations and aspirations for graduate education and Silicon Valley technology professions. The aim of this study is to focus attention on assets successful URM and female graduate students bring to their CSE academic disciplines, critique traditional graduate admissions and academic socialization practices, and to offer recommendations for diversity and inclusion goals.

This chapter offers a discussion of findings on graduate school experiences and perceptions uncovered through an analysis of qualitative data collected through in-depth semi structured interviews of eight participants who identify as URM or female in CSE graduate programs at three Bay Area CSU campuses. A discussion of implications for practice is presented in this chapter. Furthermore, the discussion includes recommendations for future research, concludes with thoughts on the role of the CSU in the region, and the social impact of less diversity in technology.

## **Discussion of Findings**

### ***Graduate Student Experience***

The analysis presented here answers RQ1: How do historically marginalized students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities? Answers to this question reside in concepts of identity development, aspirations for graduate school, gaining an offer of admission to graduate school, and adapting to the disciplinary norms and graduate student culture. The qualitative themes developed around this question emerged through a deductive and inductive coding process of interview transcripts, research notes, participant comments, and analytical memos.

Critical Theory informs the lens through which the qualitative data is analyzed in the discussion presented here. Recruitment of participants in this study required a significant investment of time. That so few participants were identified through a purposeful sample and outreach through LinkedIn, is further evidence of the graduate enrollment disparity that exists at three Bay Area CSU campuses. A rethinking of traditional graduate admission selection practices, curriculum development, and co-curricular supports may be informed through an understanding of how participants in this study experience CSE graduate education across the

region. The discussion herein is organized around significant milestones that comprise the graduate student lifecycle: identity formation as a scientist (STEM), graduate admissions, graduate school experience, and post-graduation aspirations.

Through a qualitative cross unit of study comparative analysis of in-depth semi structured interviews, ten themes emerged. These ten themes construct a view of graduate education as experienced by the participants in this study. For these participants, the pursuit of graduate education is rooted in early experiences that influence one's scientific academic trajectory. Aspirational and familial capital are motivating factors. Attributes of persistence and self-efficacy are revealed as participants break through boundaries and barriers to graduate study. Participant self-efficacy and self-directed learning are part of the graduate student experience where peer networks and opportunity for positive academic socialization are minimized by the nature of a commuter campus or the impact of the coronavirus pandemic. The critical role faculty mentors play in decisions to pursue and persist in graduate education in the CSE disciplines is evident by positive or negative experiences. The impact of COVID-19 on the graduate school experience is significant. However, resiliency, self-efficacy, and adaptability are salient characteristics that mediate its impact. Finally, self-directed learning in authentic learning in graduate school is a theme that emerges across these interviews. Discussion of additional themes that emerged to answer the second and third research questions follow.

### ***Early Exposure and Identity Development in STEM***

Traditional graduate student recruitment and admission practices, in general, do not consider early exposure to learning opportunities as higher educational recruiting strategies into the CSE disciplines. The average age of a California State University graduate student is thirty years (The California State University, 2022). Recruitment and admission practices are centered on this average age. However, the university has potential to develop a long view recruitment strategy,

true to its mission and values, investing early, through augmenting access to significant learning opportunities that are consequential on student identity development in STEM fields.

Identity development in STEM is shaped by access to technology, positive experiences in early related coursework and opportunities for undergraduate research (Burt & Johnson, 2018; Charleston et al., 2014; Eagan, 2014; Griffith, 2010; Singer et al., 2020). Participants in this study shared experiences that suggest early interest in computer sciences and engineering fields resulted from access to technology, experiences in pivotal courses, and undergraduate research opportunities. Kaleb, Miguel, and Robert shared early experiences with technology in the form of play. Kaleb developed interest through gaming. Robert had significant exposure to technology through play and Silicon Valley culture from family friends who were Black professionals in the field. Robert was exposed early on to technology and role models with whom he identified. He experimented with building computers on his own. Similarly, Miguel attributed his early interest in engineering through play with Legos and building highways and bridges for Hot Wheels cars. Miguel spoke of math classes in high school that he could relate to his early interest in engineering.

Mia and Kaleb shared early negative experiences with computer science related courses that impacted their identity as emerging computer scientists. Kaleb experienced imposter syndrome at a summer computer science program which delayed his academic pursuits, while Mia experienced experiential computer software programming courses that were heavily gender imbalanced and lacked relevancy. Although they both overcame the negative experiences and persisted in computer sciences, they referenced these experiences as impacting confidence. Ayesha and Kirana shared positive experiences in undergraduate courses that solidified their academic trajectories and identity in engineering and computer sciences.

Recent educational research suggests early identity development, meaningful course work, and research opportunities are a motivating factor for graduate education pursuits in STEM fields (Burt & Johnson, 2018; Charleston et al., 2014; Eagan, 2014; Griffith, 2010; Singer et al., 2020). A long-term recruitment and admissions strategy focused on diversity and inclusion in CSE graduate education at the Bay Area CSU campuses includes nurturing early identity development in these academic disciplines and the field. The participants in this study recall early experiences as motivating and inspiring them to a graduate degree. Universities should adopt a long-term outreach and recruitment diversity and inclusion strategy that considers early experiences from high school through the undergraduate program. Existing programs that engage high school students at the college level are models for a long-term strategy. Programs that engage high school students and parents with a trajectory toward graduate education present untapped potential for diversifying computer science and engineering disciplines at the three Bay Area CSU campuses.

### ***Aspirational Capital and Social Mobility***

Understanding URM and female graduate student motivations and aspirations for graduate education CSE disciplines at the three Bay Area CSU campuses is critical for diversity and inclusion. Participants in this study share similar motivations for pursuing an advanced degree in computer science or engineering at their Bay Area CSU campus. They perceived opportunities in Silicon Valley technology professions as a route to a prosperous career; perceived opportunities in their specific graduate program because their campus resides in a technology hub. Each participant views their academic discipline as leading to a stable and prosperous career. Aspirational capital is a theme that all participants share, critically aware of the lack of diversity in their chosen fields. Here, aspirational capital mediates perceived barriers to graduate school

and professional advancement. Moreover, a majority of participants aspire to make a social impact as they progress in their field and solve social problems.

Ayesha, Dewayne, Kirana, Mia, and Kaleb share similar ambitions to advance in prosperous Silicon Valley computer science professions. They view the professional landscape as dynamic, creative, rapidly evolving, and perceive opportunities for social mobility. The research conducted by Posselt and Grodsky (2017) suggests increased earning potential for graduate degree holders; they position this potential outcome in alignment with social justice in higher education. Robert and Ayesha were heavily influenced by their parents toward a stable middle-class profession. Each participant viewed graduate education as a path to developing as an engineer or computer scientist.

The participants in this study hold a critical self-awareness of the homogeneity of Silicon Valley technology firms and understand lack of representation in these fields. As residents of the region, the path to a satisfying quality of life in the Bay Area resides in graduate education and technology professions. Yosso's (2005) concept of aspirational capital, an ability to hope and pursue a better future, coupled with resiliency in overcoming societal barriers, is sharpened into view through the perceptions of this study's participants. They demonstrated resilience and persistence in a professional landscape understood as competitive, lacking diversity, and as gender imbalanced. These students hold a critical view of the regional professional landscape, highly aware of their minority status within graduate education and the professions, they remain undeterred. Furthermore, they hold aspirations to make a social impact in their fields. They are role models for future students.

Universities have an opportunity to develop aspirations of future CSE graduate students through an understanding of motivations to pursue these academic disciplines. Inclusion and

diversity outreach efforts should begin early, the university and academic departments must include parents of undergraduate students in discussions on the value of a graduate degree from high school through first year experiences. Furthermore, academic departments of Computer Science and Engineering can nurture aspirations to graduate education by making role models visible in early outreach efforts; URM and female graduate students in CSE graduate programs could be mentors of undergraduate students beyond a GTA role. Robert pinned his academic trajectory to early role models who looked like him. In his current profession, he acts as a mentor to aspiring computer scientists in a high school computer programming boot camp. He considers going into teaching to continue this mentorship. Alex, a current lecturer at his CSU campus, writes letters of recommendation for aspiring students, and Kirana wants to encourage more women into software engineering education and professions.

The three Bay Area universities have the opportunity to engage with professional associations interested in diversifying Silicon Valley technology professions. Two organizations, the Bay Area Council (BAC) and the Silicon Valley Leadership Group (SVLG) are engaged with regional and state actors on educational pipelines into these professions. The BAC publishes policy papers from a social mobility perspective in the context of the high cost of living reality of the Bay Area (Bay Area Council Economic Institute, 2019) and views education as a mediator. The SVLG lobbies the state government on policy issues aimed at expanding access to educational opportunities leading to technology professions from a social impact perspective (Silicon Valley Leadership Group, 2021). Both positions present worthy causes that align with the mission and values of the California State University. There is opportunity to engage organizations such as these in all phases of higher education, beginning with the juncture of

transitioning to college post-high school graduation through undergraduate studies, through graduate school.

### ***Familial Capital and Graduate School Aspiration***

The family structure is often overlooked by traditional graduate school outreach, recruitment, and retention practices. Yosso (2005) advances concepts of “familial capital” and “community cultural wealth” as a counter “deficit” approach toward URM of the status quo in education; these concepts encompass familial and community bonds that shape one’s critical consciousness and moral commitments to society. General assumptions may form around a traditional graduate student demographic, including independent adult, professional, or a successful undergraduate student. University administrators and graduate faculty may not realize the potential for diversity and inclusion through recognition of one’s family and community support structures.

Participants in this study shared narratives indicative of strong parental influence, meaningful and motivating networks of extended family and friends, and spousal support.

Educational research conducted by Charleston et al. (2014) found parental and familial support influenced decision-making toward the computing sciences among participants. These researchers identify familial capital as parental influences that motivate one to pursue and persist in computer sciences specifically. Familial capital is an emergent theme across participant interview data in this study. The participants in this study shared stories of parental influence in decisions to pursue graduate education. Ayesha pursued engineering as an undergraduate student because her father strongly encouraged her to do so. Her father supported her journalism aspirations, but only after she completed a bachelor’s degree in engineering. Ayesha acted on her father’s encouragement, she understood his life trajectory as one from limited resources and education, advancing to a general manager through a strong work ethic. Ayesha demonstrated the same strong work ethic as a networking intern, a graduate teaching assistant, and graduate



student as she persisted through her engineering program. Ayesha benefitted from a strong male role model and advocate as she pursues a career in an industry heavily dominated by men.

Robert, on the other hand, viewed his mother as a strong role model. Robert attributed his motivations to pursue a graduate degree to his mother, who had also earned a master's degree. Robert grew up in a family that valued education and his mother became an example of academic achievement. Traditional graduate outreach and recruitment practices could be repositioned and redirected early in the undergraduate student experience with engagement focused on parents. This approach is a long-term strategy.

Familial capital amongst study participants is broadened into “community cultural wealth” (Yosso, 2005), a network of family and community. Research studies included in chapter two of this dissertation study offer evidence of the impact family support has on historically marginalized and female graduate students as they persist in STEM graduate programs (Burt & Johnson, 2018; Charleston et al., 2014; Posselt et. al, 2017). These studies expand an understanding of familial capital as a motivating factor to pursue and persist in STEM graduate programs. Furthermore, Burt and Johnson (2018) find families cultivated an early interest in STEM, and a “majority of participants in this study attributed their current progress in engineering to family members’ cultivating and maintaining their interest in STEM at early ages” (p. 262).

Participants in this study shared experiences of family members who nurtured an early interest in the fields through play and exposure to technologies. Kaleb, Miguel, and Robert shared experiences through play with family and friends that translated to interest in computer science or engineering in undergraduate and graduate programs, and as a profession. Familial capital in the form of strong networks revealed in statements by Robert, Kaleb, Miguel, and Mia.

Robert developed an early interest in computers through his family friends and being exposed to Silicon Valley technology culture. Robert suggests this exposure was impactful because not only did he see Black role models in this context, but he had the opportunity to play and develop a curiosity through building computers that influences him still today. Robert also acknowledges his classmate at the University of California, an extension of his family, who went on to pursue a PhD and inspires Robert in his own academic goals. Similarly, Kaleb is in a recursive dialogue with his extended family. On one hand, he is motivated by his older cousins who have succeeded in Silicon Valley technology firms, on the other hand, Kaleb works to demystify computer sciences for his younger niece. He encourages her to pursue her education in this area. Mia shared the background of her family networks in similar ways to Kaleb. She is influenced by her siblings and acts to encourage them in their pursuit of computer sciences.

The average age of the California State University graduate student is thirty (The California State University, 2022). The participants in this study are in their mid-twenties to early fifties. Three of them have families of their own and spousal support is a strong area of familial capital and graduate school aspiration unaccounted for in the extant literature. Mia holds conflicting views on her minority status as a woman computer scientist. On one hand, she is eager to prove herself professionally and confident in her talent. On the other hand, she acknowledges that she would not have come this far without the mentoring and support of her husband. Mia attributes the support of her spouse to her success in graduate school and the profession. Dewayne balances his family life and his graduate education; however, he acknowledges significant support from his wife. Similarly, Robert acknowledges his wife's support as critical to his persistence through graduate school. She was influential in encouraging him to set boundaries between work, school and family life and to practice self-care by taking time for himself. The participants in this study

rely on their spouse for support and they are sources of inspiration and motivations to persist. Students in this study aspire to prosperous computer programming or engineering professions in order to create an enjoyable and comfortable life with their spouses.

Modeling a family like atmosphere in an academic department in one study, contributed to the successful recruitment and retention of URM and female students in a physics program. Posselt et al. (2017) studied a physics department who created a family like atmosphere intentionally to boost recruitment and retention efforts of historically marginalized and female graduate students. This family-like culture enabled family-like relationships and a supportive environment to develop from recasting academic hierarchy. Posselt et al. (2017) presents an interesting model for the rethinking of traditional recruitment and retention, specifically aimed at diversity and inclusion. Widespread adoption of practices that encourage a family-like atmosphere in the CSE disciplines at the three Bay Area CSU campuses may inspire and welcome more women and historically marginalized students to participate in graduate education. A supportive family environment may help to demystify the CSE graduate disciplines and mitigate perceived deterrents. Moreover, graduate programs may be more successful in recruitment and retention efforts if family networks are tapped and considered throughout the graduate student lifecycle.

### ***Boundary and Barriers to Graduate Study***

A critical theory lens compels us to consider alternatives to the traditional “selectivity” of the graduate admissions processes that reproduce the status quo in higher education and in specific academic disciplines. The participants in this study bring assets to their graduate CSE graduate programs; it is incumbent on faculty to expand views of qualities and attributes of students who are the “right fit” for a master’s degree program. Gaining admission to a graduate program is a pivotal aspect of the graduate student lifecycle.

Educational research suggests a broader lens is needed to achieve diversity, a lens inclusive of values, professional experience, research experience, or a multidisciplinary focus (Posselt et al., 2017). The traditional graduate admission selection process may be a barrier or deterrent for minoritized and female students in STEM fields. In the Posselt et al. (2017) study, faculty “observed a record of success among students whose profiles differed markedly from the conventional achievers privileged in graduate admissions” (p.15). This recognition helped broaden faculty members’ conception of the ideal applicant’s profile.”

The participants in this study experienced “weed out” courses that became barriers to overcome in graduate admission attainment. Furthermore, graduate programs did not recognize the value of interdisciplinarity, and several students experienced rejection by their first-choice university. Participants hold various, yet critical views of the Graduate Record Exam (GRE). They identified key faculty mentors who ensured entry into graduate school, and several students received conditional admission offers resulting from a holistic approach to application review. Participants demonstrate current and relevant critical awareness of the graduate curriculum and its relevance to the professions.

Education research on historically marginalized and female students in STEM graduate programs present a case study that calls for rethinking the traditional selection methods (Posselt et al., 2017). This case study offers evidence that alternative approaches with intention to diversity STEM graduate programs, can be successful through a recognition of student profiles that differ from the conventional achievers privileged in graduate admissions (Posselt et al., 2017). Offers of conditional admission, committed faculty mentors, and assessment of an applicant’s critical awareness of the graduate curriculum and its relation to the industry are opportunities to increase diversity and inclusion in CSE disciplines at the three Bay Area CSU

campuses. Student experiences in these areas may inform new ways for outreach and recruitment.

Kaleb, Alex, and Dewayne received offers of admission by faculty who were willing to move outside of tradition. Kaleb admitted that his undergraduate grades were not reflective of his ability; he attempted to remedy this perceived deficiency by submitting a high GRE score with his application. His admitting CSE graduate program offered conditional admission and assigned Kaleb a series of prerequisite courses to ensure that he was prepared for graduate level coursework. Alex, earned his undergraduate degree in economics and was nearly excluded in participating in graduate education. He delayed his study, but again, his admitting CSE graduate program offered conditional admission to ensure that he had the same academic preparation as his classmates. Conditional admission is one possible route to broaden participation in CSE graduate programs, particularly for students with undergraduate majors outside the disciplines. Recognizing the interdisciplinarity of CSE disciplines with those outside the academic departments may increase participation of URM and women students.

Faculty mentors are key to broadening participation of URM and women in CSE graduate programs. Participant responses in this study align with recent and current scholarship. Faculty mentors wrote letters of recommendation for Kaleb and Alex and advocated for them throughout the graduate admissions process. Kirana shared her impressions of faculty mentors who were also women; who supported her through undergraduate research experiences, admission to the computer science graduate program and on her final thesis project. Kirana saw herself in these women, a motivating factor for her to persist in graduate education. Alex understands the need to diversify the profession and the graduate education pipeline in general. As a lecturer on his Bay Area CSU campus, he is an advocate for undergraduate students who intend to pursue others. He

may be a role model for other Hispanic/Mexican American students who then see themselves in the computer sciences at an advanced level. Faculty mentors hold significant influence over one's entry into a graduate program; they are often final decision makers. University administrators and graduate program faculty have an opportunity in this space to change how graduate students are selected for admission through a focus on mentorship that begins in a student's undergraduate degree program.

### ***Graduate Curriculum***

Participants in this study are critically aware of the rapidly evolving nature of Silicon Valley technology professions and focus this awareness on CSE graduate curriculum as they experience it. The participants shared view that the core theory courses in their CSE graduate program are challenging, foundational, and relevant. However, they viewed elective courses or as not at pace with industry trends. Participant characterizations of elective courses include "required updating" or "upgrades." Participants gave examples of the evolving nature of computer programming languages in interview protocol responses to perceptions of the curriculum. Students in this study have a strong knowledge base of Silicon Valley professions and industry trends. This knowledge was developed outside the classroom through self-directed interest. Graduate faculty in the CSE graduate programs could assess such knowledge of prospective students as a more relevant means to selecting the best fit graduate students. Such an approach would require a rethinking of application evaluation, and would incorporate a consideration of the professional knowledge assets potential graduate students already hold, a knowledge (as seen through participants in this study) that has developed from family and community and overcoming potential barriers to graduate education.

### ***Funding Opportunities for Graduate School***

Funding graduate education emerged as a barrier for three participants. Participant accounts converged around the economic realities they faced that delayed or disrupted degree attainment. Educational research suggests graduate education as a route to social mobility is increasingly out of reach for students most likely to gain such social mobility with an advanced degree. Researchers continue to demonstrate that funding opportunities for graduate school increase participation, persistence, and completion rates, particularly for historically marginalized students, and evidence suggests that grant aid specifically increases the odds of degree attainment (Goldrick-Rab et al., 2016; Kim, 2012). Participants in this study may have been able to complete graduate degrees much earlier had they had access to institutional support.

The Council of Graduate Schools perspective is clear, "It is impossible to support and foster graduate education without taking an active role in identifying, securing and distributing funds for graduate student fellowships, traineeships and financial aid" (Denecke, 2004, p. 23). Senior administration, graduate faculty, and student affairs professionals must take an active role in advancing funding opportunities for graduate education that are vital to inclusion and equity, particularly when historically marginalized students rely on grants, scholarships, assistantships, and loans in order to participate.

A coordinated effort across siloed divisions between faculty and student affairs professionals on identifying, securing and distributing funds for graduate study is the change needed, and the goal of this change strategy. Faculty mentors of participants in this study are committed educators who helped their mentees gain internship offers, and graduate teaching assistantships to cover a small cost of their education. Funding issues become as much of a barrier to admission for some, as traditional selection processes and approaches.

### *Peer Networks and Academic Socialization*

Each participant in this study did not attribute interactions with peers as impactful on their graduate education. Academic socialization was a self-directed endeavor for several participants who did not receive adequate faculty advising or mentorship. Stockard et al.(2021) analyzed peer network impact on graduate school and found that URM students, particularly women, reported fewer positive interactions among peers and faculty (Stockard et al., 2021). Kaleb shared an exception; however, peer interactions are not described as overtly positive or negative by participants.

Educational research suggests supportive and collaborative peer networks amplify potential for success in graduate school and adapting to academic disciplinary norms (Charleston et al., 2014; Fernandez et al., 2019; Stockard et al., 2021). For this study, the commuter characteristics of the three Bay Area CSU campuses and the isolating effects of the coronavirus on the graduate education experience may be viewed as similar. Participants in this study acknowledge the commuter school characteristics of each of the three Bay Area CSU campuses as a limiting factor for engaging with peers and faculty in meaningful ways. With the exception of two participants, the coronavirus pandemic impacted academic socialization, opportunity to build peer networks and develop in-person relationships.

The graduate school experience became an isolating experience because of the pandemic. However, even those participants who either graduated before the pandemic began or who had an opportunity to study in-person characterize the commuter campus as not conducive to the development of meaningful relationships with classmates. These participants shared perceptions that the social media communication platforms are effective channels for student and faculty engagement. Kaleb, Dewayne, Robert, Mia, and Kirana describe the effective usage of social



media platforms that mediate peer networks within their respective academic departments. These platforms provided a space to engage outside the classroom.

These platforms became more important for some during the pivot to remote instruction on the onset of the coronavirus pandemic. Participants in this study use Discord, Slack, Twitter, and WhatsApp to engage with classmates and faculty in their various graduate programs. The students in this study present experiences that suggest graduate programs at Bay Area CSU campuses have an opportunity to encourage meaningful peer engagement. Graduate faculty and academic departments must rethink ways in which they can nurture positive peer networks and academic socialization in higher education either at a computer school campus or in a remote learning modality. Peer networks and academic socialization mediated through digital spaces could emerge as a surrogate academic department community of students and faculty. Such mediated digital spaces may create for some, what the commuter campus disrupts.

### ***Faculty Mentors***

Recent scholarship on influences and motivations for graduate education focus on faculty mentorship. Faculty in the academic department hold power to influence students in positive and negative ways. Faculty mentors often mediate acclimation to academic discipline norms and department cultures (Fernandez et al., 2019; Posselt et al., 2017; Stachl & Baranger, 2020). Committed faculty educators are features of the graduate student experience for the participants in this study. Where peer engagement was lacking due to the commuter school characteristics or impact of the coronavirus pandemic, faculty mentorship was strong.

Participants in this study share experiences with key faculty mentors who were instrumental in inspiring them to pursue graduate school, who advocated for them during the admissions process, and guided them through challenging coursework and thesis projects. “Because graduate students spend most of their time within their department and laboratory” Stachl and Baranger

(2020) state, “their sense of belonging is more connected to the few faculty mentors” (p. 28).

This statement resonates across participant experiences in this study, particularly in the context of a commuter campus environment and the isolating impact of the coronavirus pandemic.

Participants in this study shared experiences with graduate faculty mentors who inspired them to pursue graduate education. These faculty wrote letters of recommendation and guided them through the admissions process. Committed faculty mentors also facilitated internships for several of the participants in this study, an impactful component of the graduate education experience that served the individual post-graduation. Committed faculty also mentored several students in the role of graduate teaching assistant, also a significant experience in graduate education. Faculty mentors who are advocates, are key actors in retention, persistence, and achievement of graduate student mentees (Fernandez, 2019; Posselt, 2017; Stachl & Baranger, 2020). study, particularly in the context of a commuter campus environment and the isolating impact of the coronavirus pandemic.

### ***Impact of COVID-19 on the Graduate Student Experience***

The coronavirus pandemic impacted this dissertation study and the graduate student experience of participants in significant ways. The global pandemic impacted the research study inquiry into graduate student experience because it fundamentally altered the ways in which participants engage with faculty, peers and their course of study. Furthermore, participants in this study who were just beginning the CSE graduate program at their Bay Area CSU or who were mid-progress to degree experienced an altered graduate school landscape. The pandemic was an isolating experience, yet participants in this study demonstrated resilience and self-efficacy, attributes that contributed to their success. Out of isolation, and the loss of an ability to engage with peers and faculty in person, participants adapted and utilized social media communication

channels to recreate some peer and faculty engagement. Finally, participants in this study used the pandemic's moment in history to apply the knowledge and skills they developed in their graduate program on course projects or a thesis.

The pandemic was an isolating event for participants in this study. Participants shared an idealized view of graduate school and learning alongside and from classmates. The experience of dynamic seminar discussion and group work conducted remotely had been flattened out by zoom. Participants lamented the loss of opportunity to connect with peers in person. They characterized these new Zoom mediated engagements as transactional and abrupt at the end of class. Participants shared a loss of organic conversations that occurred naturally in the library or department study space, the collegial banter over theory and course assignments, getting to know classmates on a more personal level. Isolated, participants demonstrated resilience and self-efficacy that resulted in a more self-directed approach to learning. Participants sought ways to move through their degree program with limited guidance from faculty. Ayesha found guidance in industry documentation as she worked to finalize her final thesis project. Dewayne surveyed the course catalog to determine a road map to complete his degree in two years due to limited advising. Kaleb spent time mentoring classmates on group work so they could complete the assignments on time. Mia spent time watching online videos on computer programming language problems. Participants in this study worked through the isolation effect of the pandemic by focusing on their studies and engaging in self-directed approaches.

Participants in this study adapted to the realities of their graduate education experience as the pandemic continued to impact the country and higher education institutions. Participants adapted to social media platforms that became primary mediators of peer and faculty interactions. Participants shared that they become more comfortable in the remote learning environment over

time and began to develop friendships using these social media tools. Participants across the three Bay Area Universities used Discord, a social media application common among computer science students and professionals. Faculty mentors also engaged in Discord and other applications such as Twitter, Slack, WhatsApp, and LinkedIn. Kaleb shared positive experiences with graduate faculty who were more accessible to him in the online spaces. Kaleb said that he experienced immediate responses to his questions for faculty. Kaleb also used these social media platforms to connect with friends in the program, friends he characterized as sources of inspiration in the profession and in the classroom. Participants demonstrated adaptability and willingness to find alternative ways to engage with peers as the pandemic continued to impact their graduate school experience. Similarly, the commuter nature of the three Bay Area CSU campuses is prohibitive to a degree for graduate students. Engage in meaningful academic socialization in typical years is difficult, often because CSU graduate students are working, classes are scheduled later in the evenings, and the campuses are commuter in nature. Nevertheless, participants y found new ways to engage with peers and faculty in digitally mediated spaces and this suggests an opportunity for redefining academic socialization moving into the future.

Participants in this study critically reflected on their technical knowledge and skills and used circumstances created by the pandemic to flex their intellect in course projects and final thesis projects. Participants in this study viewed the opportunity to research the impact of the coronavirus on their communities and wanted to solve problems. Robert utilized his data science background to analyze the impact of COVID-19 deaths on local economies in order to show the devastating impact of loss of life and livelihood for communities in the region. Kiriana understood the social impact and consequences for children in grade school learning remotely.

She developed an application and tested it out as a component of her thesis project that would help students and teachers communicate in remote learning modalities. Participants demonstrated resilience, adaptability, and self-efficacy throughout their degree program as it was impacted by the coronavirus pandemic.

### ***Self-Efficacy and Authentic Learning in Graduate School***

Authentic learning experiences in this study included significant research projects, group work, internships, graduate teaching associate (GTA) appointments, and thesis projects (Singer et al., 2020) studied development of STEM identity formation, and results suggest positive identities as scientists formed when courses or co-curricular activities focused on the intersections of race, ethnicity, and self-perceptions as scientists. Participants in this study shared that there was a lack of discussion on ethics, diversity, or social responsibility in their coursework. This is expected for the quite narrow, focused graduate degree. Nonetheless, participants in this study focused on creating authentic learning experiences at the intersections of diversity in homogenous academic and professional spheres with a social impact. The internship is an important transition to professional life. Participants in the study who engaged in internships had a critical awareness of underrepresentation at the internship site and in the profession in general. Self-directed learning and self-reliance are evident as participants engaged in internship endeavors. Participants looked to industry documentation and professional organizations outside of the academic department for support. The experiences of participants in this study diverge from the Singer study, in that support occurred outside the academic department or classroom. Nevertheless, they identified supports similar to the Singer study, which enhanced their graduate school experience (Singer et al., 2020).

The graduate teaching associate (GTA) position was an important feature of the graduate student experience for participants in the study. Participant experience in this role suggests a threefold impact: 1) development of subject area expertise, 2) development of leadership and teaching skills, and 3) mediating the cost of the graduate programs for the student. The GTA appointment enhanced the faculty mentor-mentee relationship, and informed final research projects. Furthermore, the GTA role enhanced the development of one scientist identity. Participants spoke with confidence in the course subjects and their expertise in it. The role shaped ambitions, and several participants are considering a Ph.D. Kirana was able to participant in department curriculum committee work and provide insight into undergraduate curriculum revisions at the department level because of her experience as a GTA.

Participants engaged in self-directed projects or final research with a social impact in mind. Robert used his data science management course to develop a method to analyze COVID-19 deaths and a relational impact on local economies in the region. Mia worked to develop a user-friendly application to help farmers in India. Kirana understood the impact of the COVID-19 and remote learning on K through 12 educations. She developed an application to mediate the student experience and inform teachers of gaps in understanding of course material.

Generally, participants in the study developed a scientist identity in significant ways. They expressed confidence as an emerging scientist. Singer et al. (2020) provides a significant baseline approach to diversity and inclusion in STEM for universities to consider in reforming toward equity, diversity, and inclusion in computer science and engineering disciplines. Program offerings at the undergraduate level may translate to more interest in pursuing advanced degrees in these disciplines.

## **Perceptions of Self, Academics, Researchers, and Professionals**

Understanding how URM and women graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities is part of this dissertation study. The second research question: RQ2: How do historically marginalized graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities? is answered through analysis of experiences with curriculum and co-curricular programs. A recurrence of three themes emerged in the qualitative analysis of this dissertation study that answer this question. The cross-unit of study comparative approach substantiates these themes and instances of data saturation are found. Participant responses to interview protocol questions are similar across campuses. The three themes discussed in this section arose from participant critical consciousness aimed at their graduate education in relation to Silicon Valley technology professions. They critique the CSE graduate curriculum offered at their Bay Area CSU campus. Participants are critical of the pragmatics of a CSE graduate degree in relation to professional advancement, and are critical of the relevance of co-curricular and professional networking opportunities offered by their Bay Area university.

### ***Experience with Graduate Curriculum***

Each of the eight participants in this study demonstrate conscientização (Freire, 1970) or critical consciousness, a dominant recurring theme that consistently emerges throughout in-depth interviews and reveals perceptions and opinions of curriculum. This theme emerges to answer the second research question. Moreover, a critical theory lens to the qualitative analysis of in-depth semi structured interview data enables a transformative understanding of the lived experiences of URM and women graduate students as they navigate university life (Creswell &

Creswell, 2017). A transformative understanding of these experiences considers the expertise that participants in this study bring to their graduate program. A critical consciousness is prominent in interview discussions about CSE graduate curriculum, the usefulness of the graduate degree as a route to advancing in the profession, and co-curricular and professional networking opportunities.

The professional profiles of study participants range from entry level to mid-career professional. Furthermore, participants are engaged in computer programming or creative projects outside of a professional role or academic setting. In other words, they engaged in informal online research and self-directed learning opportunities out of curiosity and hobby. They understand emerging and evolving technologies in computer sciences or engineering, and developed this understanding outside formal academic training. Participants in this study have expertise in industry trends, the rapidly evolving nature of their chosen professions, and direct alignment of the curriculum with the evolving nature of the professions. They confidently view themselves as knowledgeable and as an authority on their area of study, in so much so, they confidently critique the currency and relevance of their graduate curriculum.

There is agreement among participants that graduate education provides an opportunity to upskill or study current computer programming or engineering specializations. Several participants stated they pursued a graduate degree to remain current in the field, recognizing how technology has changed since baccalaureate degree attainment. However, their professional and informal experiences informed the critique of their graduate program curriculum. But for Miguel, participants held positive views of the core theory courses in their individual graduate programs. Alex said, “the theory classes were good, theory never changes.” He was critical of the graduate elective courses offered and suggests revisions for currency are needed. As a lecturer at his Bay



Area CSU campus, Alex also tries to bring his professional software engineering expertise into the classroom. Similarly, Dewayne was critical of his computer science program curriculum and technology profession trends in general. He perceived “the hype of the day” has an impact on the curriculum. He focused on the relevance of theory courses in favor of hype; “maybe there isn't enough emphasis on the underlying principles or the reason why things are done the way they are.” Ayesha viewed her curriculum as requiring “updating, while Robert suggested refinement on the edges or the curriculum.

Graduate faculty in the computer sciences and engineering disciplines at the three Bay Area CSU campuses have opportunities to include graduate student expertise in departmental cultures. Kirana was given an opportunity to participate on a department committee charged with revising undergraduate curriculum. She attributes a strong sense of belonging within her computer science department to this experience. Recognizing the assets and critical consciousness of historically marginalized and women graduate students in CSE graduate programs is one way faculty can reconsider traditional approaches to the graduate admission selection process and in reforming academic department cultures toward a more inclusive environment.

### ***Pragmatics of Degree***

The students in this study hold contradictory views on the potential for a graduate degree to enhance one's competitiveness for the Silicon Valley job market. Nonetheless, each of these participants was highly motivated to complete the graduate degree because of the value of education itself. Graduate students in this study recognized that there are professionals in the field who have obtained training in coding bootcamps through Silicon Valley technology firms. They understood competition for high wage professions is dependent on long hours and the technology firms practice of administering coding assessment tests in the interview and hiring process. Competition is identified by participants in this study, as motivated self-directed

computer programmers outside the academic spheres. For Mia, the only competitive edge she perceived of her graduate degree is its technology curriculum currency. She self-taught through online courses, enough to learn some basic skills for entry into these professions. She is a self-directed learner who could update future skills through online resources; however, she views her competition as individuals who may not hold a graduate degree credential, but are hardworking and self-taught. Alex agreed, “Having a master’s doesn’t guarantee you a job or salary, you still have to grind practice problems really, really hard.” Furthermore, Kaleb characterized his potential professional competition as putting in countless hours of coding and training for coding. Participants in this study are critically aware of opportunity for professional advancement outside of a graduate program, and identify competition in their profession as taking such opportunity.

The perceptions of the participants in this study suggest graduate faculty and university administrators at the California State University campuses in the region must demonstrate the relevance of the graduate degree for professional advancement in technology and engineering professions. Scott and Kirst (2017) identify companies such as Apple, Cisco, Google, Hewlett-Packard, and LinkedIn, “create their own postsecondary training units rather than to rely on colleges to provide training” (p. 71). Such industries training opportunities, resulting in digital badges, certificates, or certifications, may be more relevant to aspiring professionals who then choose not to pursue graduate education in related disciplines. Scott and Kirst (2017) conducted a comparative analysis of the three CSU campuses in the Bay Area and found various levels of connectedness and collaboration with prominent Silicon Valley technology firms.

Students in this study shared strong preferences for their CSU campus precisely because of its proximity to Silicon Valley and the opportunities afforded by the Bay Area region. However,

participant motivations to pursue a graduate degree do not reside solely in professional advancement; there is a shared value of higher education itself, a shared value attributed to graduate school aspirations. The value of higher education is also influenced by family and family networks. Public universities in the region are positioned to mediate opportunity for a diverse graduate students' population, and must consider graduate degree relevance and the ways in which they engage with students and families in outreach and recruitment.

### **Relevance of Co-Curricular Activities and Professional Networking Opportunities**

The juncture of graduate degree attainment and entry or advancement in professional life presents a gap in the extant literature on the graduate school experience (Posselt & Grodsky, 2017). University and academic discipline specific co-curricular programming and professional networking opportunities are features of the graduate student lifecycle that reside at this juncture. The extant literature on co-curricular and professional networking opportunities offered in higher education underscores the benefits of such programming. Furthermore, current research suggests such programmatic support encourages persistence to degree attainment for historically marginalized and women graduate students in STEM disciplines. Charleston et al. (2014) found faculty and peer networks, including experiential learning, professional networking with the computing industry, were attributes that lead to success of African-American students in their study. These supplemental university or academic department programs significantly contributed to the success of these students. Similarly, Dodson et al. (2009) such programming are effective tools for socialization into the academic discipline and profession, leading to persistence and success. The perceptions and experiences of participants in this study suggest the Bay Area CSU campuses have an opportunity to improve on co-curricular and professional networking opportunities.

The qualitative analysis of in-depth semi-structured interview data reveal a thematic recurrence of critical consciousness residing in computer scientist or engineer identity development. Higher education institutions develop career services, co-curriculum, or professional development opportunities to augment identity development and the potential for post-graduate employment success. The critical consciousness that participants in this study bring to their academic department uncover opportunities to reform practice. Participants in this study possess asset-knowledge of the technology industry and individual professions. Furthermore, they bring currency to the discourse of their graduate program. Study participants are aware of their minority statuses in both academia and in technology professions, and view their presence as an act of change. They command an authoritative scientist identity in reflexive views of co-curricular programming or professional development opportunities. Each participant in this study was aware of supplemental programming aimed at professional development. However, they did not actively participate. Participants held similar views that these offerings were better suited for undergraduate students and did not match their level for potential development. They perceived career services as basic resume or practice interview workshops. Participants reflected on their experiences and suggested academic departments would better serve students with workshops that developed them in professional discourse, or to prepare for industry coding assessment tests, new features of the interview process at technology firms. The participants in this study cast a critical lens on the academic department and integrations with industry in the region. Real professional development opportunities or co-curriculum programming related to career, for these participants, requires direct engagement with Silicon Valley technology firms, including engagement on issues of diversity in the professions.

The shared opinion that current co-curricular and professional networking opportunities were at a basic level or not relevant, is situated in the context of the Silicon Valley region and lack of diversity in technology professions. Several participants in this study chose their Bay Area CSU campus due to the location and proximity to Silicon Valley. Prior to enrollment, each participant held a perception that their academic department was tightly integrated with the dynamics of the technology workforce. Mia expressed disappointment over the co-curricular and professional networking opportunities in which she participated. She made an assumption that her computer science department directly engaged technology firms in the region and was surprised to find opportunities only for management or business students, nothing deep in technology. That co-curricular and professional networking opportunities are not aligned with the Silicon Valley opportunity structure, suggests universities and academic departments have areas to improve.

Current educational research underscores the influence relevant co-curriculum programming has on the academic success of historically marginalized and female students in STEM fields, particularly computer sciences Charleston et al. (2014) and engineering Burt & Johnson (2018). The critical awareness of graduate curriculum and related industry opportunities that participants in this study hold suggests a need for universities and departments to elevate co-curriculum programming and professional networking opportunities to a higher level more appropriate for its graduate students. This study reveals a lack of university alignment to the opportunity structures in Silicon Valley, a misalignment of program offering within their graduate degree area of focus, and subsequent lack of enthusiasm from participants for the programs on offer. Scott and Kirst (2017) survey of the California State University campuses in the region suggest a lack of collaboration and coordination with technology firms, a commonly shared perception amongst participants in this study.

## **URM and Female Graduate CSE Students as Silicon Valley Professionals**

The professional experiences of graduate student participants in this study range from entry level internships to decades in a professional role in the Silicon Valley workforce. Participants are knowledgeable about industry trends and evolving technologies, the competitiveness of the job market, and what is required to advance in their fields beyond a graduate degree, such as firm specific coding knowledge and the ability to prove one's skills in the hiring process. The perception of self as a Silicon Valley knowledge economy professional is the focus of the third research question that guides this study. RQ3: How do historically marginalized graduate and female CSE students view themselves as Silicon Valley knowledge economy professionals? These perceptions are important in the context of graduate education, because these students critically reflect on their graduate experience as it relates to the field and the popular and political discourse on lack of diversity in their chosen field.

### ***Critically Self-Awareness***

The California State Universities in the Bay Area region have significant opportunities to engage the dynamism of the Silicon Valley knowledge economy and mediate opportunity structures for its historically marginalized and women graduate students in Computer Science and Engineering disciplines. Opportunities to engage with Silicon Valley reside in the graduate students themselves. Participants in this study demonstrated a strong sense of agency as they navigated graduate school and professional advancement in fields that are traditionally male-dominated and homogenous. The participants remained engaged in the discourse of diversity issues in the technology workforce. They possess a critical awareness of their own minority status in the higher education and professional spheres. The views of self as Silicon Valley professions that participants in this study hold, in the context of minority status, are important features of the graduate student lifecycle that can further institutional efforts for diversity and

inclusion in the CSE disciplines. Analysis of the qualitative interview data reveals students mediate their minority status in these fields by actively engaging with discourse on diversity issues in CSE graduate disciplines and related professions outside academia. Furthermore, participants in this study have claimed an authoritative voice in these academic and professional fields through experience and overcoming barriers. Participants' voice resides in the potential for a social impact they may make as they advance in their profession.

Participants are critically aware of their minority status in academic and professional spheres, and mediate this status through strong self-agency and engagement with the popular and political discourse on lack of diversity in technology professions. Robert perceived Black representation at his University of California to be about two percent. He had early exposure to the Silicon Valley technology culture through Black family friends, and early exposure sharpened his opinions of the necessity for strong Black mentorship for young student aspirations to the profession. Robert consistently referred to the concept of role models as a way to amplify diversity and the need for such role models for young Black students in K-12. Kaleb grappled with the perceptions of affirmative action in graduate education and in the professions, perceives it to be non-existent, and characterized assumptions of affirmative action benefits White people may hold as overblown. Ayesha insisted she prefers to be judged on her own merit, not given special consideration in the hiring process because she is a woman; however, she views Silicon Valley firms' proclamations in favor of diversity and inclusion to be hollow gestures. Ayesha sought out support from professional organizations such as the Grace Hopper Foundation that supports women engineers and scientists. Engagement with this organization helped Ayesha develop a sense of solidarity with women in technology. Mia was critical of the lack of women representation amongst the online do-it-yourself computer programmer communities and aspires

to change this. Kirana lamented the lack of women software engineers at her workplace, and in her current graduate program. She noted that there were two women in her engineering program when she pursued her undergraduate degree twenty years ago, and noted there were two women in her current graduate program today. Kirana reads books published by women in the technology sector, a source of solidarity. The participants in this study remain undeterred in the face of real and perceived barriers or hurdles to advancement. The strong self-agency that motivates them through a homogenous male-dominated sphere is the result of unwavering familial and aspirational capital and a commitment to achieve.

### ***Social Impact***

The participants in this study hold similar values and moral obligations in technology professions as they look toward the future. There is agreement in views of self as actors in the Silicon Valley technology culture. Participants in this study are resistant to the current Silicon Valley status-quo and their very presence is, for them, a significant act. The participants in this study aspire to make a social impact in their professional roles. They share opinions about corporate diversity initiatives and why lack of diversity persists. Furthermore, they express a moral obligation to pave the way for other underrepresented minority aspiring computer scientists or engineers. Robert, Alex, and Kaleb understand the need for more Black or Hispanic computer scientists and engineers, and they are proud to reside in this space. With a critical awareness of their minority status in these professions, the very act of pursuing graduate education and their chosen profession is action toward changing the status quo.

The intersection of gender and professional aspirations in a male-dominated workforce is profound and the women participants in this study view their participation and aspiration as a challenge to the status quo. The three women participants in this study understand the roles women may take in the Silicon Valley workforce. Ayesha, for example, perceives women in



these professions to take on roles other than engineering or software development. The women who she engaged with in prior professional roles were in Human Resources or marketing. She said, “You know, all the, I think all the executives are men. You don't see many executives, women. They don't exist.” For Ayesha, her minority status as a woman in this field is real and ever present. Similarly, Mia sees a trend of subjecting women in these fields to “design” roles. She characterized a split in the technology professions to occur at the juncture of design and engineering. She shared perceptions of women being guided toward the design side of website development or User Interface (UI) or User Experience (UX) side of technology. This could be an area of further research. She has taken note of the lack of women online in the do-it-yourself computer programming community and intends to make an impact in this area. Kirana characterizes her workplaces, "you know, I mean, it's mostly men.” She lamented, “I wish it would be 50-50.” Furthermore, Kirana follows the public and political discourse on the lack of diversity in technology professions. She follows the headlines on legislation and activist organizations trying to improve diversity in technology. She said, “you know, I'm part of the group that they're fighting for. But I've put myself into this field;” For Kirana, just being part of this field is a significant act toward change.

Participants in this study intend to make a social impact as they advance in their profession. They see opportunities in solving social problems. Mia is developing an application to help farmers in India navigate the fluctuations in grain prices and allow them to better forecast to improve their own business model. Kirana, similarly, developed an application that mediates learning in the remote or online classroom. She is interested in pursuing software engineering projects such as this in future work to inspire more young women into computer sciences. She aspires to write a book on women in technology professions. Robert continued to refer back to

his early exposure to Silicon Valley technology culture by Black role models. This experience impacted Robert in significant ways and he is a strong advocate for mentorship in computer sciences. Robert revisits his stance on the necessity for early exposure in these fields. He said, “I feel that I feel that we could do better at the K through 12. And especially in certain areas, like certain schools, school districts.” Mentorship at an early age, in Robert’s opinion, is a critical strategy for diversity in the computer science professions and a moral and social obligation. Miguel views Silicon Valley technology professions intersecting with civil engineering and public works projects in offering cutting edge solutions to conservation and a clean environment. His professional stance is centered on realizing a clean and healthy environment through evolving technologies.

Participants in this study express a moral obligation to pave the way for other underrepresented minority aspiring computer scientists or engineers. Kaleb said, “first of all there's...there's not...there's not people doing it; and that's not their fault, it's not the university's fault.” Kaleb does not lay blame on the students or the university. He believes that the profession needs to be demystified and that assumptions about computer science as math intensive may deter students from pursuing computer science in the first place. He tries to persuade his cousin that computer science is simple math. He is a strong advocate for demystifying the academic disciplines in computer sciences so that the profession will diversify. He is actively advocating his extended family to pursue computer science even in the face of math anxiety. Kaleb is aware of the anxiety surrounding math for many students. He is confident in his ability at math, and is eager to share how math is related to computer sciences. His argument for enhancing diversity resides in a demystifying of math as it relates to computer science.

Robert is a mentor in his new professional role and is considering going into teaching. He is an education facilitator and a software engineer at a [computer programming school] that offers an intensive computer programming curriculum. He is a mentor to many young students in computer sciences and a role model. He believes teaching in this area as a career may have a social impact. He sees the thread of early mentorship and opportunities as directly related to graduate education aspirations and computer science professions. Kirana is interested in pursuing a role in computer science education in the future where she can directly impact young women in the field. Kirana wants to make a direct impact on the diversity issue in technology professions. Alex also wants to make an impact in his field. He understands his status as a role model for other Mexican-Americans aspiring to the computer science professions and he uses his role as a lecturer to influence his students. He is also an advocate for potential graduate students and writes letters of recommendation for graduate school aspirants.

The concept of “boundary” is invoked in a discussion of results of an Applied Physics program that intentionally and successfully recruited and retained URM and female students. (Posselt et al., 2017). The boundary contains graduate education, its academic culture; where the ability to cross the boundary into a graduate program is perceived by students and faculty differently. Posselt et al. (2017) charges faculty to rethink how they assess one’s ability to succeed in a graduate program, and advocates for a look into one’s social or moral stances. Posselt et al. (2017) boundary erasure study sees value in attention toward students who want to make a social impact. Each participant in the study sees potential for social impact through technology. Traditional graduate admission selection practices can be revised to obtain a student’s social or moral obligations as related to the CSE disciplines. Such action would redraw the boundary for the discipline and alter the academic department culture toward inclusion.

## **Discussion and Implications**

The objective of this dissertation study was to explore, through in-depth interviews, the perceptions and experiences of Underrepresented Minority and female graduate students in CSE disciplines at three Bay Area CSU campuses. The lack of diversity in the graduate student body in computer sciences and engineering at these institutions, mirror the lack of diversity in related Silicon Valley technology professions. This dissertation study presents implications and recommendations for practice specific to inclusion and diversity in CSE disciplines at Bay Area CSU campuses. Implications and recommendations discussed herein are organized around graduate outreach and recruitment, academic socialization, and professional identity development in CSE professions.

### ***Graduate Outreach and Recruitment***

Rethinking definitions of “good fit” in graduate admission selection and developing a long-range strategy are paramount in inclusion and diversity work in CSE graduate education. Intentional approaches to recruitment and outreach for diversity require expanding the definition of “good fit.” Posselt et al. (2017) offers evidence of successful graduate program recruitment for diversity required faculty and administrative staff to oppose “prevailing schemes about ‘merit’ that undercut admission of students from underrepresented backgrounds” (p. 8). Assumptions about merit and an ability to succeed in a graduate program are influenced by the use of standardized tests in admission selection. Recent studies suggest limited correlation between high GRE scores and academic success in science and technology disciplines disrupting traditional assumptions (Sealy et al., 2019). Scholars call for in-depth study on the impact the GRE may have on access and participation across gender, race, and ethnicity (Pacheco et al., 2015). A more holistic approach to graduate admission may demystify the graduate school boundary and broaden the scope of recruitment and outreach. The use of LeetCode, similar

computer programming coding tests that mimic industry interview norms or project-based portfolios in the admission selection process are perceived as more relevant by participants in this study to their graduate curriculum than the GRE exam. The perceptions of study participants offer alternative, yet highly relevant, assessment alternatives for academic potential in graduate school. Holistic admission selection should be discipline specific, however, must be considered as an alternative to current ossified practices.

A long-range strategy toward recruitment and outreach of URM and female CSE graduate students for the Bay Area CSU campuses is essential. The experiences and perceptions of participants in this study may inform a long-range strategy for public higher education in the region. Participant motivations and aspirations for computer science and engineering began early in life, through exposure often through play, through foundational courses, and through undergraduate research opportunities. Moreover, family influence on motivation and aspiration is evident. An understanding of early identity formation in the computer sciences or engineering may inform a long-range strategy for inclusion and diversity efforts in these disciplines. Educational research supports this claim. Charleston et al. (2014) demonstrate positive social influences, community, and sense of belonging, impact self-efficacy and scientific identity. Family influence and early exploratory experiences of participants in this study are aligned with this claim. Where Singer et al. (2020) suggests active learning influences student achievement in STEM, Eagan et al., (2014) argue undergraduate research is a critical formative opportunity resulting in further academic achievement while mediating imposter syndrome. Again, participants in this study shared experiences that align with such claims.

A long-range strategy that acknowledges and nurtures early experiences in CSE may lead to transformative inclusion and diversity initiatives. Burt & Johnson (2018) recommend practices

that influence internal and external motivation at all class levels, with emphasis on early exposure. University administrators and faculty have the opportunity to develop co-curricular programs that impact undergraduate student identity formation. Co-curricular outreach and recruitment programs could include summer coding boot camps or engineering projects for regional high school students, incoming first year undergraduate students, that encourage and engage parents, co-taught by Graduate Teaching Associates and faculty. Programming could be topically focused on using technology to solve community issues. Universities could sustain such engagement throughout undergraduate studies by offering relevant research opportunities that enhance scientist identity. Charleston et al. (2014) finds family and multifaceted mentors, both senior students and faculty significantly influenced academic trajectories in computer sciences. This research, and the perceptions and experiences of the participants in this study suggest a long-range recruitment strategy would include family and mentors in early academics. The relevant university is one that is responsive to the region and community in which it resides. Student support programming could replicate a relevant community in undergraduate studies that affirms the cultural wealth backgrounds of its URM students.

### ***Academic Socialization***

Academic socialization relevant to this dissertation study includes peer networks and faculty mentors as features of the graduate student experience. The commuter campus, a characteristic of each of the three Bay Area CSU campuses, in general, is challenging for positive academic socialization with peers and faculty. Furthermore, the challenge of positive academic socialization was amplified by the coronavirus pandemic through the duration of remote learning as experienced by participants in this study. The nature of the commuter campus results in less opportunity for on campus experiences, amplified by the average age of CSU graduate students

who have professional and family obligations. Nevertheless, peer and faculty networking are critical features of graduate school and when positive, result in persistence.

Fernandez et al. (2019) argues that a healthy academic department climate is one which resembles peer collaboration over competition and faculty mentorship over hierarchy. Furthermore, a healthy climate is a mediator for isolation underrepresented minority students in the classroom and academic department may face. The commuter campus is inherently isolating and the coronavirus pandemic amplified this feature of Bay Area CSU graduate student life. Stockard et al. (2021) examined peer network impact on the URM and women graduate students and found that URM students, particularly women, reported fewer positive interactions among peers and faculty. Participants in this study did not share experiences of microaggression, bias, or sexism; however, their experiences with peers were not characterized as impactful on the graduate school experience. The participants in this study whose graduate education was impacted by the coronavirus pandemic did adapt to new forms of peer engagement. Participants engaged with peers through various social media channels to complete group projects; furthermore, they used these channels to engage with faculty mentors. Those participants who earned their graduate degree before the coronavirus pandemic shared a similar lack of meaningful peer engagement opportunities due to the character of the commuter campus. The Bay Area CSU campuses have opportunities to leverage social media channels and other technology platforms to create spaces for peer engagement. While the coronavirus pandemic recedes and graduate education returns to a more familiar experience, the realities of a commuter campus remain.

Faculty mentors were identified by study participants as impactful on their graduate student experience. Faculty mentors played critical roles for participants in gaining admission to and

persistence in graduate school. Study participants either benefitted from faculty role model representation or wished to see themselves in faculty representation. These perceptions and experiences align with current scholarship. Burt and Johnson (2018) recommend increases in Black representation of faculty as a meaningful outreach and recruitment strategy directed at Black students. Burt and Johnson (2018) argue, "having more Black representation at the faculty and student levels motivates students to persist" (p. 50).

Scholars identify the lack of minority representation in the professoriate as impacting participation rates of URM and women in STEM disciplines. (Figueroa & Hurtado, 2013; Griffith, 2010; Stockard et al., 2021). Recruitment of a diverse professoriate is a long-range strategy that must be considered in inclusion and diversity initiatives in the region's California State University campuses. A short-term strategy for inclusion and diversity efforts is the use of adjunct professors or lectures to be deliberate in representation. Moreover, adjunct professors who are current professionals may advance curricula at a pace more aligned with the evolving nature of the Bay Area industry (Scott & Kirst 2017).

Recent educational research and the experiences of study participants suggest strong family and community influence on motivations and aspirations for graduate education in STEM fields. University administrators and graduate program faculty should acknowledge family influence in inclusion and diversity initiatives. Posselt et al. (2017) studied the success of an applied physics department in recruitment and retention of URM and female students and found an intentional family-like atmosphere was key to inclusion and diversity efforts. Opportunity exists with this acknowledgment to rethink traditional academic department cultures moving away from hierarchy toward inclusive community. The academic department may become a surrogate for family and community. An academic department approach that incorporates features of family



and community support reduces perceptions for competition in the discipline and encourages collaboration among peers and faculty.

### **Identity in the Silicon Valley Knowledge Economy**

Professional identity development throughout graduate degree attainment and entry or advancement in the Silicon Valley knowledge economy workforce presents an opportunity for the California State Universities in the region. The Bay Area CSU CSE graduate programs can improve approaches to inclusion and diversity by recognizing the assets current URM and female graduate students possess in relation to experiences with the curriculum, campus professional networking opportunities, and external stakeholders in the region.

### ***Experience with Graduate Curriculum***

Study participants possess strong knowledge of rapidly evolving Silicon Valley technologies and trends. They direct a critical consciousness on to their graduate program curriculum and usefulness of their graduate degree in relation to the competitive Silicon Valley technology workforce. Participants in this study perceive core theory as relevant to their academic and professional trajectories; however, they are critical of the elective courses offered suggesting revisions are needed to remain current with the fields. One participant in this study, a lecturer at his Bay Area CSU campus, agreed that theory courses were strong, but other courses needed updating. Also, a full-time software engineer for a Bay Area technology company, this participant tries to incorporate current technology development trends in the courses he teaches. This case presents a twofold opportunity to enhance the URM and women graduate student experience: 1) hiring more adjunct lecturers who are current professionals is a short-term strategy for diversifying faculty so URM and women see themselves as represented and 2) adjunct lecturers bring current industry knowledge back to the academic department and can inform curriculum revision. Scott and Kirst (2017) argue, “adjuncts fulfill a number of functions

for colleges and companies, but one of them is certainly bridging” (p. 187). The use of adjunct faculty to serve as role models and inform curriculum revisions is an area of opportunity for inclusion and diversity initiatives. Furthermore, Scott and Kirst (2017) state “adjuncts can also spot promising students and funnel them to opportunities within the industry” (p. 187). Adjunct lecturers then become key influencers for internship placement or post-graduation employment. Alternatively, adjunct lecturers could influence young URM and female professionals with whom they work, to pursue graduate school to advance their knowledge and skills in their profession. Graduate student internship experiences, and inclusion of graduate students on advisory board groups may also inform curriculum currency. University and graduate programs could demonstrate cultural humility in inclusion and diversity efforts by recognizing the critical consciousness of industry and program curriculum and engage them as experts in order to keep the curriculum relevant and current.

### ***Internships, Graduate Teaching Associates, Professional Development***

Participants in this study were critical of university career services and employment engagement opportunities, perspectives that were shaped by the context of Silicon Valley and their chosen profession. Internships and Graduate Teaching Associate roles had significant impact for the majority of the students in this study, and were more meaningful as they transitioned to professional opportunity. Fernandez et al. (2019) indicate graduate students who held research and teaching assistants were more productive in their academic discipline than other students. Similar educational research underscores the influence relevant co-curriculum programming has on the academic success of historically marginalized and female students in STEM fields, particularly computer sciences (Charleston et al., 2014) and engineering (Burt & Johnson, 2018). The critical awareness of graduate curriculum and related industry opportunities

that participants in this study hold suggests a need for universities and departments to elevate co-curriculum programming and professional networking opportunities to a higher level more appropriate for its graduate students. This study reveals a lack of alignment to the opportunity structures in Silicon Valley, a misalignment of offering with their graduate degree area of focus, and lack of enthusiasm for the programming on offer. Study participants were at a much higher level professionally than the simple resume or interview workshops offered by campus career services. Employer engagement opportunities were also of little interest or relevance to study participants, due to the mismatch with their chosen fields. Internships and assistantships were characterized as more meaningful. Rethinking professional development opportunities on campus may include an expansion of internships into meaningful and relevant professional sites.

Advisory Boards could be reformed to include graduate student participants. Scott and Kirst (2017) argue that advisory boards are important to curricular currency and student opportunity. Scott and Kirst (2017) share an example, “in one CSU college, advisory board members would attend meetings where students did “senior design” presentations in which a group of students go to some company and solve problems for them” (p. 189). This approach may be more meaningful than the beginner approach offered at campus career services. A recommendation to expand any advisory board to graduate students is in order to not only increase shared governance of the curriculum, but to recognize and develop the expert knowledge graduate students possess. Professional development opportunities must be matched to the level and skills of an institution's graduate students. Study participants had awareness of their campus offerings, but found them irrelevant or too basic in nature. The Bay Area CSU campuses have an opportunity to offer professional development programming that is more relevant and meaningful to CSE graduate students.

### ***Professional Conferences and External Organizations***

Each study participant possesses a critical awareness of their own minority status in the higher education and professional spheres. Several participants sought support outside of their campus and academic departments in national organizations that support URM and women in computer science and engineering professions. The Bay Area CSU campuses have a unique opportunity to support their student engagement with campus chapters of Society of Hispanic Professional Engineers, National Society of Black Engineers, and Hispanic Association of Computer Scientists. Moreover, universities and academic departments can support student engagement in the Grace Hopper Celebration or Tech Ladies by funding conferences and memberships.

Universities and CSE departments should engage with Bay Area organizations involved in diversity and inclusion initiatives in the region. The Silicon Valley Leadership Group (SLVG) and Bay Area Council (BAC) are examples of such groups. Coordinated efforts from community college to four-year institutions to professions and graduate school opportunities are areas to focus investment in order to expand opportunities and be true to diversity and inclusion initiatives. The BAC and SVLG should bring administrators and faculty from the region's rich institutional landscape for better coordination of education and policy advancement at the state level. Partnering with external organizations that share California State University mission and values toward a more inclusive and diverse society brings the graduate student lifecycle full circle and results in more advocacy, more role models for other aspiring URM and women computer scientists and engineers.

### **Discussion and Future Research**

The findings of this study reveal the perceptions and experiences of Underrepresented Minority and female graduate students in Computer Science and Engineering disciplines at three

Bay Area California State University campuses. The significant themes that emerged through qualitative analysis of in-depth interview transcripts both align with, and expand the extant literature in the area of URM and female graduate student persistence in STEM fields. This research study may inform educational practices that aim for inclusion and diversity in graduate education. Continued research into URM and female academic trajectories into specific STEM fields of computer sciences and engineering are warranted. The lack of diversity in technology professions related to these academic disciplines augments the recommendation for continued research. Recommendations for future research include undergraduate students in related disciplines who forego graduate study, graduate students who do not persist, graduate faculty experiences, continued research on the impact of COVID-19, and Bay Area technology firm recruiters.

Research on undergraduate URM and female student experiences in Computer Science and Engineering (CSE) at public universities in the Bay Area region is critical to broadening our understanding of the sources of motivation and aspirations into these professions and decisions to pursue graduate education or not. Early exposure to technology, often through play, is a shared experience across participant narratives in this study and in the extant literature. Longitudinal studies on the imprint of early exposure to technology and academic trajectories that commence after graduate degree attainment would significantly expand understanding of student persistence in academia and CSE professions. Studies focused on undergraduate student trajectories into graduate education or CSE professions are critical to expanding our knowledge on graduate school motivations.

While this study focused on successful URM and female graduate students in CSE disciplines, and understanding of the experiences of those graduate students who drop out of

their graduate program would enrich the current literature. Underrepresented minority and female students who do not persist in CSE graduate programs are likely to have perceptions and experiences of graduate school that markedly differ from those who do persist. Such studies would broaden our understanding and provide meaningful data to inform improvement of practice.

Perspectives and experiences of graduate faculty in CSE disciplines at public universities in the region present an area of research critical to understanding the experiences of URM and female graduate students in CSE. The faculty mentor role, a significant feature of the graduate student experience, has been presented from the student perspective in this study and in extant literature. A broader understanding of faculty mentor-mentee experience must include faculty voice. Research inclusive of graduate faculty may reveal additional barriers to admission, alternative perspectives on the selection process, institutional structures that aid or stymie inclusion and diversity in CSE disciplines. Graduate faculty voice is also critical to broadening an understanding of challenges with curriculum currency. Research on graduate faculty perceptions and experiences would add significant depth to our understanding of inclusion and diversity in STEM fields.

The coronavirus pandemic and participant experiences brought into view the potential for augmented and amplified use of social media platforms or similar technologies to create meaningful spaces for student engagement. Use of technology to enhance the graduate program academic socialization is an area for future research.

Research at the juncture of degree attainment and entry or advancement in CSE professions is warranted in order to further understand the perceptions and experiences of URM and female graduate students. Research in this area may include study of successful university

programmatic integrations with industry, study of advisory boards that inform academic departments and curriculum development, internship to career pathways, and study of key informants in Bay Area technology recruitment roles.

The California State University is charged to serve and respond to its region. The three Bay Area CSU campuses have a role to play in mediating lack of diversity in CSE disciplines and in related technology professions. Continued meaningful research into the public and private computer science and engineering spheres and how students engage within them, is vital to the future economic prosperity of the state and region. Moreover, continued research may help shape cultures in both Silicon Valley and in academia.

### **Limitations**

This study is limited. It is specific to Bay area CSU campuses. The sample size is small, but purposeful, and indicative of the problem of practice that guides this dissertation study. Furthermore, URM graduate student experiences in the CSE disciplines at the three Bay Area California State University campuses is specific to the context of the Bay Area region. The impact of the coronavirus pandemic on this study is notable. The social and physical interactions that occur in an academic department on campus have been transferred to a digital space of email, zoom videos, learning management platforms, and online modules.

### **Concluding Thoughts**

#### ***Barriers Remain***

The participants in this study have assets that influenced and motivated them to pursue graduate education. An equity lens compels us to consider those students who do not have rich familial and community networks, or opportunities for early exposures that influence academic and professional trajectories in STEM fields. Institutional investment in funding opportunities for graduate education in STEM fields is critical for equity and inclusion, and diversity. Kim (2012)

argues that financial aid opportunities mediate access to academic pursuits, particularly for URM students. University administration must focus on access to funding opportunities at the graduate level in order to mediate enrollment disparities. A focus on funding should include legislative advocacy<sup>1</sup>) and 2) engagement with Silicon Valley technology firms to fund scholarships, grants, and co-curricular programs.

Legislative advocacy with partner organizations such as the Silicon Valley Leadership Group may include an expansion of the State University Grant (SUG) Program at the graduate level, raising the Expected Family Contribution (EFC) ceiling above the \$4,000 limit to increase participation. Furthermore, advocacy to expand the CSU's Educational Opportunity Program (EOP), charged with providing services to historically underserved students throughout California to include graduate students (The California State University, 2022), may mediate barriers to graduate education. The Bay Area economic landscape provides opportunity for regional university administrators to engage with firms committed to diversity in the workforce. Such engagement may lead to partnerships that expand targeted grant aid, scholarships, and programmatic opportunities for URM and female students who are unable to overcome the financial barriers to graduate education.

### ***Role of the California State University System***

The California State University role and mission are enshrined in the state constitution and reaffirmed by the state legislature centered on expanding broad participation in the California economy (Legislative Analyst's Office, 2005). Furthermore, Gerth (2010) offers a history of the California State University, responsive to communities and regions that as an institution pushed boundaries on education programming, they were allowed by the state to offer as the demand for higher education grew and in diversification of the student body. The last CSU systemwide in-depth policy study on the importance of graduate education occurred in 2004. A task force



composed of statewide academic senate published *Rethinking Graduate Education in the CSU: Meeting the Needs of the People of California for Graduate Education for the 21st century*, an attempt to challenge the status quo, expand access to graduate programs, and modernize curriculum. The Governor's Office of Planning and Research published the Master Plan for Higher Education in California and State Workforce Needs and acknowledges "priorities of research, graduate education and undergraduate education are tightly intertwined" (Office of Planning and Research, 2018). Educational research on early identity formation and undergraduate research opportunities aligns with this claim. The OPR states, "close alignment of higher education with regional economic and workforce needs is, however, generally fragmented and limited" (Office of Planning and Research, 2018, p. 48). The Bay Area CSU campuses have a critical opportunity to mediate the lack of diversity in the Silicon Valley Workforce through reforming practices that support inclusion and diversity in graduate education, specifically for Silicon Valley knowledge economy professions.

### ***Technology Firm Credentialing, Badges and Closing the Profession***

Graduate degrees enhance opportunity for professional advancement and social mobility (Posselt & Grodsky, 2017), and in the Bay Area, Computer Science and Engineering disciplines prepare students for entry or promotion into high wage knowledge economy jobs. However, California State University enrollment data indicates equity and opportunity gaps at the graduate education juncture and implicates the three Bay Area campuses in the closing of the profession, contributing to lack of diversity in the Silicon Valley technology workforce. Scott and Kirst (2017) and their research partners investigate how organizations in the higher education arena and Silicon Valley workforce connect and collaborate. These researchers acknowledge the Silicon Valley knowledge economy requires a highly educated workforce and the California

State University must fill that role; however, each of the three Bay Area CSU campuses vary in engagement with the region. In response to uneven engagement, Scott and Kirst (2017) identify that Apple, Cisco, Google, Hewlett-Packard, and LinkedIn, strategize to “create their own postsecondary training units rather than to rely on colleges to provide training” (p. 71). These training result in unaccredited, subjective credentialing in the form of digital badges, digital certificates or certifications, which are only recognized by the firm that provided the in-house education. These technology firms may perceive a gap in academic instruction, but the result is a closing of the profession.

The three Bay Area CSU campuses have not only an obligation to diversify the Computer Science and Engineering disciplines, they have the power and moral position to do so. When firms fill the perceived educational gap in offering unaccredited computer science and engineering training programs, they further close the profession and limit the industry mobility of employees to outside competition. These company trainings do not address the lack of diversity in the Silicon Valley technology workforce, while the three CSU campuses can. The California State University must reaffirm its role in preparing a diverse, highly educated workforce demanded by the Silicon Valley technology workforce to ensure that the software engineering, algorithms that underpin daily technologies that comprise the internet of things, and emerging artificial intelligence are representative of a multicultural democracy. There is a risk to reproducing structural racism and the status-quo in the knowledge economy infrastructure, the digital spaces in which we conduct ourselves (Benjamin, 2019; Williamson, 2017). If different cultures, ethnicities, races and genders are not represented in the design rooms or board rooms, they will not be acknowledged or visible in the end products created by the software engineers in the design room.

### *Recursion in Higher Education and the Status Quo*

Lack of diversity in the CSE disciplines at the three Bay Area CSU campuses and in the Silicon Valley technology workforce have implications for the region and society at large. A homogenous Silicon Valley technology workforce will design products that reinforce the dominant culture and maintain the status-quo. A multicultural democracy, so entrenched in technological comforts and instruments that transform all facets of our lives, is at risk with the lack of ethnic, racial, and gendered voices and imagination in the design rooms and boardrooms of technology firms that create such technology infrastructures. Layers of technology platforms are now applied to the humanistic dimensions to education. The technology platforms overlaid on to the work of faculty, academic advisors, enrollment managers, directors, deans, and students are all encompassing data collection machines created in design rooms that lacks diversity. The scholarship of Benjamin (2019) and Williamson (2017) provides context and a warning for this emerging trend. These systems represent a recursion of the status quo, were designed by a homogenous technology workforce uneducated in culturally responsive pedagogies or leadership; the origins of these systems have impacts yet to be seen. Therein lies the contradiction: the CSU, a system built to serve marginalized Californians is subjugated to technological infrastructure built by a workforce that does not resemble the student body and does not account for cultural nuance. A recursion of the status-quo is unfurling through layers of technology.

The CSU has a role to play in the diversification of the Silicon Valley technology workforce so that more voices are in the rooms. The lack of ethnic, racial, and diversity in technology professions reproduces homogeneity in the professional workforce, and this workforce operates in discursive frames that advance, and sustain the knowledge economy according to the dominant culture. This lack of diversity has profound consequences for society at large.

Technology firm design rooms lacking in diversity, lack in diversity of cultural perspectives, diversity of imagination, diversity in syncretic processes that could result in novel and just infrastructures. The impacts are far reaching. The California State University as an equalizer of educational opportunity must assert its authority in shaping the region's workforce.

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**Appendix A:  
Email Message for Potential Interview Participants**

Dear Student,

I am a doctoral student at San José State University conducting educational research on graduate students in Computer Science and Engineering programs at three Bay Area CSU campuses, I am also a university administrator at San Francisco State University focused on graduate education and improving the graduate student experience. I am currently conducting a research study that explores the experiences, perceptions, and attitudes of historically underrepresented graduate students in Computer Science and/or Engineering (CSE) disciplines at three public universities (CSU EB, SJSU, and SFSU) situated in the Silicon Valley knowledge economy.

I am reaching out to you today to ask that you share this email and the attached flyer with your members. I would like to invite you all to participate in my study. Would you be interested in participating in a 45–60-minute interview? Please consider sharing your graduate school experience by participating in this study. If you are interested in participating in an interview by Zoom, please contact me at [noah.price@sjsu.edu](mailto:noah.price@sjsu.edu) or [nprice@sfsu.edu](mailto:nprice@sfsu.edu).

**Study Title**

Factors that Contribute to Lower Enrollments of Underrepresented Minority and Female Graduate Students in Computer Science and Engineering (CSE) and Mitigating Factors from Student Perspectives

## **Purpose of Study**

The purpose of this qualitative research study is to explore the experiences, perceptions, and attitudes of underrepresented minority and female graduate students as they navigate the student lifecycle in Computer Science and Engineering (CSE) disciplines at three Bay Area California State University campuses. This research may guide campus climate reform, the development of graduate student support programs, foster a sense of belonging, and inform curriculum and faculty development.

**Appendix B:  
Email Message to Academic Department Chairs**

**Date:**

**Academic Department Chair Name:**

**Title:**

**Campus:**

**Dear**

I am a doctoral student at San José State University conducting educational research on graduate students in Computer Science and Engineering programs at three Bay Area CSU campuses. My study will explore the experiences, perceptions, and attitudes of historically underrepresented minority graduate students in Computer Science and Engineering (CSE) disciplines at three public universities situated in the Silicon Valley knowledge economy.

I am writing to request that you share this email with students in your graduate programs within your academic department.

I appreciate your consideration in sharing the attached recruitment notice with your current and former students.

Sincerely,

Noah Price

### **Study Title**

*Factors that Contribute to Lower Enrollments of Underrepresented Minority and female Graduate Students in Computer Science and Engineering (CSE) and Mitigating Factors from Student Perspectives.*

### **Purpose of Study**

California State University graduate programs in Computer and Information Sciences experience a twenty percent decrease in underrepresented minority (URM) student enrollment compared to undergraduate URM enrollment at three Bay Area campuses. A similar, but to a lesser extent, fifteen percent URM decrease in participation at the graduate level in Engineering is also found. The Bay Area region witnesses a lack of diversity in the Silicon Valley technology professions, a subject of current political and popular discourse. Graduate education is a lever of social mobility, professional advancement, and provides opportunities to access knowledge economy professions. The CSU campuses in the region are situated at the nexus of the knowledge economy. This decrease in URM student participation in these disciplines at the graduate level is a problem of practice that raises issues of equity in opportunity, campus climate, sense of belonging, and the role and mission of the CSU in the region. The social impacts of less diversity



in the Bay Area knowledge economy results in new layers of digital infrastructures and applications that reinforce dominant cultural perspectives and biases. Lack of diversity in the technology professions results in less diversity in thought and imagination in design spaces and decision rooms, and more homogeneity in a professional workforce. This study explores the experiences, perceptions, and attitudes of historically underrepresented minority graduate students in Computer Science and Engineering (CSE) disciplines at three public universities situated in the Silicon Valley knowledge economy.

**Faculty Advisor**

Dr. Bradley Porfilio, Director and Faculty in the Department of Educational Leadership

College of Education, San Jose State University

[Bradley.Porfilio@sjsu.edu](mailto:Bradley.Porfilio@sjsu.edu)

**Researcher**

Noah Price, Doctoral Candidate, Department of Educational Leadership

College of Education, San Jose State University

[noah.price@sjsu.edu](mailto:noah.price@sjsu.edu)

**Appendix C:  
Consent form for Interviews**

**Consent Form**

Thank you for your participation in this semi-structured interview on graduate student experience in Computer Science and Engineering disciplines at Bay Area California State campuses. The results of this interview will help guide the researcher's project and contribute to their obtaining their degree, and may guide discussions and research on campus climate and sense of belonging in CSE.

**Informed Consent**

You are invited to participate in a research study on perceptions and experiences of traditionally underrepresented students on the graduate student lifecycle at Bay Area California State University campuses. You were selected as a potential participant because you self-identify as an underrepresented graduate student in Computer Science and Engineering disciplines at a Bay Area CSU campus. Please read below and decide if you consent, before proceeding with the semi-structured interview and indicating your agreement to be in the study.

**Study Title**

Diversity and Opportunity for the California State University in Computer Science and Engineering Graduate Education: Parallel Problems in Graduate Education and the Silicon Valley Workforce.

**Faculty Advisor**

Dr. Bradley Porfilio, Director and Faculty in the Department of Educational Leadership

College of Education, San Jose State University

[Bradley.Porfilio@sjsu.edu](mailto:Bradley.Porfilio@sjsu.edu)

### **Researcher**

Noah Price, Doctoral Candidate, Department of Educational Leadership

College of Education, San Jose State University

[noah.price@sjsu.edu](mailto:noah.price@sjsu.edu)

### **Purpose of Study**

California State University graduate programs in Computer and Information Sciences experience a twenty percent decrease in underrepresented minority (URM) student enrollment compared to undergraduate URM enrollment at three Bay Area campuses. A similar, but to a lesser extent, fifteen percent URM decrease in participation at the graduate level in Engineering is also found. The Bay Area region witnesses a lack of diversity in the Silicon Valley technology professions, a subject of current political and popular discourse. Graduate education is a lever of social mobility, professional advancement, and provides opportunities to access knowledge economy professions. The CSU campuses in the region are situated at the nexus of the knowledge economy. This decrease in URM student participation in these disciplines at the graduate level in is a problem of practice that raises issues of equity in opportunity, campus climate, sense of belonging, and the role and mission of the CSU in the region. The social impacts of less diversity in the Bay Area knowledge economy results in new layers of digital infrastructures and applications that reinforce dominant cultural perspectives and biases. Lack of diversity in the technology professions results in less diversity in thought and imagination in design spaces and

decision rooms, and more homogeneity in a professional workforce. This study explores the experiences, perceptions, and attitudes of historically underrepresented minority graduate students in Computer Science and Engineering (CSE) disciplines at three public universities situated in the Silicon Valley knowledge economy.

**Procedure and time required:**

If you agree to be in this study, I would ask you to participate in a semi-structured interview. The interview should take about 45-60 minutes to complete. The interview consists of a series of open-ended questions with a few demographic questions.

**Risks and Benefits of being in the Study**

Your name and interview responses will not be connected in any way. As a result, there is minimal risk of the possible breach of confidentiality. Interview questions are not invasive so no likelihood of the risk of experiencing possible discomfort. There are no direct benefits to the participants in this study.

**Compensation**

None

**Confidentiality**

The records of this study will be kept private. In any report that the researcher might publish, the provided information will not make it possible to identify a participant. Research records will be stored securely and only the researcher will have access to the records. Study data will be encrypted according to current University policy for protection of confidentiality.

## **Participant Rights**

Your participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with San Jose State University (SJSU), the California State University (CSU) or University of California (UC) systems. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships. You also have the right to skip any question you do not wish to answer. This consent form is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You will not waive any rights if you choose not to participate, and there is no penalty for stopping your participation in the study.

## **Questions or Problems**

You are encouraged to ask questions at any time during this study. The researcher conducting this study is Noah Price. You may ask any questions you have now. If you have questions later, you are encouraged to contact me at [noah.price@sjsu.edu](mailto:noah.price@sjsu.edu) or contact my dissertation advisor, Dr. Bradley Porfilio at [Bradley.Porfilio@sjs.edu](mailto:Bradley.Porfilio@sjs.edu)

- For further information about the study, please contact my dissertation advisor, Dr. Bradley Porfilio at [Bradley.Porfilio@sjs.edu](mailto:Bradley.Porfilio@sjs.edu)
- Complaints about the research may be presented to Dr. Bradley Porfilio at [Bradley.Porfilio@sjs.edu](mailto:Bradley.Porfilio@sjs.edu)
- For questions about participants' rights or if you feel you have been harmed in any way by your participation in this study, please contact Dr. Mohamed Abousalem, Vice President for Research & Innovation, San Jose State University, at 408-924-2479 or [irb@sjsu.edu](mailto:irb@sjsu.edu)

## **Consent**

If you wish to participate in this research study, please sign the consent form. I agree to be part of this study and have read the consent form.

Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

## **Appendix D: Interview Protocol**

Noah Price  
Semi-Structured Interview Protocol  
Fall 2021 | San José State University

The following research questions guide this study and aim to uncover characteristics of the underrepresented minority graduate student experience:

1. How do underrepresented minority graduate students perceive and experience the graduate student lifecycle in Computer Science and Engineering (CSE) at three Bay Area California State Universities?
2. How do underrepresented minority graduate CSE students perceive themselves as academics, researchers or scholars in relation to diversifying Computer Science and Engineering (CSE) graduate education in three Bay Area California State Universities?
3. How do underrepresented minority graduate CSE students view themselves as Silicon Valley knowledge economy professionals?

### **Background Information (script for interview)**

Interest in student development among higher education administrators, faculty, and professional staff, a popular topic among professional organization conferences and publications, increasingly focuses on healthy campus climate at both the undergraduate and graduate levels. Many practitioners and professors understand the structures in academia need to evolve in order to be truly inclusive and to value diversity. The California State University mission is to provide access and excellence for Californians who desire higher education. The Bay Area is a distinct economic region and the CSU has a role to play in preparing leaders in this economy, to mediate the lack of diversity in the Silicon Valley professions that comprise it. The three Bay Area CSU campuses lack diversity in Computer Science and Engineering disciplines that lead to Bay Area professions. My research attempts to understand the experiences of students who do pursue these disciplines. A deeper understanding of the student experience may help university stakeholders shape campus reform.

**Research Question 1: Perceptions and experiences of graduate education in CSE at local campus**

How did you first develop an interest in computer science or Engineering? [RQ2]

*Prompt:*

*Authentic learning experiences*

How did you come to learn about graduate school/aspire to pursue your master's degree? [RQ2]

*Prompts:*

*Role models*

*Campus clubs*

*Events*

*Mentors*

How is graduate school different from your undergraduate experience? [RQ1]

How does the academic department or faculty mentor support you through your program? [RQ1]

How do you describe your overall campus climate? [RQ1]

*Prompt:*

*Do you wear any school mascot or logo apparel? [RQ1]*

How do you characterize the academic department climate? [RQ1]

Describe your social interactions amongst your peers in the graduate program? Do you socialize outside of class? Group work? [RQ1]

How has remote learning due to the pandemic impact your graduate education? [RQ1]

Describe your study habits? [RQ1]

Describe your exposure to and interactions with the international students in the program? [RQ1]

**Research Question 2: Self-Perceptions as academics, researchers in relation to Computer Science and Engineering (CSE) graduate education**

How do you view yourself in relation to your academic discipline and current research? [RQ2]

How do you characterize your interactions with your faculty mentor(s)? [RQ1] & [RQ2]

Tell me your opinions of the curriculum? Is it challenging? [RQ2]

What is your area of specialization, research focus? [RQ2]

Who inspires you in your field? Researchers, engineers, innovators? [RQ2]

What do you think you will contribute to the academic discipline? [RQ2]

Tell me about a negative experience that you have had in the program [RQ1]

Tell me about a positive experience that you have had in the program [RQ1]

Describe your path through the degree program so far. Challenges. Successes. [RQ1]

Describe obstacles to your success in the program [RQ1]

Do you perceive bias from peers or faculty? Describe the scenario. [RQ1]

**Research Question 3: Self-Perceptions of Silicon Valley knowledge economy professionals**

Describe your professional network to industry as it is today? [RQ3]

Describe authentic learning experiences that you have had in the graduate program that you believe prepared you for the profession? [RQ3]

Describe your professional network now...

and what do you think your network will look like after graduation? [RQ3]

How do you characterize the political and popular discourse on the need for diversity in the Silicon Valley Workforce? [RQ3]



What are your thoughts on of lack of diversity in Silicon Valley Workforce? Laws like AB 970 which require diversity in the board room? **[RQ3]**

What are your post-graduate degree career goals? **[RQ3]**

Describe a social impact you may make as you advance or develop in your career? **[RQ3]**

How do you view opportunities available to you in the Bay Area as they relate to your graduate degree? **[RQ3]**

How do you view your graduate program in relation to Bay Area professional opportunities?  
**[RQ3]**

**Appendix E:  
Deductive Codes**

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Deductive Codes	Notes
Academic socialization	An individual's process for adapting to the norms of the academy, the discipline and the discourse that is specific to the area of study
Academy	Scholars, researchers, professors in a discipline collectively engaged in promoting the discipline and its standards
Advocacy	Faculty mentors engage in active pursuit of grant aid for URM students, promote equity in access to education through procuring additional funds so that those who cannot afford graduate education may have a change to pursue this goal
Anti-Bureaucracy	Challenge institutional practices that may be barriers to widespread participation in graduate education
Barriers to education	Institutional, financial, systemic, blocks to education opportunity

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Belongingness	A sense of belonging to a group or institution
Campus climate	Experiences of students engaged in learning, peer and faculty relationships, inclusion, diversity, sense of belonging
Committed Educators	Student advocates, mentors, advisors
Cultural Capital	Knowledge and skills an individual accumulates and can tap into as needed to demonstrate social status
Discourse	Knowledge creation in relationship to subjectivity and power relations and the circular relationship involved in the knowledge creation (Foucault)
Diversity	Inclusion of racial, ethnic, sexual minority groups outside of the status quo. Pluralism
Engagement	Level and quality of participation with/in an institution or discipline and with the groups of stakeholders involved
Equity	Fair, unbiased and just. Everyone has access to

resources, power, and opportunity

Grant Aid

Non-repayable funds in higher education that support research, student services, and students themselves as a means to pay for tuition and fees

Habitus

Ways of being, or our disposition to that which is around us (Bourdieu)

Hard Work

As an indicator of potential for success in a graduate degree program, measured in work/professional life an undergraduate student may have engaged in simultaneously to study.

Health & Wellness

Student success is also dependent on health and wellness, food insecurity, housing insecurities are stressors that impact participation rates, completion rates and general success in graduate education

Holistic Admission

Assessing other factors beyond GRE, GPA for academic preparedness in selection process for a graduate degree program

Identity development	Understanding of self, inclusive of values, beliefs, disposition, motivations
Identity Groups	Perceived membership in particular social group or student groups on campus
Imposter Syndrome	Self-doubt, a feeling of not belonging, a sense of inadequacy
Institutional Support	The degree to which an institution actively supports URM recruitment, admission, and support throughout the graduate student lifecycle, or lack thereof.
Intentionality	Affirmative action in the graduate admission selection process that includes seeking out and recruiting URM students
Intersectionality	Interconnectedness of socially constructed categories such as gender and race, creating layers of discrimination and disadvantage
Intervention	Disruption of the status-quo in graduate admission, research, and scholarship

Mentor	Someone who trains, counsels, advises through the processes of scholarship in higher education
Network	A group or groups in which a person has perceived and real sense of belonging and who is able to use social capital privileges
Passion	Enthusiasm or commitment for the discipline, research and/or profession. Passion is also an indicator in the holistic admission review process
Professoriate	College professors/faculty defined as a collective group in this particular term
Scope of Commitment	Outside university life, mentorship that is transformative
Selective "right fit" admissions	Competitive admission process.
Social Capital	Potential for individuals to access benefits of society or social classes. networks of relationships in society, social groups, a shared identity, a shared

understanding, shared norms or values, ways of being, reciprocal relationships (Bourdieu)

Social Justice Fairness in society, access, just distribution of privilege

Social Mobility Movement of people from one social class to another, typically upward mobility in the context of education

Social Status As an indicator of access to/ or participation in graduate education

Socioeconomic Status As a barrier to graduate education, impact on undergraduate studies, socialization within university life

Standardized Tests Consistent method for assessment. Biased barrier to education

Strategic Outreach Leveraging one's network to encourage URM participation in graduate education, as well as leveraging one's network to obtain grant aid

**Appendix F:  
Inductive Codes**

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Inductive Codes	Notes
Adaptability	Ability to adjust or shift in new context or new conditions
Authentic learning	Experiential or applied moments of learning that integrate practice and theory
Community Cultural Wealth	Encompass familial and community bonds that shape one's critical consciousness and moral commitments to society
Commuter campus	A university to which a majority of students commutes for classes, rather than living on or off the actual college camp
Competitive Workforce	Ample supply of candidates for limited opportunities
COVID-19	An infectious disease caused by the SARS-CoV-2 virus
Critical consciousness	One learning to perceive social, political, and economic contradictions, and to act against such contradictions.

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Critique of curriculum	Critical lens focused on relevance of curriculum and learning outcomes in relation to industry
Culture of technology	Manifestation of the industry specific nuances of behavior, inputs and outputs
Early exposure through play	Exposure to technology through toys and games
Economic hardship	Lower socioeconomic status, unemployed, limited means
Experiential learning	Applied moments of learning that integrate practice and theory
Male-dominated	Comprised mostly of men, decisions made by men
Mentors	Individuals who provide guidance, advise, emotional support, role modeling
Minoritized status	Subordinated to the dominant groups
Misaligned campus opportunities	Co-curricular programming does not meet student

expectation or match curriculum

Persistence

Endurance in face of barriers or challenges

Professional leverage

Ability to advance or make gains in one's chosen industry

Professional trends

Evolving features of a profession or currently popular aspects of a profession

Public good

Benefit to communities and public spheres

Resilience

Ability to bounce back, cope mentally or emotionally in the face of challenges

Responsibility to community

Social obligation to community

Role models

Inspiring individual; demonstrates successes

Self-directed

Initiative, goal oriented, driven

Self-efficacy

Belief in one's self to achieve and take action to realize such achievements

Social and moral obligations	Commitment to values that serve the social spheres that reside in a moral sense of duty toward the social
Social media engagement	Student and faculty interaction in digital spaces
Sources of solidarity	Groups, affiliations, organizations with others of similar circumstance
Strong sense of self	Perception of self as capable, what one stands for, and views about purpose
Support of Spouse	A more intimate form of familial capital or familial support, influencing motivations for academic and professional achievement
Technology hub	Concentration of technology firms or companies in a particular city or region

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