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Examining the role of cultural capital in access and equity for female C-STEM learners of color

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Graduate School of Education and Psychology

EXAMINING THE ROLE OF CULTURAL CAPITAL IN ACCESS AND EQUITY FOR FEMALE C-STEM LEARNERS OF COLOR

A dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Philosophy in Global Leadership and Change

by

Tiffany L. Wright

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Martine Jago, Ph.D. – Dissertation Chairperson

This dissertation, written by

Tiffany L. Wright

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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DEDICATION

I dedicate this work in the loving memory of my grandparents, Theresa and Lynwood Wright, Louis Edwards, and uncle, Anthony Wright. You were all physically here with me when I began my doctoral learning journey. Though I lost your earthly presence along the journey, I am grateful to have your continued support as you cheer me on from heaven. You have been key members of my “village” since my earliest days of schooling. Thank you for seeing me through to this monumental achievement in my educational journey.

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Committee and Participants
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Assistance in the Research Process
Dr. Seung Lee, as both a colleague and friend you have motivated me to continue pressing forward even in the most challenging moments of this journey. I am eternally grateful for the many hours that you have dedicated to helping me make this life-changing project possible.

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GSEP Faculty
Dr. Kfir Mordechay, thank you for allowing me to pursue a course paper independently which eventually led to my dissertation work. The support you provided to get me started on this journey is not forgotten.

Dr. Eric Hamilton, thank you for your years mentorship. Your work to support STEM learners is inspiring. I value the opportunities that you have provided me to be a member of this research community.

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Michelle Blas, Jane Tucker, and Regina Meister, you all have seamlessly supported me as a colleague and in my doctoral work. I am ever so grateful for each display of encouragement along the way.

GSEP Student Services Team, you all are the work family who have cheered me on since day one. I thank you for believing in me continuously.

Dr. Robert deMayo and Marianne Nicholas, thank you for the multiple professional opportunities that you have provided me. The Psychology division will always have a special place in my heart due to your graciousness and unwavering support.

Dr. Maria Marion Wright and Dr. Charles Gross, seeing you both pursue your doctoral journeys years prior inspired me to press forward in scholarship. You both provided me safe spaces to share throughout my learning and professional journey. Thank you for your listening ears.

Christell Neal, I remember when pursuing my doctoral degree was just a thought in my mind. Thank you for being so supportive as I've navigated from the application process and now to this pivotal point.

Friends
Irene Artavia-Misciagna and John Baker, your friendship and spiritual support have been game changers along this journey. Thank you for encouraging me to utilize the gifts that God has given me to support his people.

GSEP-PGBS Bible Study, your prayers and listening ears have been powerful. Such support helped to get me through some particularly challenging points during the journey. I thank you.

Eva Williams, your spiritual wisdom and mentorship has pointed me back to the center many times. I thank God for our bond.

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Yvonne, Ramon, and the Edwards family, your prayers have been felt from miles away. Thank you for being a part of the village that has supported me through this journey.

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Shawna Wright, thank you for keeping me laughing throughout this journey. Especially during the high stress moments as I wrapped up. You remind me that family truly is the heart of everything.

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Toya and Garry Wright, your continued investment in my education has been life changing. Each school you selected in my younger days, years of writing tuition checks, the events you have attended without hesitation, and countless other sacrifices that you have made led to this moment. The foundation you have provided me with has allowed me to humbly bless many others in their learning journeys. I pray that the Lord blesses you both multiple times over for what you have poured into me. Thank you for being such incredible role models and parents.

VITA

EDUCATION

PhD, Education (emphasis: Global Leadership and Change), Pepperdine University, Graduate School of Education and Psychology, Los Angeles, CA – September 2018-current

Dissertation Defended– January 2024/ **Expected degree completion:** Spring 2024

Research interests: Computer Science Equity; STEM Education and Female Learners; Access and Equity in C-STEM Education; Diversity and Inclusion in Technology; Female Leadership in Computing

M.A., Education, Loyola Marymount University, School of Education, Los Angeles, CA – 2013

Kappa Delta Pi Honor Society, 2013

TEACHING EXPERIENCE

Pepperdine University, Graduate School of Education and Psychology (GSEP) - Psychology Division

Los Angeles, CA

PSY 680 Directed Study- Graduate Research Study (Course Instructor) **Spring 2024**

- Supervise 1 student on independent qualitative research project
- Guide student through study design and timeline benchmarks in order to advance project

PSY 626 Research and Evaluation Methods for Mental Health Professionals (Course Instructor) **Spring 2024**

- Develop curriculum for the course by designing modules to teach students various elements of quantitative and qualitative research methods
- Design course exams for student assessment
- Supervise teaching assistant
- Manage course materials and communication using Sakai (Courses) learning management platform
- Course enrollment: 22 MA Clinical Psychology and MA Psychology program graduate students

PSY 626 Research and Evaluation Methods for Mental Health Professionals (Course Instructor) **Fall 2023**

- Developed curriculum for the course by designing modules to teach students various elements of quantitative and qualitative research methods
- Designed course exams for student assessment
- Managed course materials and communication using Sakai (Courses) learning management platform
- Supervised teaching assistant
- Course enrollment: 24 MA Clinical Psychology and MA Psychology program graduate students (section 1); 22 MA Clinical Psychology and MA Psychology program graduate students (section 2)

PSY 626 Research and Evaluation Methods for Mental Health Professionals (Course Instructor) **Spring 2023**

- Developed curriculum for the course by designing modules to teach students various elements of quantitative and qualitative research methods
- Designed course exams for student assessment
- Managed course materials and communication using Sakai (Courses) learning management platform
- Course enrollment: 18 MA Clinical Psychology and MA Psychology program graduate students

PSY 692 Scientific Writing in Psychology (Course Instructor) **Spring 2023**

- Revised curriculum for course by preparing academic writing exercises and assignments for students to develop their research skills
- Provided faculty mentorship and curriculum advisement for a parallel course section

- Manage course materials and communication using Sakai (Courses) learning management platform
- Course enrollment: 18 MA Psychology program graduate students

PSY 692 Scientific Writing in Psychology (Course Instructor) **Summer 2022**

- Developed curriculum for course by preparing academic writing exercises and assignments for students to develop their research skills
- Managed course materials and communication using Courses learning management platform
- Course enrollment: 12 MA Psychology program graduate students

PSY 658 Individual, Couple, and Family Development: A Life Cycle Approach (Course Instructor) **Spring 2022**

- Revised curriculum for course by incorporating human development concepts and theories into practical scenarios for mental health practitioner application
- Managed course materials and communication using Sakai (Courses) learning management platform
- Course enrollment: 24 MA Clinical Psychology and MA Psychology program graduate students

PSY 692 Scientific Writing in Psychology (Course Instructor) **Spring 2022**

- Developed curriculum for course by preparing a step by step guide for students to write an academic literature review
- Managed course materials and communication using Courses learning management platform
- Course enrollment: 13 MA Psychology program graduate students

Pepperdine University, GSEP - Education Division **Los Angeles, CA**
MATP 691 Educational Foundations, Equity and Social Justice (Guest Facilitator- Invited) **Fall 2019**

- Facilitated graduate student research presentations for MA Teacher Prep Education course
- Provided students feedback on their presentations
- Assisted course instructor with grading in-class presentations

Long Beach City College **Long Beach, CA**
Learning Skills (Guest Lecturer- Invited) **Fall 2019**

- Provided a course lecture on the Theory of Multiple Intelligences (Gardner)
- Created lecture and in-class activity
- Provided feedback to students on their learning progress throughout the activity

Pepperdine University, GSEP - Education Division **Los Angeles, CA**
MATP 692 Design and Participatory Action Research 2 (Guest Lecturer- Invited) **Summer 2018**
"Presentation Tools by TED"

- Presented to graduate students in the MA Education program on poster presentation delivery as required for their capstone project
- Developed presentation and questions for class discussion

MAED 670 Self in a Social World (Course Instructor) **Spring 2018**

- Co-developed curriculum for MA Education course integrating social psychology theories with practical tools students can utilize as educators
- Created a collaborative learning environment for graduate student professional development through course material
- Managed course materials and communication using Courses online platform

California Hospital Medical Center **Los Angeles, CA**
"Computer Skills" (Co-Instructor) **2015**

- Co-taught 3-week basic computer skills course covering Microsoft Office document production
- Assessed student's skill level in basic office computer functions
- Provided students feedback on areas for continuing development after course

PUBLICATIONS

Wright, T. (2023, October 8-12). Examining the role of cultural capital in access and equity for female computer science learners of color. In G. Arastoopour Irgens & S. Knight, *ICQE23 Doctoral Consortium* [Conference Session]. International Conference on Quantitative Ethnography (ICQE) 5th International Conference, Melbourne, VIC, Australia. https://www.qesoc.org/images/pdf/ICQE23_Supplement_Proceedings.pdf

Wright, T., Oliveira, L., Espino, D., Lee, S.B., Hamilton, E. (2021) *Getting there together: Examining patterns of \ a long-term collaboration in a virtual STEM makerspace*. Springer. https://doi.org/10.1007/978-3-030-67788-6

Espino, D., **Wright, T**., Brown, V.M., Mbasu, Z., Sweeney, M., & Lee, S.B. (2021) Student emotions in the shift to online learning during the COVID-19 pandemic. In A.R. Ruis & S.B. Lee (Eds), *Advances in Quantitative Ethnography: ICQE 2020 Conference Proceedings* (pp. 334-347). https://www.qesoc.org/images/pdf/ICQE20_Proceedings_Supplement_Final_web.pdf

RESEARCH EXPERIENCE

Pepperdine University, GSEP- Education Division **Los Angeles, CA**
Principal Investigator **2021-2024**
Doctoral Dissertation: Examining the role of cultural capital in access and equity for female C-STEM learners of color

- Prepared study proposal and literature review
- Conducted interviews for 15 study participants
- Developed codebook for the study and led team of 3 coders on coding study data
- Utilized Epistemic Network Analysis (ENA) online tool for discourse analysis of qualitative data

Research Assistant **2020-2021**
NSF Funded International Community for Collaborative Content Creation (IC4) Grant Project

- Contribute to the development of qualitative research papers for publication
- Conduct research utilizing the Epistemic Network Analysis (ENA) tool for Quantitative Ethnography studies
- Review transcriptions of international cross-collaboration student meetings for accuracy
- Assist research team with creating STEAM educational challenges for high school students participating in the virtual makerspace from international school sites spanning the United States, Brazil, Kenya, and Cameroon
- Code and analyze qualitative data

Student Researcher **2020-2021**

- Collaborated with a faculty led international team of researchers to produce poster and paper conference submissions for two studies related to COVID-19
- Coded data from a public data source to analyze themes in the study
- Developed discussion section of the poster submission
- Contributed to the introduction and literature review portions of the paper submission along with general feedback provided to the team for remaining paper content

Research Assistant **2020**
Quantitative Ethnography (QE) Data Challenge 2020: Pepperdine University in partnership with the University of Wisconsin-Madison

- Collaborated with a research team composed of professionals from Pepperdine University, University of Wisconsin-Madison, and African educational organizations
- Coded data for Coronavirus (COVID-19) news articles in efforts toward an international research challenge data presentation.
- Provided feedback to team leadership for data analysis write up

CONFERENCE PRESENTATIONS

International Conference for Quantitative Ethnography (ICQE) 2023 **Melbourne, Australia**
Doctoral Consortium **October 2023**

- Presented research findings from dissertation work on female learners of color in C-STEM
- Collaborated with faculty and doctoral students from global universities to on dissertation projects
- Selected from a highly competitive group of students resulting in a total consortium group of 10 doctoral students

International Conference for Quantitative Ethnography (ICQE) 2021 **Virtual**
Getting there together: Examining patterns of a long-term collaboration in a virtual STEM makerspace
November 2021

- Presented research findings based on qualitative study utilizing Epistemic Network Analysis (ENA) utilizing discourse analysis
- Described practical applications for research in primary-secondary school digital makerspace communities

International Conference for Quantitative Ethnography (ICQE) 2020 **Virtual**
Student emotions in the shift to online learning during the COVID-19 pandemic **January 2021**

- Shared research findings related to study of the emotions exhibited by students amid the sudden shift from in-person instruction
  to online learning
- Described how findings were gathered utilizing ENA to analyze student's discourse patterns

Stellenbosch University Experiential Education Conference (SUEEC)- Stellenbosch, South Africa **Virtual**
Competencies & Tasks of Global Executive Leaders During Crises **November 2020**

- Disseminated findings of a team structured literature review examining key skills and competencies for effective leadership during crises
- Participated in a roundtable discussion regarding crisis leadership practices specific to higher education and student support systems

International Leadership Association (ILA): Women and Leadership Conference **Virtual**
Exploring the Use of Educational Gaming in Girls' Leadership Development Programs **June 2020**

- Presented exploratory research on the benefits of educational gaming for girls' leadership development programs
- Facilitated discussion among faculty members, researchers, community leaders and fellow graduate students regarding research

New Delhi Institute of Management (NDIM) Symposium **New Delhi, India**
Self-Efficacy in Leadership Development **June 2019**

- Presented exploratory research on the impact of professional presentation on leadership efficacy
- Collaborated with international partners on cultural considerations for the self-efficacy of global leaders

PROFESSIONAL PRESENTATIONS

Pepperdine University, GSEP - Education Division **Los Angeles, CA**
PGLC 767 Advanced Research and Qualitative Analysis (Guest Presenter- Invited) **Fall 2022**
"*Preparing for Dissertation Studies*"

- Presented to third year doctoral students on preparing to enter the dissertation phase of their studies
- Facilitated discussion question and answer session

Pepperdine University, GSEP - Psychology Division **Los Angeles, CA**
PSY 658 Individual, Couple, and Family Development: A Life Cycle Approach (Guest Lecturer- Invited)
Fall 2022

- Presented to graduate students in the MA Psychology and MA Clinical Psychology MFT programs on Adolescent Development
- Developed guest lecture and questions for class discussion

Pepperdine University, GSEP - Education Division **Los Angeles, CA**
EDTE 611 Capstone Integration Experience (Guest Presenter- Invited) **Summer 2020**
"Framing Your Coursework Artifacts for Academic and Professional Opportunities"

- Presented to graduate students in the TESOL Education program on transitioning their course assignments into opportunities to disseminate their work for academic and professional purposes
- Developed presentation and questions for class discussion

MSED 604 Program Design and Evaluation (Guest Presenter- Invited) **Summer 2020**
"Turning Your Coursework into a Conference Proposal"

- Provided guidance to graduate students in the MS Education program on how to develop their course assignments into a conference proposal
- Developed presentation and facilitated accompanying class discussion

Pepperdine University, GSEP - Psychology Division **Los Angeles, CA**
PSY 671 Career Development Theory and Techniques (Guest Lecturer) **Spring 2018**
"Pathfinder: Career Transitions and Self-Concept"

- Presented to graduate students in the MA Psychology and MA Clinical Psychology MFT programs on Developmental Self Concept theory (Super)
- Developed presentation and questions for class discussion

ABSTRACT

This study aimed to examine the impact of cultural capital (Bourdieu, 1973; Bourdieu & Passeron, 1977) on the access and equity of C-STEM learners of color under the following four tenets of Yosso's (2005) Community Cultural Wealth model: aspirational, familial, social, and navigational capital. A theoretical framework of Critical Race Theory (CRT; Crenshaw, 1988) was utilized to frame the study. Research questions explore the impacts of cultural capital upon the perceived access and equity of female C-STEM learners. Qualitative methodology guided the study under the integrated approach of Quantitative Ethnography (QE) which examines qualitative data with the support of statistical analysis. This was done utilizing the Epistemic Network Analysis (ENA) webtool. Discourse analysis provided the researcher with a lens through which data from participants' interview responses were analyzed. As a retrospective study, the researcher sought to explore the impact of participants' cultural background on their educational and career trajectories in C-STEM. Participants consisted of fifteen women of color who self-identified is Black/African American, Hispanic/Latina, and Korean-American with degrees in computer science and closely related C-STEM fields. Interviews were conducted via Zoom from March 2023-July 2023. Each interview lasted for approximately 60 minutes. Data was transcribed and analyzed by three coders (including the researcher) as a form of interrater reliability. Initial codes for the study were as follows: access, equity, aspirational capital, familial capital, social capital, and navigational capital. Emergent codes of cultural, financial, and spiritual resources emerged from the data. Key findings indicate a positive relationship between the connection of access to aspirational, familial, social, and navigational capital. Strong connections were also identified with the emergent codes of cultural and financial support. The findings indicate that the female C-STEM learners of color in the study found encouragement in their journeys, were able to navigate various structures, and had the ability to thrive in community as a result of access to financial & cultural resources. Furthermore, the findings indicate the success that results from positive community networks for learners of color.

Implications for future research explore developmental opportunities for organizational change in C-STEM learners from an assets-based lens.

Keywords: computing education, C-STEM, access, equity

Chapter 1: Introduction

Chapter Overview

Chapter 1 introduces the reader to Computer Science (CS) education, specifically in the larger context of Science Technology Engineering and Mathematics (STEM) education, through the background of the study. Taking this into consideration, the reader will refer to the broader area of C-STEM to encompass the broader area of computing education in STEM. A problem statement follows which introduces the need for the study. The purpose statement clarifies what the study seeks to accomplish. Through the significance of the study the researcher provides further background on the study as connected to study relevance. A definition of terms clarifies various words and phrases introduced in the chapter.

The conceptual framework introduces the researcher's lens for the study and associated literature as guided by a foundational theoretical framework. Two overarching research questions are introduced. Limitations, delimitations, and assumptions help to define parameters for the study. The researcher's positionality is shared in connection with elements of the study. A brief organization of the study shares what is to come in subsequent chapters. Lastly, the study concludes with a chapter summary.

Background of the Study

Equitable computing education is essential to diversity in our rapidly evolving global world. Computing principles and associated content can expose learners to the foundational operations of today's virtual world. Technology guides our classrooms, workspaces, social networking, interaction with health professionals, and much more. As an array of individuals utilize technology for varying purposes, it is necessary to consider the multitude of ethnicities, cultures, beliefs, and other significant aspects that compose user identities.

Equity and access in C-STEM education is vital to advancement in the technological workforce.

Researchers have identified two primary issues in equitable computing academic and professional work (Goode, 2010a; John & Carnoy, 2019; Metcalf, 2010):

i. Challenges presented by the educational pipeline.
ii. Toxic, unwelcoming work environments that further oppress marginalized populations.

While this study focuses on the C-STEM educational pipeline issue, discussion of the technology workforce is essential to understanding root cause issues early in the pipeline. Primary school exposure to technology and related STEM topics has a lasting impact on students' mathematics skills and supports independence with utilizing technology (Schuetz et al., 2018). Additionally, early engagement with CS specifically, and C-STEM more broadly, curriculum encourages students to explore technology career options during their higher education studies (Lambert, 2018).

The establishment of technological identity is key to the elements of equity and access in C-STEM education. Prior studies indicate that learners from high earning households experience increased engagement with computer data and research as compared to their peers from lower income households (Goode, 2010b; Warschauer et al., 2004). Furthermore, female learners at economically advantaged high schools are offered opportunities to take Advanced Placement (AP) courses in CS yet felt less prepared than their male peers (Goode et al., 2006). Such has a bearing on their technological identity. Goode et al. (2006) provide the following in terms of the challenges created by deficient CS preparation on learners' technological identities:

For many college students, not having a strong technology identity is a product of an

> unequal high school education and disparities in home resources, yet the consequences of one's technology identity has a powerful influence on the attitudes and decisions students make regarding their academic and life plans. It is these constraints and affordances of a technology identity – which seep into academic, social and work life – that truly reflect the depths of the digital divide. (p. 509)

It is significant to understand how inclusiveness may impact genders and racial groups differently in the shaping of their technological identities. Support resources that promote inclusivity, such as tutoring and workforce experience, has been indicated to make female learners feel more welcomed and encouraged to persist in computing education (Kargarmoakhar et al., 2020).

It is assumed through C-STEM educational pathways that female learners of color will assimilate to mainstream culture to develop the skills necessary to advance through their education in CS and related fields (high school to university level to career). However, these learners' cultural capital should be highlighted in the C-STEM classroom environments to promote their unique potential contributions to the field as well as to the diverse group of global technology users that they will represent in their work.

While the topic of C-STEM educational equity and access is United States (U.S.) centric in the context of this study, significant global implications have been identified. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO; 2017), global disparities remain a concern for women in engineering & computing careers. This is significant because women globally rely on education in computing in efforts to advance themselves in ways that their male counterparts can achieve more steadily. For instance, UNESCO (2017) highlights female learners in the United Arab Emirates (UAE) in their quest to contribute to the knowledge economy:

> Emirati female engineering students have said that they are attracted to a career in engineering for reasons of financial independence, the high social status associated with this field, the opportunity to engage in creative and challenging projects and the wide range of career opportunities. (p. 2, para 6)

Global deficits also exist regarding participation at the higher education level (Melak & Singh, 2020).

Problem Statement

Currently, representation in technology is a concern because the diversity of the workforce neglects to reflect the diversity of technology users. The C-STEM educational pipeline plays a significant role in this issue as marginalized groups, such as female learners of color, are benefiting less from early preparation for the workforce.

According to George et al. (2022), “the demographics of the workforce are far from mirroring those of tech users and the U.S. population, as evidenced by the severe underrepresentation of women and racially minoritized groups” creating a “lack of diversity [which] impedes not only the economic mobility of women and racially minoritized employees…but it also runs the risk of stifling creativity and innovation” (p. 2). Therefore, an opportunity exists for research that examines C-STEM education retrospectively from the lived experiences of women of color.

Purpose Statement

The purpose of this research study is to explore the impact of cultural capital in the C-STEM learning experience of female learners of color as it relates to their perceived access and equity in field studies. The researcher conducted a quantitative ethnographic study examining the perceptions of equity and access for the identified population.

Significance of the Study

Significance of Representation

Representation in technology aids in fostering diverse outputs with various possibilities to adequately depict our global world. Blickenstaff (2005) highlights the significance of diverse perspectives in science and technology for greater advancement:

> [S]cientific and technical endeavors can only be improved by having a greater diversity of perspectives in the search for knowledge and solutions to human problems. As scientists construct understanding of the world, the ability to see questions and answers from many perspectives will help make scientific explanations more robust and complete. (p. 370)

Efforts to build a diverse workforce have the potential to take root in early educational systems.

Regarding race, Ryoo et al. (2020) provide that students and teachers should challenge stereotypes about computer science capability being limited to identities of dominant cultures such as smart, White males. Instead they suggest embracing a mindset that all can benefit and succeed in computing education. Furthermore, Buolamwini (2019) highlights how women and communities of color have been underrepresented and less sampled in AI data. She argues that such limitations in practice have created technology that represents a limited group of global users. Considering these challenges, it is relevant to consider how minority-majority presence is imperative to representation within jobs of the future (U.S. Census Bureau, 2010; Vargas & Conlon, 2011).

Diversity Overview

Equity in technology has the power to advance a more diverse global world with increased tolerance in the digital space. Thus, it is significant to examine representation of

the individuals, such as engineers, computer programmers, and other technology professionals that shape our digital world. C-STEM education will be examined in this study by exploring root educational sources for preparing future technology professionals for professional work. This supports the education to career pipeline argument which reasons that educating a more diverse group of learners will, ideally, result in a more diverse group of technology professionals.

Labor related policies should also be considered as educational pipeline issues that will impact the workforce. Economically speaking, the education to career pipeline for computing learners has significant long-term implications. The United States Bureau of Labor Statistics (U.S. BLS; 2018) expects a growth of 13% in computer and information technology professions within the period of 2016-2026. Furthermore, the gender wage gap in computer and mathematics jobs is the most significant of STEM occupations (John & Carnoy, 2019; United States Department of Commerce, 2011). Thus, creating a need to develop and support women throughout their technology career journeys. Fry et al. (2021) report an “uneven progress” in STEM jobs with the following

> And while women now earn a majority of all undergraduate and advanced degrees, they remain a small share of degree earners in fields like engineering and computer science – areas where they are significantly underrepresented in the work force (p. 3, para 1)

Such supports the real time impact identified in the technology work force as Meta (formerly known as Facebook) recently noted a decline in female worker representation (Nix, 2021).

In terms of the overall significance of culture, cultural capital, and intelligence support progression of both the educational pipeline and employment retention arguments that contribute to why minority women may choose to not pursue computing careers long

term. Both arguments point to their unique cultural contributions being undervalued compared to their majority peers.

Recognizing Bias in Technological Outputs

Inclusive outputs in the form of software and other technological products are essential to representation in a globally diverse world. Bias in technology can have a long-term impact upon users so it is essential that intentional discussions address related issues. According to Rainie and Anderson (2017), “algorithm creators (code writers), even if they strive for inclusiveness, objectivity and neutrality, build into their creations their own perspectives and values” (para. 1). Additionally, the age of big data presents obstacles in which marginalized populations are being negatively impacted by algorithms’ influence on areas such as housing, economics, public policy, and various other social structures (Benjamin, 2019; Eubanks, 2018; O’Neil 2017). Thus, greater diversity in C-STEM professionals is crucial in efforts toward a more balanced and inclusive digital ecosystem.

Noble (2018) emphasizes that “[t]he web is characterized by a source of opportunity for oppressed and marginalized people, with tremendous focus put on closing the hardware, software, and access gaps on the Internet for various communities” (p. 160). Technology leaders such as Google and Microsoft are making concerted efforts to incorporate more diverse recruitment opportunities that reflect their diverse users. Lehman et al. (2016) detail an example of such efforts in the following account:

> In response to women’s declining participation in computing fields, there have been widespread efforts to recruit more women. Organizations such as Girls Who Code and the National Center for Women and Information Technology (NCWIT) have partnered with industry giants, such as Google and Microsoft, to address gender inequalities by launching various programs to attract young women to computing and interest them in CS majors in college. (p. 278)

Such opportunities can position marginalized female students as leaders (not just followers) in the direction of greater C-STEM equity by examining the way their factors of cultural capital contribute to their upward trajectory in C-STEM education. These diverse experiences can advance them toward more diverse opportunities in their career paths.

This study aims to examine how factors that have historically marginalized this population in C-STEM can be reconfigured as assets to the field. The researcher hopes to provide study results that inspire collaborative work between C-STEM educational leaders and policymakers. Gaskins (2016) suggests culturally responsive teaching as an avenue to engage marginalized students:

> the education of racially, ethnically, and culturally diverse students should connect in-school learning to out-of-school living; promote educational equity and excellence; create community among individuals from different cultural, social, and ethnic backgrounds; and develop students' agency, efficacy, and empowerment (para 4).

Additionally, employers are making efforts to prioritize belonging initiatives which recognize diversity while initiating early outreach. Various big tech companies have designed initiatives to encourage belonging early in the recruitment process to include partnerships with universities to identify students of color for career opportunities (International Business Machines [IBM], 2020; Torres, 2022). Other organizations have recognized the need to increase belonging initiatives overall to serve future and current employees (Google, 2022).

Diversity Efforts to Reduce Bias in Technology

An enrichment practice in addition to hiring STEM professionals specifically could involve inviting scholars and practitioners with diverse backgrounds who are equipped to identify human challenges in technology beyond solely operational aspects. For instance,

biases in data could be more readily identified by practitioners with critical theory backgrounds. Noble (2018) expands upon this idea in the following:

> With all of the aberrations and challenges that tech companies face in charges of data discrimination, the possibility of hiring recent graduates and advanced-degree holders in Black studies, ethnic studies, American Indian studies, gender and women's studies, and Asian American studies with deep knowledge of history and critical theory could be a massive boon to working through the kinds of complex challenges facing society, if this is indeed the goal of the technocracy (p. 163).

These considerations are significant because "[i]ssues of bias in AI tend to most adversely affect the people who are rarely in positions to develop technology" (Buolamwini, 2019, para. 8). Hiring from backgrounds beyond traditional technology majors and specializations could provide a diverse workforce that optimizes user representation.

Additionally, the representation of women in technological development is essential to equitable advancement in the progress of a virtual society. Lehman et al. (2016) asserts that "if more women are involved in the development process, their diverse perspectives will improve new technology". Furthermore, the authors expound upon their position by sharing that "[w]hen more women are a part of developing of new technology, they can help design products that better serve the needs of both men and women" (p. 278). Given these examples, inclusion provides a tool to rapidly grow technology fields in a humanistic manner expanding beyond basic technical measures.

Tech Equity and Representation: Public Policy

From a policy perspective, the problem impacts the branches of education and communication independently but also indicates an intersection (Hansen & Zerbino, 2022). It is significant to examine public policy in the discussion of computing educational equity and user representation because policy shapes how systems operate. At a granular level,

educational policy directly impacts learner opportunity and equity. From a broader perspective, public policy shaping technology and communications influences the representation and digital protection of users.

United States (U.S.) public policy plays a key role in the equitable representation of users. From a leadership standpoint, U.S. policy makers can provide safeguards for marginalized populations who may have less direct influence in technological development (Noble 2018). Governing bodies such as the U.S. Federal Communications Commission (FCC) have provided safety measures by imposing vital legislation such as the Communications Decency Act (CDA) which sought to guard children from inappropriate sexually explicit sites through its Section 230 legislation (Dickinson, 2010; Noble, 2018). Though, the act also supports controversial matters such as freedom of expression and provides exemption from liability for "[i]nternet service providers, search engines, or any other Internet site that is trafficking content from other people, organizations, or businesses - companies such as Google, Facebook, Verizon, AT&T, WordPress, and Wikipedia" (Noble, 2018, p. 158). Policies that create accountability through decency standards help to combat misrepresentation. An example, for context, is the potentially flawed results of a website search which "might not reflect the social or historical context of the lives of each group or their desire to be represented this way" (Noble, 2018, p. 160).

It is imperative that a variety of voices are represented in conversations and research regarding the advancement of technological education. Rodriguez and Lehman (2017) provide the following regarding theoretical support when assessing this area:

> First, scholars who investigate participation gaps in computing fields may be making decisions in their research that are not theoretically grounded. Theory may be overlooked in part because the scholars focused on broadening participation in computing come from myriad disciplines (e.g. education, economics, sociology,

> psychology, business, and computing, to name but a few), and each of these disciplines has different norms around the use and application of theory in research. (pp. 239-240)

A collective of researchers from various disciplines and backgrounds could help to alleviate assumptions or disregard non-evidence based content when unpacking issues in computing participation.

Definition of Terms

- **Access:** "Freedom or ability to obtain or make use of something" (Merriam-Webster, 2022)
- **C-STEM:** An acronym for Computing, Science, Technology, Engineering, and Mathematics studies. The definition is utilized to represent the various disciplines represented by participants in this study as related to their contributions to technology. (Researcher Definition)
- **Cultural Capital:** As defined according to the Community Cultural Wealth (CCW) model of Yosso (2005). Includes the following tenets of cultural capital: aspirational, familial, social, navigational, resistant, and linguistic.
- **Diverse:** "Differing from one another" (Merriam-Webster, 2022)
- **Diversity:** "An instance of being composed of differing elements or qualities: an instance of being diverse" (Merriam-Webster, 2022)
- **Educational Pipeline:** The progression of educating students from primary to baccalaureate school levels for the purpose of producing professionals in the workforce. (Researcher Definition)
- **Equity:** "Justice according to natural law or right; specifically : freedom from bias or favoritism" (Merriam-Webster, 2022)
- **Ethnicity:** "A particular ethnic affiliation or group" (Merriam-Webster, 2024)

- **Inclusion:** Inclusive behaviors and attitudes toward underrepresented groups such as women and individuals of color. Specific to the subset of a North American population for the purposes of this study. (Researcher Definition)
- **Participation:** Enrollment in coursework and enrichment programs specific to C-STEM and computing studies. (Researcher Definition)
- **Race:** "A group of people sharing a common cultural, geographical, linguistic, or religious origin or background" (Merriam-Webster, 2024)
- **STEM:** An acronym for Science, Technology, Engineering, and Mathematics which focuses on hands-on, problem-based learning (Southern Illinois University [SIU], 2022)

Conceptual Framework

The Community Cultural Wealth (CCW) model (Yosso, 2005) frames this study as it provides an assets-based approach to learners' educational experiences. Furthermore, CCW takes various elements of capital and provides a foundation for aspects of an individual's educational and life experiences to strengthen their learning as opposed to expecting them to conform to an environment built according to a more dominant, homogeneous model. This is especially significant for female learners of color striving for a safe space to explore their technical interests and develop a technological identity supportive of their backgrounds. For learners of color regardless of gender, cultural capital under the CCW model brings culture to the forefront while navigating imposed norms of a mainstream culture.

Under the CCW model framework, underrepresented learners are allowed to lead learning experiences through exploration of their cultural capital. In connection to the theoretical framework of this study, examining these elements of the learner's experiences helps to highlight their intersectionality (Crenshaw, 1991). Intersectionality is key in

understanding the learner's full experience and how that shapes their learning access and potentially their navigation of career pathways.

The conceptual framework of this study centers around an equity-minded foundation which encourages learners to be leaders of their educational experiences. In computer science education specifically, learners can benefit from ownership of the material as they progress through the computing education to career pipeline. The convergence of Bourdieu's (1977) Cultural Capital theory, Crenshaw's (1988) Critical Race Theory, and Yosso's (2005) CCW model all compose this study's conceptual framework. With the two former theories providing a base for Yosso's model, the CCW centered theoretical framework supports the significance of the learner's cultural assets. Theories comprising this collective framework are detailed throughout the literature review.

Why Cultural Capital

Cultural capital provides a lens through which the researcher can examine learners according to the sum of the experiences which shape them. Examining a student's experience singularly by their educational ability or success in prior coursework puts limitations on their potential to shape multiple facets of the field. All learners, regardless of gender and race, should be prepared to represent a diverse group of technology users through the products they create and contribute to. Cultural experiences encourage the learner to consider multiple perspectives when solving technical problems.

Cultural capital could play a role in both sides of the educational pipeline versus technology workplace culture argument. Educational opportunities may assist in bringing learners into the field, but retention efforts will determine how to help them stay there, transitioning into technology careers. The impact of cultural capital may be different for learners and professionals at various stages of life. While the variable of equity is anticipated to remove barriers, the variable of access could be seen as the supporting factor

in helping the population reach their career goals. The distinct types of cultural capital represented under the Community Cultural Wealth model (Yosso, 2005) will allow the researcher to determine which aspects of the model contribute more to challenges versus opportunities.

Theoretical Framework

The Critical Race Theory (CRT; Crenshaw, 1988), a derivative of critical theory, is central to this phenomenological study. CRT emphasizes the value of the lived experiences of people of color that persist to navigate dominant structures. Such structures in C-STEM educational settings may create deep rooted institutional barriers which the research will look to explore further through interviews with participants and analysis of their discourse. The assets-based approach that is foundational in CRT and derivate critical theories empower individuals as leaders through the knowledge they contribute to their environments (Bernal, 2002). Additionally, CRT as a foundational theory has been utilized to support prior research examining learner inequality and needs for educational reform (Ladson-Billings, 1998).

Research Questions

The overarching research questions that guide this study are as follows:

- RQ1: What aspects of cultural capital, if any, have an impact on the perceived access of female C-STEM learners of color?
- RQ2: What aspects of cultural capital, if any, have an impact on the perceived equity of female C-STEM learners of color?

Aspects of cultural capital refer to the elements defined in Yosso's (2005) CCW model.

Limitations

The scope of this study is limited to a subset of learners, female-identifying people of color which may not accurately reflect the broader experience of female learners in C-STEM

education. As a result, experiences may not reflect those of male-identifying or non-binary individuals in the discipline. Furthermore, the scope of the study excludes minority male groups such as Black male STEM learners whom researchers have seen enrollment declines in Lunn, Zahedi, et al. (2021).

Additionally, the researcher selected from a purposive sample which was valuable for qualitative research. However, the sample was directly connected to participants within the researcher's reach as professional and personal networks of the researcher were relied upon to recruit participants. Also, snowball sampling was utilized to expand recruitment. This increased the likelihood that participants who recommended colleagues and friends (who met the study criteria) may have unintentionally identified individuals with similar experiences as they may have walked the learning journey together.

In a global context, it is significant to note that this study is focused on female learners of color in the United States. While research indicates existing challenges in STEM learning for female students worldwide (UNESCO, 2017), co-existing factors of class and country of origin may present differently in other countries than it does in the U.S. Economic factors are a sub-consideration of this point as this study is being conducted in the U.S., a first world country with a solid economic infrastructure and varying degrees of factors such as poverty and wealth among citizens.

Delimitations

Delimitations of this study concentrated on female learners of color specifically and their educational experiences in U.S based institutions. Discipline-wise, research efforts focused on C-STEM fields which centered on computer science but also included related fields such as engineering and information technology (see Chapter 4 for full listing) degree earners. Participation was limited to individuals in the U.S. that met inclusionary factors for the study such as an earned degree in a C-STEM field.

Assumptions

The research assumes that female learners share similar core concepts within aspects defined by the CCW model (i.e., aspirational, familial, navigational, and social capital). It is also assumed that participants associated various elements of the model with access and equity as defined by the researcher for the purpose of this study. The researcher recognizes that subcultural differences may shape attitudes, beliefs, and motivations differently. Countries of family origin may also impose specific societal norms regarding education and community (i.e., individualistic versus collectivist).

Additionally, it is assumed that participants were being truthful about their experiences. Specific to the retrospective nature of this study, it is assumed that their memories were clear and they were able to accurately recall educational experiences throughout the pipeline. Some participants recently completed undergraduate degrees and were currently working toward graduate degrees in the field, recalling more recent experiences. However, others completed their C-STEM degree several years prior, some even having pivoted career roles, which may have influenced their recollections of the experiences they were being asked to share in response to interview prompts.

Positionality

As a female of color, the researcher can identify with the general challenges of the population as related to being a minority learner. Marginalization has not only impacted the researcher's female gender but also as a Black individual in America. In the learning space, this has presented the researcher with unique challenges such as connecting her culture to curriculum in 20+ years of formal education. Specifically, the tenets of the CCW model have been complex to navigate as the various forms of capital often do not align with dominant learning systems. A similar concern was expressed through the work of Bourdieu and Passeron (1977) in which they sought to understand how forms of capital were valued

among more elite groups but may have been considered less valuable for groups regarded at lower social status. It is also significant for the researcher to recognize her intersectionality as a Black woman journeying through the academic space. Once a STEM learner and now a professional conducting research in the field, she aims to serve traditionally marginalized populations, including other Black women (Erete et al., 2023).

Regarding STEM learning, the researcher has experience as a biology major of 3 years in her undergraduate prior to switching to a Liberal Arts major and graduating with an English degree. Though life sciences such as biology placed different demands on the researcher than those of information sciences like computer science, challenges as a female, underrepresented learner were faced like those described in the literature. One challenge faced by the researcher while majoring in a STEM discipline was lack of access to faculty of color that the researcher could identify with. Furthermore, while some female faculty were present, they were often teaching laboratory sections while White and Asian males led large lecture courses. Black, female faculty (mirroring the identity of the researcher) were not present in the department during the researcher's experience as a science major.

Another challenge was that of consistent access to foundational science and mathematics resources (i.e., tutoring, enrichment programs) that were able to meet the researcher's various levels along the learning journey. Some scholars may refer to "hidden curriculum" in education which sets expectations for all students to enter the learning environment with the same level of understanding as peers who hold access to unlimited learning resources (Ralston, 2011). These resources are often readily available to groups with higher socioeconomic status whose guardians and support network can finance private education, one-on-one assistance (tutors, learning coaches), or close connections to family members or mentors with careers in the prominent fields they seek to pursue post degree.

Organization of the Study

This research study is presented in 5 chapters. Chapter 1 presents an introduction to the study, highlighting the background, significance purpose, research questions, conceptual framework, theoretical framework, and additional foundational elements of the study. Limitations, delimitations, assumptions, and positionality provide an opportunity for the reader to gain clarity on the reader's lens on the study before reviewing additional study chapters in detail.

In Chapter 2, the reader will find a literature review focusing on C-STEM education, specifically in the context of equity and access for learners. Chapter 3 contains research design and methodology elements of the study in which the researcher will share details of participants and plans for how the study was conducted. Chapter 4 presents the research findings as displayed through Epistemic Network Analysis (ENA) models of participant's analyzed discourse. Qualitative data is shared in the form of direct quotes (or "utterances") from participants to support study results. Chapter 5 concludes the study with a discussion of five key study findings, an exploration of future research, and the researcher's final reflections.

Chapter Summary

A background of the study provided context to the issue of C-STEM education regarding historical issues in the discipline. Foundational issues in STEM education that parallel were also provided for context. Background focus was placed on female learners and learners of color in C-STEM. The problem statement emphasized challenges in representation from education to the technological workforce, creating a pipeline issue. The purpose statement introduced readers to the researcher's curiosity of cultural capital in the space of C-STEM learner equity and access. The significance of the study provided details

of educational inequity and the challenges that it creates in employment, policy, and for technology users.

A definition of terms provided context for keywords and phrases used throughout the proposal. The conceptual framework introduced cultural capital theory and the CCW model which led into discussion of CRT as the study's theoretical framework. Two overarching research questions were introduced for the study. Limitations, delimitations, and assumptions explored study elements within the context of gender and geographical location. The researcher's positionality was shared to provide a background of her association with the study. The chapter concluded with an organization of the study briefly describing chapters 1-5 as represented in this manuscript.

Chapter 2: Literature Review

Chapter Overview

The Chapter 2 literature review begins by exploring the historical context of computing education then proceeds to describe the origins of impact on marginalized learners. Specific to this study, the marginalized population of female learners of color is explored. The central themes of diversity, equity, and access are discussed. An overarching conceptual framework of the CCW model (Yosso, 2005) is central in this review as it guides the study. The conceptual framework models the researcher's outlook on C-STEM equity and access as an organizational change dilemma with potential solutions that can be explored as leadership opportunities.

Context

The purpose of this quantitative ethnographic study is to explore the impact of cultural capital in the C-STEM learning experience of female learners of color as it relates to perceived access and equity in their field studies. The researcher posed two overarching research questions:

- RQ1: What aspects of cultural capital, if any, have an impact on the perceived access of female C-STEM learners of color?
- RQ2: What aspects of cultural capital, if any, have an impact on the perceived equity of female C-STEM learners of color?

Conceptual Framework

The researcher conceptualizes this study under the framework of Cultural Capital and the CCW model (Yosso, 2005). Cultural capital originates from the ideas of Pierre Bourdieu (1973) and further developed with Jean-Claude Passeron (Bourdieu &

Passeron,1977) to highlight the significance of one's social assets. Bourdieu (1985) further developed the concept by categorizing three forms of cultural capital as embodied capital, objectified capital, and institutionalized capital. According to Goode (2010a), embodied capital is central to the learner's immediate environment as detailed in the following statement:

> Cultural capital in an embodied state, according to Bourdieu, is acquired by an individual, often through socialization processes with family and friends. This type of capital is closely linked to "habitus," or a person's character and way of thinking. In the context of this technology, knowledge and attitudes bestowed by students' communities of practice would qualify as an embodied state of cultural capital. (pp. 589-590)

Regarding environment-learner connections, Goode (2010a) further asserts that "K-12 institutions often reward students who already have technological proficiency and deny other students access to this vital knowledge" (p. 590). Such favoritism toward students with greater access may further play out into institutionalized cultural capital. Under the framing of institutionalized cultural capital, one's academic and professional background holds value. In computing education, this can have a direct impact on a student's educational progression in the field as well as their career trajectory into technology and related fields.

Yosso (2005) offers the CCW model to expand upon traditional interpretation of Bourdieu's original forms of cultural capital, empowering minority students' differences as strengths. She also draws upon the work of sociologists Oliver and Shapiro (1995) to examine factors of the wealth gap between African American/Black and White

(Caucasian) populations; revisiting the Bordieuan framing of assets and resources in the discussion of capital. Yosso's model encourages thought expansion regarding previous definitions of wealth and suggests that traditional structures consider the unique, notable assets of people of color. Morales-Chicas et al. (2022) details Yosso's work in the following:

> CCW builds on critical race theory, which considers the various social, political, and historical factors shaping the experiences of people of color in education. CCW takes a critical race theory perspective to critique a Bourdieuean cultural capital approach (Bourdieu, 1986) that uses narrow, white, middle-class notions of success. Yosso challenged this deficit lens by, instead, identifying the cultural strengths of nondominant groups and the multiple skills, abilities, and cultural knowledge they bring while resisting oppressive barriers (p. 2)

Shifting the scope of Bourdieu's original framing, institutionalized capital can encompass what Yosso (2005) refers to as aspirational capital. The scope of aspirational capital focuses on "the ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers". Yosso (2005) specifies that "[t]his resilience is evidenced in those who allow themselves and their children to dream of possibilities beyond their present circumstances, often without the objective means to attain those goals" (pp. 77-78). This literature review emphasizes the aspects of aspirational, familial, and social capital under the CCW model.

Computer Science Education

In the discussion of computer science equity, researchers present two (primary) opposing schools of thought:

i. Challenges presented by the educational pipeline.

ii. Toxic, unwelcoming work environments that further oppress marginalized populations.

Both arguments recognize the equity and access gaps that exist for both CS learners and professionals of color, specifically those identifying as female. In this literature review, the researcher will focus on the educational pipeline argument as it is central to the retrospective study proposed in this manuscript.

Computer Science (CS) and its umbrella discipline of STEM education play a key role in digital equity from the primary to tertiary school levels. Participation in these fields has a long term impact on students' technological identity development, access to college majors, and participation in the workforce. According to Goode (2010a), “[t]here are potentially tremendous costs to not being fluent with technology”. Specifically, “[h]igher education and many professional careers have technology-rich environments, and students without the necessary expertise in computing before they enter college might miss educational opportunities” (p. 588).

Historical Context

The historical context of CS education has roots in STEM fields such as mathematics. Thus, it is significant to examine the history of such fields to obtain a better understanding of CS. For instance, Huntington (2015) analyzed undergraduate mathematics curriculum over the course of 100 years from the period of 1905-2005 through examination of major degree requirements and course descriptions. Key findings indicated that the rise of computer programming began in the 1950s during which the subject became more accessible and increased in popularity. As a result,

computer science coursework evolved from a subfield within mathematics departments to its own department. The researcher also determined that applied courses eventually became incorporated within other disciplines.

The general field of information science also provides roots for the study of computer science. Aspray (2011) explores changes in information science over time. Specifically, Aspray's theme of *professionalization of information domains* highlights the evolution of professional organizations and networks. The idea of professionalization is significant in creating historic markers and pivotal points of progress within a specific field. Such work influenced future studies examining the role of women leaders, specifically, who contributed to the professionalization of CS (Lunn, Zahedi, et al., 2021).

Similarly, Aspray (2011) questions professional role shifts between men and women in information science as it relates to larger historical events such as World War II. The war shifted employment trends in the industry, resulting in a majority of women programmers. Aspray's observations lead to the exploration that the impact of business and economics had on information science as a field at large. Furthermore, Aspray (2011) labels the theme of *the information society* in reference to societal networks sharing information on a global scale. Specifically, he challenges scholars to explore the economic and political impact of the global dissemination of information.

> These scholars are interested in questions such as the impact on institutions and professions of the spread of information, the cultural embeddedness of information, the relation of information to globalization, the economic and political impact of information and information technology, information technology used

> for economic development purposes, and the digital divide" (Aspray, 2011, pp. 238-239)

Though Aspray's 2011 work is dated in the context of this study, his research poses the significance of information networks.

His work also emphasizes how access can impact who is able to obtain and share such information as global advancement continues to occur. Additionally, narratives in media also have influence on gender limitations in the history of computer science representation. For instance, in studying the identity and attitudes that shape CS majors, Miller (2015) discovers that men are often portrayed as heroes in historic events while women typically have little to no role in these stories. The production of computer science research also presents significant areas for exploring representation in the field. Lunn, Marques Samary and Peterfreund (2021) provide insight into researchers and institutions who have contributed to studies in the field during the period of 2015 to 2020. They utilized the data collected (including related conferences and journal entries) in efforts to create a guide with the goal of global collaboration in CS educational research, specifically within the scope of higher education.

Cultural Presence in CS Curriculum and Workforce Preparation

Introductory coursework in higher education has a profound impact on student's early associations with the field of CS. Such coursework is often the point of initial exposure for students in the field (George et al., 2022). Researchers such as Miller (2015) have found that socially responsive curriculum can have a profound impact on learner's identities, particularly for women and other minority learners. Miller (2015)

encourages CS educational environments where learners' cultures are celebrated as assets.

> What we need to equalize participation in computer science and create environments where ethnic-minority people will thrive, is to train people in cultural fluency. We need an environment that is truly integrated, and not one in which everybody comes in and gets whitewashed into the existing norm" (p. 154)

Highlighting cultural diversity can also help foster collaboration. One result of Miller's (2015) study emphasized "that many students decided to major in computer science once they discovered for themselves how truly collaborative the field really is" which could lead to more steady retention of minority students in the field (p. 153).

Education to Career Pipeline

Cultural diversity also holds value in workforce hiring processes. Lunn and Ross (2021) explore the hard and soft skills that tech employers search for in candidates and how the cultural wealth of minority candidates can be leveraged to fulfill the skills employers are seeking during the hiring process for computing jobs. Hard skills relate to the practical skills required to perform job duties, often gained through the job or in education. The authors define soft skills as "an individual's personality, attitudes, behaviors, and ability to interpret social cues, to communicate, and to interact with others with emotional intelligence and empathy" (Ahmed et al., 2012; Lunn & Ross, 2021, p. 2). They utilize the CCW model (Yosso, 2005) by highlighting the following factors: aspirational capital, social capital, navigational capital, resistant capital, linguistic capital, and familial capital. More context regarding the CCW model will be provided later in this literature review as a part of the theoretical framework.

Changing the Trajectory of Female Participation

Female learner participation in computing education has previously focused on efforts such as increasing self-efficacy in the subject or encouraging male learners to be more welcoming of their female counterparts. However, more contemporary efforts may need to be examined such as appealing to female learners' interest in social activism. Sax et al. (2017) provides suggestions such as appealing to the philanthropic contributions that can be produced by the field of computer science. Researchers provide the following:

> efforts to attract more women to computer science will need to highlight the ways in which the field positively impacts communities—locally and globally. These efforts may help to increase interest among women with stronger activist orientations but may also help them to understand the ways in which the field contributes practically, not just theoretically, to improving the world around them (Sax et al., 2017, pp. 284).

Extending career possibilities beyond the theoretical context of computer science education provides female learners with fresh opportunities, allowing for new narratives that extend beyond antiquated stereotypes previously connected to their academic association with the field.

Sax et al. (2017) also highlights the way the female learner’s trajectory in computer science interest has shifted over time. Their study highlights how new opportunities such as social activism through technology may have created a more modern space for female learners to thrive. The researchers suggest relying more heavily on current times such as 2011 which marks the end of their 40-year analysis

(1971-2011). Such observations support their suggestion for educational leaders to market the creative opportunities that female learners can find in computing education and utilize such to recruit them into the major at the college level.

Prior research from Sax et al. (2016) emphasizes the importance of focusing on factors that attract STEM majors to their specific field of interest in efforts to determine representation gaps, specifically in the case of gender. The researchers share that "comparatively less empirical work has examined what predicts individuals' decisions to pursue *particular* STEM fields" and the way STEM "fields are inherently distinct and may attract different types of students" (Sax et al. 2016, p. 571). They also argue that differentiation among STEM disciplines could provide educational leaders, specifically policymakers and practitioners, a means to examine gender gaps more constructively (Sax et al., 2016). For instance, female learners in the engineering major may have different recruitment and retention needs than their counterparts in computer science.

CS and College Access/Participation

Computer science representation at the U.S. college level provides a reflection of who is represented in the technological workforce. U.S. BLS (2024) data from the Current Population Survey reports a total of 6,502 individuals comprised the computer and mathematical occupations representing racial identities of 63.5% White, 9.2% Black or African American, 24.0% Asian, and 8.8% Hispanic or Latino. Additionally, only 26.9% of that total identified as women. According to John and Carnoy (2019), "the computer science major in U.S. higher education is also becoming increasingly masculinised, suggesting that gender employment trends could reflect pipeline issues"

(p. 422). Women in CS majors indicate self-confidence concerns related to their abilities in mathematics and computing (Lehman et al., 2016).

Previous research also indicates the need to examine retention efforts of women and other underrepresented students in CS majors as they work to advance to degree completion (Lehman et al., 2023). Palmisano (2006) elaborates upon the vitality of innovation in the constant transformation of our global society in the following:

> Today more than ever, the premium comes from the fusion of invention and insight into how to transform how things are done. Real innovation is about more than the simple creation and launching of new products. It is also about how services are delivered, how business processes are integrated, how companies and institutions are managed, how knowledge is transferred, how public policies are formulated -- and how enterprises, communities, and societies participate in and benefit from it all. (Systemic Changes, para 3)

Encouraging innovation among students, through participation, is key in preparation for the technological workforce.

Access

It is significant for students to engage with computing educational content early in their academic experience as such encourages the pursuit of technological career paths from primary and secondary school levels into higher education (Lambert, 2018). According to Ryoo et al. (2020), teachers play a vital role in student's trajectories as they "must acknowledge and value the unique perspectives and wealth of knowledge that youth are bringing into the classroom, encouraging those connections between CS, self, and transformative social change" (p. 357). Student's early life experiences paired

with early CS exposure encourage inclusivity and creativity. Ryoo et al. (2020) further acknowledge that learner experiences and creative expression should reflect that of the CS field in which change and innovation are central factors. Additionally, student accessibility is crucial to this step in the creative process.

The way the learner approaches content from lived experiences can vary as accessibility may differ according to socio-economic demographics. Goode (2010a) notes that “students who are the least likely to encounter technology in schools also have the least access at home” (p. 586). These early experiences can further shape students’ attitudes and beliefs regarding technological academic and career pathways.

Goode (2010a) provides the example of marginalized learners such as “college-bound youth attending high-poverty schools” by emphasizing potential academic challenges to be considered in their technological learning experiences. Specifically, the way this student group “transition[s] to institutions of higher education, which increasingly rely on an electronic infrastructure, might create logistical, academic, and psychological obstacles” (p. 588). Such obstacles may have bearing upon how learners define their roles in technological education. Furthermore, intentional inclusion is key as Michell et al. (2017) assert that technology classrooms “need to fit with students’ social identity and give them a sense of ‘ambient belonging’ if they are not to alienate them” (Michell et al., 2017, p. 408).

For female learners specifically, attitudes, beliefs, and expectations projected by guardians and society at large can also shape how they see themselves in the STEM learning space. Koch et al. (2019) reflect upon mindset as they apply the thought leadership of Dweck (2006) in the following statement:

> In addition to parental support, expectations of success, particularly school success and their mindset about school success, can affect girls' persistence in STEM. What girls say to themselves and others about their ability in STEM school subjects—whether they have a growth or fixed mindset—can influence their persistence. (Koch et al., 2019, p. 266)

Frazier's (2020) explored female high school student's interest and disinterest in CS education and determined that disinterest was related to factors such as support system, perceived inability, and low self-efficacy. Though students who took prior course work in CS reported higher responses to questions related to self-efficacy and were more interested in further developing their skills. Frazier concluded that the earlier students (especially female learners) are introduced to computer science education, the more likely they are to build a higher self-efficacy as related to the field and become more interested in continuing with the subject throughout their education.

Technological Identity

Technological identity is established early in a student's academic career. Goode (2010a) defines technological identity through the following statement:

> Computer expertise is more than a set of technical skills - it is a holistic conglomeration of interactions, experiences, and understandings with new technologies. Knowledge about computers might also affect the technology stance of an individual, that is, their attitudes and feelings about technology. Previous opportunities to engage in computing contribute to the formation of a technology identity that encompasses the knowledge and stance a student holds around computers. (p. 588)

The development of such identity is too fragile to be delayed until college years or into post-college career settings as that is the time when students should be embarking upon opportunities in the workforce. Goode (2010b) addresses concerns of time and accessibility in the following:

> For many college students, not having a strong technology identity is a product of an unequal high school education and disparities in home resources, yet the consequences of one's technology identity has a powerful influence on the attitudes and decisions students make regarding their academic and life plans. It is these constraints and affordances of a technology identity – which seep into academic, social and work life – that truly reflect the depths of the digital divide. (p. 509)

Students should be provided with the opportunity to engage with technology alongside their developing life and learning experiences at the primary and secondary levels. Goode (2010a) explains how this impacts students' technological proficiencies:

> Students with a strong technology identity, then, have robust beliefs about their technological proficiencies, believe technology is important, are eager to learn more about technology, and sense there are opportunities to learn more about computing. On the other hand, students with weak technology identities have low levels of technological proficiency, do not view technology as important, do not perceive learning opportunities around technology, and are not motivated to learn more about computers. Most students, however, have a non-linear relationship with technology along these four dimensions due to unique and complex individual experiences shaped by opportunity, knowledge, and attitudes. (p.590)

Challenges in the digital divide have continued to impact African American and Latinx students as have had less access to digital devices (i.e., laptops and desktops) and broadband subscriptions (U.S. Census, 2017). However, the Coronavirus 2019 (COVID-19) further highlighted disturbing disparities in the U.S. digital divide (Dede, 2020; Koh, 2020; Tosh & Kaufman, 2020).

Technological identity can also have a long term impact on one's socioeconomic mobility. Brock et al. (2010) explores this idea through the concept of *technical capital*. They provide that "[t]echnical capital serves as a power resource as certain groups mobilize around their technical expertise to gain resources and position". Furthermore, technical capital "accrues through education, economic means, and social networks that include others knowledgeable about ICT [information and communication technology], and unfettered access to ICT" (Brock et al., 2010, p. 1042-1043).

Threats to Innovation, Access, and Technological Freedom

Innovation is key to progress in equitable technological representation. Bias in reference tools such as traditional textbooks or search engines can have an adverse effect on innovation in the educational environment with a rippling effect into the broader global technology space. Researchers such as Smith-Ditzio et al. (2016) see social media as a viable avenue for diverse representation among users. The researchers share that "[s]ocial media has the potential to motivate users to work in unison in generating innovative idea sharing to solve common problems" (p. 380). While social media may provide users with opportunities to express their authentic voice, algorithmically controlled technological spaces such as search engines may offer far less independence.

Smith-Ditzio et al. (2016) details Google's PageRank feature as an "algorithm [which] evaluates links, assuming that web pages linked from many important pages are themselves likely to be important" (p. 381). Such implies the control of non-human decision making upon human's reliance for vital information. Additionally, if algorithms are built by primarily homogeneous groups (such as males from dominant backgrounds), this may lead to biased search results that neglect to consider the gender, cultural, and other significant factors that represent the users that search platforms service. Shortcomings in this area could also be traced back to computing classrooms in which gender, for example, is given less priority in learning material such as textbooks. Blickenstaff (2005) provides the following:

> Other ways that sex bias can show up in texts include the wording of problems and examples, and in the attention paid to the contributions of female scientists. Texts do seem to have improved in these areas as well. (p. 377)

While Blickenstaff (2005) does indicate that "a good deal of the current textbook bias work has to do with race and ethnicity, not sex", it indicates progress in one respect but implies a need to recognize the intersectionality of users (p. 377). For instance, it is possible for a user to identify as Black and female in which the two identifiers converge in expectation of unique needs as a user of technological services.

A high-level examination of this issue may include increasing the early introduction of women of color in technology roles. Advocacy programs strive to increase these efforts for female learners at large but especially those of color. Research indicates that the underrepresentation of female architects and engineers

pose further threat to an existing decline among women in computer occupations (Nix, 2021; Fry et al., 2021) which is why early association can be essential for progress.

Intersectionality

Historical context has also been used to analyze the intersectionality (Crenshaw, 1991) of female learners in computing education. Lunn, Zahedi, et al. (2021) analyzed the way notable female figures influenced historical events, field specific educational foundations, and professional organizations in computer science. Researchers determined a lack in scholarly sources to support computing contributions by women of color. Early work from researchers such as Aspray (1984) also emphasize a dearth of information on key historical figures as well as minimal focus on innovation impacting the needs of users. Intersectionality also indicates how a shortage of history available on female leaders in the field presents a challenge to fresh perspectives and viewpoints from minoritized representatives which have an ultimate impact upon the users they serve.

Another benefit to exploring intersectionality within a historical context is that additional underrepresented populations may appear in resulting data. For instance, Lunn, Zahedi, et al. (2021) found that the participation of Black men in computer science declined over the period studied between 1987 and 2018. While the researchers focused on the gaps that impacted minority women, identifying a decline among this subgroup of minority men may help to highlight communal disparities impacting one race (i.e., Blacks/African Americans) regardless of gender.

These disparities across a racial group can shed light on the cultural needs of one female learner group which may vary from another. Such may point to larger issues

faced by underrepresented racial minorities (URM) who Sax et al. (2016) indicate “are less likely to attend high schools that offer rigorous curricula that would prepare them for college level STEM courses” according to literature in the field” (p. 573). Examining the issues from a lens of intersectionality can provide unique solutions to specific disparities for minority computing learners.

Additionally, Rankin & Thomas (2020) introduced the concept of intersectional computing to highlight the importance of intersectionality for women of color, particularly Black women, in computing. Through this concept, the layered identities of these women are pushed to the forefront, encouraging their ability to persist in CS fields of discipline. Furthermore, recognizing their intersectionality helps to discourage the gendered racism that they may face as a result of gender reform efforts in CS. Gendered Racism addresses a general approach typically taken in CS gender equity discussions when the focus of equity for women in the field is centered around their Caucasian peers and neglects to resolve challenges that women of various backgrounds may face in the field (Hill Collins & Bilge, 2016).

Increasing Access

Teachers are vital players in the success of underrepresented students in computing as they assist in guiding knowledge inquiry. Ryoo et al. (2015) share the following regarding the pivotal role of teachers:

> Computers don’t create cultural change within schools; rather, it is the teachers and administrators who do. Teachers require the space to think big and be bold with their teaching transitions. For this to happen, it is not just teachers who must change, it is the entire school culture and administration. (p. 367)

Teachers can also assist school administrators and districts in expanding upon what is working while intentionally discovering new methods to adjust that which may need to be improved in computing education.

Additionally, teachers can serve as role models to students. A role model dynamic is especially significant in computing education. Lehman et al. (2016) share how teachers are essential in influencing student's career possibilities in teaching CS education as well as encouraging the recruitment of marginalized students into CS fields. Department chairs in university level CS departments have also been identified as key educators in broadening participation in the discipline (Lehman et al., 2022).

Equity

The significance of intentional equity, inclusion, and creativity efforts should be a key point of consideration for school administrators & districts as they work to support teachers. Ryoo et al. (2015) builds upon the example of their own computer science enrichment program in recommending that school leadership, such as principals, should be cognizant of how school demographics are represented in computer science programs. Representation should also reflect gender balance in numbers. The authors elaborate that school leaders are part of the "village" that can lead to greater organizational change. Additionally, support from various leadership levels promotes a collaborative learning environment for teachers and students alike.

Teacher education in computing also requires examination within the conversation of equity and progress. A need exists for increased cultural competencies among computer science teachers, specifically (Goode, Runninghawk Johnson, & Sundstrom, 2020). Researchers such as Goode, Ivey, et al. (2020) promote cultural

competency through professional development programs which aim to equip teachers with tools to meet the needs of their diverse students. The literature also suggests curriculum integration to create a more diverse group of teachers. For instance, Chipps (2020) suggests the establishment of micro credentials in CS education so that teachers can incorporate content into any discipline without having to pursue a separate teaching credential.

Pipeline Challenges Impacting the Workforce

Education plays a vital role in creating a diverse pool for the technological workforce. Noble (2018) expresses the repercussions that accompany representation needs of underserved employees in the technology fields. She cautions that “[t]he lack of a diverse and critically minded workforce on issues of race and gender in Silicon Valley impacts its intellectual output” (p. 163). Furthermore, a long term challenge is that toxic work environments are less inclusive when welcoming marginalized groups. John & Carnoy (2019) provide that “the work climate in high tech may need to be altered to be more hospitable for minority workers, similar to making the work climate better for females" (p. 433). Negative attitudes could stem from toxic behaviors that were not addressed prior to entering the workforce.

According to Michell et al. (2017), unresolved sexist behavior can become more significant in the workforce if not addressed during key educational years. The authors provide the following in reference to the issue:

> If some boys and young men already hold to exploitative views of women prior to entering university and on campus, then, unless there is a change of mind, we would expect them to continue to hold those views in the work place and not

> actively embrace gender equity there…exploitation is more likely to happen when students enter the workforce than to be evident during study. (Michell et al. (2017, p. 414)

Thus, the promotion of equitable learning environments can create a foundation for more tolerant workplaces with healthier climates for diverse groups of individuals.

Extracurricular learning opportunities (occurring outside the classroom) can also promote more balanced connections and improve communication skills (McCall, 2017). Specifically, technology corporations' promotion of equitable opportunities allows students professional experiences to develop computing skills and introduce them to career pathways in technology. Lehman et al. (2016) explore "marketing campaigns, such as Google's Made with Code initiative, [which] may be helpful in educating students about the many career fields to which coding skills are relevant" (p. 291).

Educational Policy Related Issues

Educational policy has a noteworthy influence on long-term employment and technological policy making. According to the Code.org Advocacy Coalition (CAC; 2018), "[c]omputer science is one of the few policy issues that can address both foundational education needs and workforce development demands for a state's future workforce" (p. 4). Thus, it is imperative that policymakers gather system-level data on student's advancement in the discipline while ensuring that teachers have access to the data to support their instruction (WestEd, 2011). Tracking student enrollment data in computer science can provide indication of race, gender, and other equity related trends prior to attempting to solve gaps in representation at the workforce level.

According to data reported by Computer Science for California ([CSforCA], 2023) for the 2018-2019 school year, enrollment in computer science coursework reflected 70% male identifying students but only 30% of female identifying students were represented. Race/ethnicity data reported may seem to reflect increased diversity with CS enrollment at 51% representing Pacific Islander, Native American, Filipinx, Black, and Latinx students. However, these 6 racial/ethnic groupings were compared against their White and Asian peers, representing only 2 ethnic groups, at 45%. The additional 4% of students in the CSforCA data were distinguished as *multiple races/other*.

CS Pedagogy and Equity

A variety of educational gaps could be reviewed as early causes for long term gender and race inequities in technology. Differences in male and female learning styles has indicated more bias toward male learning preferences in STEM coursework (Kulturel-Konak et al., 2011). Specifically, “[w]omen tend to prefer hands-on learning experiences, they make intuitive or feeling based judgments, they are people oriented, and they are comfortable with ambiguity”. Alternatively, “[m]en tend to take an analytic approach to their learning, they think logically and rationally, and they enjoy working with symbols and like structure” (Kulturel-Konak et al., 2011, pp. 15-16). A higher value is currently placed on analytical skills in technology fields, placing less emphasis on the feeling-based skills.

Emphasizing the latter could provide opportunities to fill gaps posed by traditional logistic approaches. The working style of males, evolving from the classroom pre-career, could create dominant, unwelcoming effects within the field. Such ill effects could transition into long term obstacles in the work environment.

Disparities in CS course availability may also serve as precursors to a lack of representation in technology fields. CS curriculum is not mandatory in many states including California (Lambert, 2019). Such distinction has the greatest impact on underserved schools and school districts who face challenges with existing gaps in curriculum. Furthermore, “state and federal policies relegate most CS courses besides [Advanced Placement Computer Science] to be vocational and non-academic, thereby maintaining a gap between the 'high status' knowledge of today's world and the learning opportunities available in schools” (Ryoo et al., 2013, p. 169). CS equity advocates such as Girls Who Code (GWC) support transparency in state level enrollment tracking (GWC, 2019) to ensure distributed access to CS learning opportunities.

Diversity

Pedagogical Solutions for Forward Progress

The role of practical experience may serve as a catalyst for increased diversity. According to Kulturel-Konak et al. (2011), internship and practical learning outlets, specifically, can provide “hands-on experiences [that] give students opportunities to immediately practice what they have learned” (p. 16). Blickenstaff (2005) proposes additional pedagogical solutions to address STEM underrepresentation which include equal access to resources, assignments and examples that acknowledge quality of life, implementation of gender diverse cooperative groups, expressing zero tolerance for language and behavior that promotes sexism (including classroom resource materials), restructuring focus of introductory courses, and exploring political underpinnings within scientific inquiry.

College-level computer science departments, such as that of Harvey Mudd College, have redesigned introductory coursework by experience level in efforts to be more equitable for those entering with less prior access to CS concepts than their experienced peers (Weisul, 2017). Experiential learning and collaboration were also made central in the progressive learning settings described. Weisul (2017) details the college's success in increasing the number of female STEM graduates by promoting "creative problem solving, using real-life examples" and instructors who "encouraged collaboration and paired students on homework assignments" (para 7). Regardless of the introductory course students enrolled in, they were all encouraged to take the next level of computer science coursework.

Furthermore, the Building, Recruiting and Inclusion for Diversity (BRAID) initiative was founded in 2014 by Maria Klawe, the fifth president of Harvey Mudd College, and Telle Whitney, former CEO of the Anita Borg Institute. The BRAID initiative consists of U.S.-based CS departments which aim to increase the participation of women and marginalized students majoring in the discipline (Lehman et al., 2016). Previous research has supported these initiatives in that all female learning environments have increased self-efficacy and collaboration while fostering an interest in continuing to take CS classes (Drobnis, 2010).

Scientific learning integration has been shown to provide equal opportunities in CS education through curriculum integration with non-science subjects. WestEd (2011) reported the following regarding scientific learning integration:

> Some schools overcome this challenge by integrating science with other content areas, typically English language arts. Teachers who frequently integrated

> science with other subjects offered science an average of 130 minutes a week, compared with an average of 94 minutes per week for teachers who rarely or never integrated science…integration across the curriculum helps students realize that science permeates everything—they begin to see science in their everyday lives. (p. 14)

In addition to pedagogical practices in the classroom, highlighting the significance of cultural capital in computing education provides an opportunity for learners from a variety of backgrounds to align learning with their life experiences.

Community Cultural Wealth

The CCW model (Yosso, 2005) has roots in Kimberlé Crenshaw's theoretical contribution of CRT (Crenshaw, 1988). CRT is built upon a foundation which recognizes skills and abilities among individuals of color as assets rather than emphasizing deficits imposed by standards of the majority (Yosso, 2005; Crenshaw, 1988). CCW utilizes CRT to challenge the early interpretations of cultural capital according to Bourdieu and Passeron (1977) which assume that people of color need formal education to reach an elevated level of social equality. Yosso (2005) seeks to enhance the initial positioning of traditionally minority groups by allowing them to enter the educational environment with skills and abilities supported by their own cultural capital rather than being expected to work toward a skill level predisposed by a dominant cultural group leadership.

CRT originates from a legal field focus which called out racism in American law (Crenshaw, 1988) but evolved into "a broad literature base of critical theory in law, sociology, history, ethnic studies, and women's studies" (Yosso, 2005, p. 71). Scholars such as Solorzano & Yosso (2001) utilize CRT derivatives (Association for the Study of

Higher Education [ASHE], 2015) such as LatCrit (Museus, 2013) to analyze Latinx research populations. The researchers explore the use of counter narratives to challenge the generalizing nature of dominant culture. For context, the researchers share Iglesias' (1997) definition of Lat Crit in the following:

> explor[es] how Critical Race Theory might be expanded beyond the limitations of the black/white paradigm to incorporate a richer, more contextualized analysis of the cultural, political, and economic dimensions of white supremacy, particularly as it impacts Latinas/os in their individual and collective struggles for self-understanding and social justice' " (Solorzano & Yosso, 2001, p. 479).

Such is relevant to the conversation of CRT as the richness of one's cultural environment and experiences is central to their academic and professional contributions. Additionally, educational scholars have utilized CRT as a foundational framework to highlight the voices of students of color and shed light upon traditional educational practices that have promoted the White supremacist systems that create barriers for these populations (Delgado, 1989; Iftikar & Museus, 2018; Museus et al., 2012; Yosso et al., 2009).

Community Cultural Wealth in STEM Studies

Samuelson and Litzler (2016) explored the value of CCW in the persistence of engineering students. While navigational capital was found to be most prevalent among their participants' experiences at 68%, 61% [of students] referred to one or more forms of aspirational capital, 39%...described familial capital, and 39%...indicated a form of resistant capital" (Samuelson & Litzler, 2016, p. 100). Researchers also noted significant differences in capital reporting between African American male and female

students except for the area of aspirational capital in which there was a small point difference. Additionally, Rincón et al. (2020) found that resistant capital can vary between first and continuing generation students. First generation students have reported the necessity to challenge dominant educational structures, voicing their value in a way that their continuing generation peers, who can leverage existing traditional forms of capital, may not.

Within the realm of technology, aspirational capital can be applied to examine the educational paths of marginalized groups. Aspiration to pursue technical interest at early educational levels could influence one's engagement with and long-term interest in technological advancement. The impact of technological identity could also be examined under the umbrella of aspirational capital.

Regarding technology, Yuen et al. (2016) recommend that schools be proactive in providing families with the cultural capital necessary for their children to progress. Researchers provide the following as related to the school-family partnership:

> Schools should play a subsidiary role to that of parents, and in regard to building cultural capital for students from lower SES families, facilitate formal and informal learning with new digital practices. Education programmes [sic] should provide help [to] parents, so they can gain a better understanding of information literacy and the effect of new technologies on their children. (Yuen et al., 2016, p. 516)

The above recommendations can also increase the collective aspirational and navigational capital of families; better positioning their opportunities for technological progress in their professional and home environments.

Additionally, Emmison and Frow (1998) provide that “familiarity with...the burgeoning technologies of the information age can be seen as an additional form of cultural capital bestowing advantage on those families which possess them and the means of appropriating their full potential” (p. 44). Such can also provide greater context to the technologies families rely on daily for healthcare, communicating with loved ones and colleagues, and even navigating housing related matters.

Gender dynamics also play a significant role at the intersection of cultural capital and technology. Yuen et al. (2016) found that among students and families studied in Hong Kong, families placed more investment in the progression of their male students than they did for female learners. The researchers analyzed their study results to find that “male students perceive[d] more parental guidance and worry than female students, and students in higher SES families perceive[d] more parental guidance than those in lower SES families” (Yuen et al., 2016, p. 516).

Linguistic capital, another significant component of Bourdieu’s (1985) conceptualization, provides further opportunity to explore areas in which the unique experiences of marginalized populations can create advantages in computing educational equity. Beyond the traditional scope of language, linguistic capital can also include unique cultural contributions such as art and storytelling (Delgado, 1989; Denton et al., 2020). LatCrit and AsianCrit scholars also emphasize the value of rich, rooted stories in one’s journey to push against the barriers of oppressive systems that promote a status quo (Iftikar & Museus, 2018; Museus, 2013).

Family Support

Familial capital as support for female STEM learners is significant in their progression toward careers in the disciplines. Persistence is a key factor in adults' support for this population. Koch et al. (2019) found that "the support from parents, the social norms of the family, and the context of the home had high influence on girls' persistence in STEM and non-STEM activities" (p. 264). Researchers of the study also found that the learners who shared personal interest with parents, along with their persistence in those activities, were also significant. Furthermore, Koch et al. (2019) noted a correlation between high persistence in the pursuit of STEM learning and high parental support.

Family beliefs and attitudes toward technology career paths for female students also has an impact on their trajectories. Families with less favorable dispositions toward this topic may cause female learners to doubt their potential contributions to and significance in the field. Alternatively, parental challenges in career trajectories (i.e., within immigrant families) may be a driving factor for first generation STEM learners' perseverance in the field (Morales Chicas et al., 2022).

While some researchers support the collaboration between home and school (Koch et al., 2019), several factors should be considered. According to their study findings, Koch et al. (2019) offer the following:

> [T]o increase the likelihood that girls will consider a future in STEM, there may need to be greater opportunities for girls and parents to connect STEM learning and experiences across the interdependent settings of home, school, and afterschool. By making more connections to the home and involving girls' support

> networks across all three settings, we may encourage more girls from diverse non-dominant backgrounds to persist in STEM learning and careers. (p. 268)

It is significant to highlight the way family support may vary across cultures. In Latinx populations, for example, it is common for students to garner support and encouragement from relatives beyond their nuclear families and community members of their same ethnicity (Eyo-Idahor, 2022). Further, research has indicated that family support to pursue STEM studies encouraged middle school Latinx males to persist despite institutional barriers (Morales-Chicas et al., 2021).

Impact of Social Support

George et al. (2022) determined that in addition to family support, connection to field related student groups resulted as a positive predictor of students' maintained interest in computing careers. The researchers provide that "[r]ecognizing that student learning continues beyond the classroom, prior studies have also highlighted the importance of student organizations, technical conferences, and other professional development activities in fostering computing career aspirations", highlighting the intersection of social support and building practical knowledge in the field (p. 4). Adversely, unwelcoming environments that are exclusionary to minority students' cultures can impact student's interest in computing careers. George et al. (2022) suggests the following of university computing departments at a micro level:

> [They] ought to continually examine what messages (e.g., stereotypes, culture, fit) students of all groups are receiving or interpreting about computing careers so that students from groups historically underrepresented in computing might develop an interest in a computing career following the intro course (p. 16).

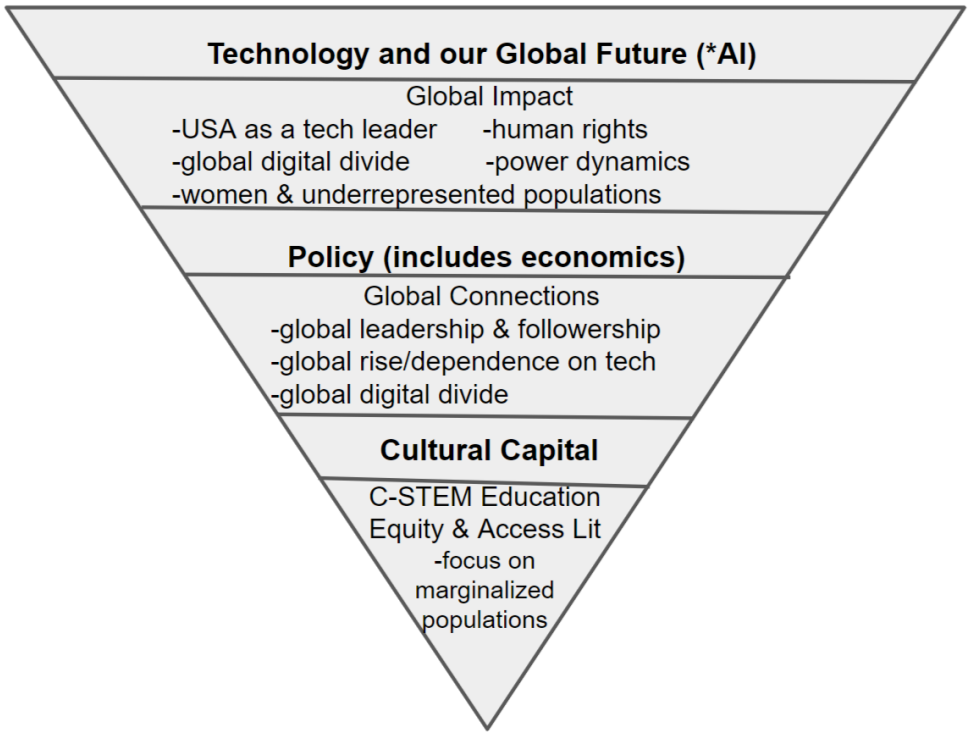
At a macro level, they suggest that institutions provide support by fostering a sense of belonging for students. Such inclusive practices may appear in the form of “training faculty and teaching assistants on inclusive pedagogical practices and building a sense of community in these courses may bolster students’ interest in joining the computing workforce” (George et al., 2022, p. 17). The researchers' suggestions imply a collaborative model to maintain student’s support in the field beyond introductory courses. The goal is to create inclusive environments that engage all learners in a manner that will produce a culturally rich pipeline of students to seek out computing career paths post-degree. The significance of social capital has been highlighted as essential for social and physical development in disciplines beyond STEM such as health (Ferlander, 2007) and music education (Vasil & McCall, 2018).

Global Implications of Cultural Capital

Global implications of cultural capital are significant to the broader conversation of technological advancement. In Figure 1, the researcher provides a concept funnel connecting cultural capital in C-STEM education to larger scale issues in policy and global technology matters.

Figure 1

Cultural Capital-Global Implications Concept Funnel



The literature presents U.S. centric concerns regarding the C-STEM educational pipeline. While C-STEM education may vary across countries, the pipeline still has a significant impact upon a global technology workforce which is not limited to geographical bounds. This also has a profound impact on the virtual environments in which we operate as referenced in the Chapter 1 study significance discussion. Gale and Parker (2017) examined cultural capital in the context of Australian higher education and determined that college students from low socio-economic backgrounds held greater cultural capital due to exposure provided by their institutions. The researchers compare their study to the conversation of social inclusion in European educational environments which highlights a comparative case for cultural capital outside of the U.S.

Leadership and Organizational Change in C-STEM Education

Under a high-level frame of organizational change as represented by the Argyris & Schön (1974) single and double loop learning theory, exists an opportunity for the study to exhibit a two-fold learning exposition in which:

1. The research illustrates existing challenges.
2. The research offers an assets-based approach for collaboration opportunities in which the learner's culture is central to their success in the field.

Currently, the literature presents C-STEM education leadership at the learner level to exist in mentee-mentor relationships among peers (Blaney, 2018; Morales-Chicas et al., 2022; Wofford, 2021). In the context of the CCW model, mentorship is reported to have a significant impact on social capital specifically in comparison to the other forms of capital represented in the model (Eyo-Idahor, 2022).

Argyris & Schön's (1974) concept implies a deeper understanding of internalizing practical lessons and reflecting for application to future scenarios. Under the frame of single loop learning one can learn lessons at surface level. Though, double loop learning requires that multiple factors be examined when encountering various scenarios. While the concept is typically applied within an emotional intelligence context, often in professional settings, it can also be utilized to review broader organizational issues such as the policies and practices that guide C-STEM education and resulting workforce implications. Furthermore, challenges in developing the leadership identity of female learners, specifically, has revealed that sexism faced in learning environments has created inconsistencies in their perceived leadership capabilities (Blaney, 2018). Such a dilemma presents an opportunity to examine change

under single and double loop learning as these challenges for females in the classroom carry into the workplace.

Transformational leadership can provide inspiration to support the greater good (Kuhnert, 1994; Northouse, 2019). Specific to this study, transformational leadership can promote a lasting presence for equity and access in C-STEM education. In the context of C-STEM educational equity, teachers, school administrators, and policymakers are typically considered as the traditional leaders. Though students also hold leadership capability in the quest for more equitable C-STEM learning opportunities. Specific to the classroom environment, “[o]utstanding learning is ultimately a collaborative experience between the formal leader [the teacher] and the informal leader-followers [the students]” (Riggio et al., 2008, p. 91).

A traditional top-down leadership approach provides the opportunity for experienced leaders to guide followers in a manner that empowers and prepares them for future endeavors. Conversely, a bottom-up leadership dynamic highlights the voices of those in the traditional follower role - promoting inclusion of the individuals and groups who will be directly impacted by change. According to Kezar (2012), the two leadership concepts are distinctly defined as follows:

> Top-down efforts are those initiated and conducted by people in positions of authority within the organization who possess formal power. Bottom-up efforts are those initiated and carried by those without positions of authority and formal power. Top-down does not necessarily mean that the change is dictated or mandated, although often it can be handled in this manner. (p. 728)

Incorporating both leadership approaches supports collaboration and diversifies solutions. In connection with transformational leadership, both could create sustainable change through motivational efforts.

Behavior is also key under the transformational leadership model. Northouse (2019) emphasizes that “[t]ransformational leadership requires that leaders be aware of how their own behavior relates to the needs of their followers and the changing dynamics within their organizations” (p. 183). Social influences connect with behavior within transformational leadership in that behaviors of leaders and followers can be interdependent of one another. Bass and Riggio (2005) share the following regarding this idea:

> There can also be a moral commitment to one’s own beliefs and values, to the values of others in the organization, and to the values of the organization as a whole. Leaders in organizations can play an important part in affecting organizational members’ levels of commitment by fostering followers’ commitment to the team, to the leader, and to the organization. The effective leader is able to align these facets of commitment to show how the goals and values of the follower, the group, the leader, and the organization are in basic agreement. (p. 34)

Furthermore, the author of the current study conceptualizes a leadership frame as adapted from the Path-Goal model (House,1971,1996). Underrepresentation in C-STEM learning creates immediate obstacles in primary and secondary education with longer term impacts in tertiary education and the technological workforce. An opportunity exists to examine the potential goals of equitable C-STEM education and

promoting diverse representation in the workforce. A bottom-up leadership approach provides an opportunity for learners to guide improvement efforts through strengths gained from aspects of their cultural capital.

On the path of C-STEM education, leaders and followers currently face obstacles that can have significant impact toward career opportunities. A specific obstacle being the underrepresentation of marginalized students in K-12 C-STEM education, impedes upon professional representation in technology fields. Goals seek to overcome such obstacles include equitable C-STEM education and access that leads to greater representation in technology careers.

Gaps and Inconsistencies in the Literature

The researcher has identified gaps and inconsistencies in the literature to support the significance on the current study. On a foundation level, there is a dearth in historical CS context that includes contributions of women of color. Black male students are also an under researched population which points to the need for more studies centering people of color and African American/Black students specifically on a cultural level (Lunn, Zahedi, et al., 2021). Previous researchers have identified that many studies in the field present gaps in interviewing learners of color due to sampling convenience issues (Wofford, 2021). Additionally, researchers have identified a need for increased studies centering around technological identity formation of participants who are women of color or representative of LGBTQIA communities, as a focus has been placed on females who identify as White and heterosexual (McCall, 2017).

From a theoretical lens, the Social Cognitive Career Theory (SCCT) is often utilized as a framework in existing literature but reduces assets of the student (George

et al., 2022; Sax et al., 2017). There is a presence of the CCW model in other studies examining STEM learners. However, a number of these CCW focused studies are limited in the populations they focus on which tend to represent Latinx populations (Eyo-Idahor, 2022; Morales-Chicas et al., 2022; Rodriguez et al., 2022; Yosso et al., 2009). There is a need for research that highlights other communities of other such as African American or Pacific Islander (Eyo-Idahor, 2022).

Continuing the discussion of population limitations, many existing studies are focused on undergraduate college students because they are an easier population to access (Wofford, 2021). The community college student population also represents an underrepresented group in the literature. While there is some discussion of the (role) of community colleges in the CS educational pipeline discussion, the research is not as extensive as four-year institutions. The research in this study is not centered around the community college population. However, it is a point of significance because community college is a key educational destination that many students obtain their learning at before transferring to four-year universities.

Geographical and institutional gaps also appear in the literature. There is a nature of participant populations stemming from one or a few of the same institutions which could present further challenges in population diversity. For example, in a study conducted by Eyo-Idahor (2022) on first generation Latinx college students, the author shared that the “study’s population consisted majorly of students who attended VU, with only one other student attending a different university” (p. 146). In examining the geographical location of study publications, many CS-specific researchers represent institutions located in concentrated areas primarily on the West Coast (UCLA and

University of Oregon) and new research coming out of Florida (Florida International University). It is significant to note that some researchers are currently working to expand this reach by presenting students with global research opportunities (Lunn, Marques Samary, & Peterfreund, 2023). Institutionally, the literature indicates limitations in CS studies conducted with Historically Black Colleges and Universities (HBCU) populational or published by researchers publishing at these schools. Rich data could be available regarding the cultural capital of African American/Black C-STEM students.

The researcher has aimed to contribute a unique lens to the existing literature. For instance, the current literature tends to be U.S. centric in most part. Though the examination of global context may provide a deeper review of general C-STEM educational pipeline, particularly considering the global implications of technology discussed in Chapter 1. Similarly, there is a lack of connection to organizational change and leadership (these aspects are typically focused on business related fields) which may help bridge the gap between the educational pipeline issue and employment retention issue debate also discussed in Chapter 1 (John & Carnoy, 2019).

Linking to the prior point raised, there is a gap in the presence of retrospective studies, seeking feedback from minority participants on their educational and professional experiences in C-STEM fields and how those experiences may have influenced how they navigated the field. This also emphasizes the need for qualitative studies which share the lived experiences of participants. Many studies in the CS and broader C-STEM space are quantitative which provide helpful data connected to participant's learning experiences but cannot capture it in their words they way that qualitative methods (such as interviews or focus groups) can. Additionally, studies that

may take a qualitative approach are not able to present the statistical grounding that is characteristic of quantitative research reporting. Thus, the researcher's utilization of an integrated approach to C-STEM in this study could support bridging methodological gaps in existing literature.

Chapter Summary

In Chapter 2, literature central to the field of computing education was presented within the themes of access, equity, and diversity. An overview of the literature followed with connections between computer science education and parallel C-STEM fields, such as engineering, to provide a broader scope for the current study. Study context reintroduced the reader to the two overarching research questions. The conceptual framework provided a pathway for the reader to review the study under the researcher's lens which takes an organizational change approach to reviewing inequities of the topic. The Community Cultural Wealth model (Yosso, 2005) provided a foundation for Chapter 2 discussion as well as for the overall study.

Subtopics of cultural presence, education pipeline challenges, participation and access were discussed. The concept of technological identity was also introduced with a follow up discussion of intersectionality to prepare the reader for a more detailed discussion on the central research question points of access and equity. The CCW model framework was highlighted with a discussion of existing literature from researchers who also utilized the framework to emphasize the cultural assets of marginalized students in dominant leaning environments. Here the various areas of capital in the CCW model were discussed in detail: aspirational, familial, navigational, social, linguistic, and resistant.

Global implications are explored to emphasize the greater issue of computing educational equity and the technological workforce. Furthermore, conceptualization of the literature provided readers with the perspective of computing learners as leaders as opposed to their traditional follower role in the learning environment. The author poses equity and access as an organizational change issue with potential to be addressed in the context of top-down, bottom-up leadership approach. The chapter concludes with an overview of gaps and inconsistencies identified in the literature.

Chapter 3: Research Design and Methodology

Chapter Overview

Chapter 3 reviews research questions of the study in alignment with the study purpose and research methodology and design utilized to examine the research sample. Discussion of human subjects consideration, instrumentation, validity, and reliability help to ground the overall study design. Data protocols are reviewed in description of the data collection, data management, and data analysis. Lastly, a plan for the reporting of Chapter 4 findings will be presented. The chapter concludes with a summary of the above.

Introduction

The purpose of this quantitative ethnographic study is to explore the impact of cultural capital in the C-STEM learning experience of female learners of color as it relates to perceived access and equity in their field studies. Participants who self-identified as female were asked about the impact of cultural capital, if any, on their learning experiences. Analysis of participants' responses will examine any further impact of their current professional experiences. This retrospective impact study examines any long-term impact that participants' cultural capital in C-STEM education may have had on their career development.

The overarching research questions in this study is as follows:

- RQ1: What aspects of cultural capital, if any, have an impact on the perceived access of female C-STEM learners of color?
- RQ2: What aspects of cultural capital, if any, have an impact on the perceived equity of female C-STEM learners of color?

Theoretical Framework

The theoretical framework (see Table 1) serves to ground the study and guide the research process. According to Rocco and Plakhotnik (2009), "[t]he importance of any study is demonstrated through the linkages made between research questions and larger theoretical concepts or policy issues" (p. 121). This study employs CRT (Crenshaw 1988) which is a derivative of critical theory. The CCW model described in Chapter 2 was built upon the foundation of CRT. Through extensive focus on the participant's race, gender, and ethnicity as central to their lived experiences, the researcher can support the significance of this research through their voices.

Table 1

Theoretical Framework

Purpose	
The purpose of this research study is to explore the impact of cultural capital in the C-STEM learning experiences of female learners of color as it relates to perceived access and equity in their field studies.	
Goal	To explore
Approach	Qualitative
Worldview	Interpretivism
Methodology	Phenomenology
Methods	Questionnaire; Interviews
Tools	Adobe Acrobat; Calendly; Epistemic Network Analysis

Note. Author's own work based upon Conceptual Framework for Theoretical Frameworks (Jago, 2023) shows the theoretical framework that was applied to conduct this research study.

Research Design

Purpose and Approach

Discourse analysis is rooted in phenomenology through its examination of language for the interpretation of lived experiences (Miles, 2010). The analytical nature of this approach allows for the participants' language to be explored in a social context which can be deconstructed in efforts to empower their voices.

Worldview

The researcher's worldview identifies most closely with interpretivism. Some texts refer to interpretivism as social constructivism which indicates a quest to understand the world in which one exists and meaning is made based on experiences (Creswell & Poth, 2018).

Creswell and Poth (2018) indicate that "[t]he more open-ended the questioning, the better, as the researcher listens carefully to what people say or do in their life setting" (p. 24). This aspect of the worldview is essential to the data methods selected for this study. Interpretivism is reflective in nature. Since this study explores how culture impacts individuals' education and careers, it is imperative that the researcher take her own background into account when conducting the study. Creswell and Poth (2018) offer the following in terms of researcher interpretation in qualitative research study:

> Researchers recognize that their own background shapes their interpretation, and they 'position themselves' in the research to acknowledge how their interpretation flows from their own personal, cultural, and historical experiences. Thus the researchers make an interpretation of what they find, an interpretation shaped by their own experiences and background…The researcher's intent,

> then, is to make sense of (or interpret) the meanings others have about the world. (p. 24)

Reflection under this worldview will be significant to the data analysis process. Discussions of validity in this chapter will review plans to address research bias.

Methodology

This qualitative study is aimed at identifying any impact of cultural capital on the learning experiences of female-identifying C-STEM learners. As a retrospective study, the researcher sought to explore the impact of participants' cultural backgrounds on their educational and career trajectories in computing. Data collection entailed analyzing interviews through discourse analysis.

Methods

Semi-structured interviews were conducted using an interview script (see Appendix A). Interview data was transcribed using the Zoom audio transcription feature. Transcript data was converted into an Excel spreadsheet designed to align with a code book created by the researcher. Three researchers (the researcher and two coders) independently coded the data then collectively reviewed the data in a determination to reach a consensus of the discourse phenomena. This process is referred to as inter-rater reliability (Multon & Coleman, 2018).

Tools/Instruments Used

The Epistemic Network Analysis (ENA) webtool, and online database, was employed to analyze content gathered from participants' interview discussions. The ENA webtool ensures a network analysis of qualitative interview data. ENA also

provides researchers with a method of visualizing data to determine patterns in participants' discourse. (See figures in Chapter 4 for data visualization.)

Statistical analysis is integrated into the visualization technique. Furthermore, "ENA models the connections among relevant constructs in the data by quantifying the frequency of their co-occurrences within conversations" (Shaffer, 2017; Wright et al., 2021). ENA has been utilized by researchers examining related topics such as college access, cultural learning practices in Indigenous education, and gender differences in identity development of STEM learners (Donnelly, 2022; Akumbu, 2022; Espino et al., 2022) which align with significant issues connected to the worldview and theoretical framework of this study.

Sample and Population

Data Sources

Interviews were conducted from March 2023 to July 2023 for the purpose of providing data for the researcher. Twenty contacts were made directly with potential participants through email and LinkedIn. The researcher reached out to twenty-two network contacts for leads. Study participants were also asked if they were able to suggest lead recommendations.

Population and Sampling Processes

The population for this study were individuals who identify as women of color and are college graduates over the age of 18 years old. Participants within this population obtained a degree in computer science or related fields at a U.S. institution. While most participants were currently practicing professionals in the field (academia or industry) or

had done so prior to a career change, it was not a requirement for participation. A recruitment sample of 15-20 women was anticipated.

Sixteen participants expressed interest in being interviewed for the study. Fifteen participants (*n* = 15) were interviewed. One potential participant participated in an interview but revealed after the start of the interview that she did not complete her degree in the C-STEM field of her occupational background in computing. Data from this interview was not analyzed and the potential participant is not included in the total count (*n* = 15) of study participants.

Inclusion criteria required that participants identify as people of color and have completed an undergraduate degree or higher in the discipline. Participants were recruited by the researcher's outreach via LinkedIn and email. Participants provided their email address to the researcher for further communication. The researcher utilized participants' LinkedIn profiles to ensure that they met the academic degree inclusion criteria for the study. Additionally, participants were asked to confirm their degree information via email.

Additional inclusion criteria will require that participants of the study be 18 years or older and hold a bachelor's degree in computer science or a related field. The following exclusion criteria will exclude participants under the age of 18 years old, do not hold a bachelor's degree in computer science (or related field).

Female C-STEM (Computing, Science, Technology, Engineering, and Mathematics) degree holders were recruited through LinkedIn and the researcher's university email. The researcher advertised the study through a post on the platform

along with a flyer attachment. A total of six individuals on the platform reshared the recruitment post.

Participant selection was based on a purposive sample. According to Galvan & Galvan (2017), “[p]urposive samples are selected based on the careful judgment of the researchers regarding the types of individuals they consider to be especially good sources of data for a particular research topic” (p. 82). In addition, the snowball sampling method was utilized to recruit additional participants to meet the researcher’s goal of 15-20 interviews conducted by the end of the study. The snowball sampling method created a pool of potential participants (Crouse & Lowe, 2018) through existing participant referrals. Additional efforts to create a purposive sample included pre-screening participant profiles and reaching out to contacts with professional connections in the field. These steps ensured that inclusion criteria were met prior to potential participant outreach.

The recruitment flyer (see Appendix B) was posted on LinkedIn for public view. Share settings were enabled so that community members were able to share the digital flyer with their networks. The researcher also shared the recruitment flyer as an email attachment with extended network contacts to expand reach. The flyer informed interested parties to contact the researcher via LinkedIn messaging if they were interested in participating in the study. Likewise, the researcher also contacted potential participants and network contacts via LinkedIn messaging, including the recruitment flyer as an attachment, in effort to maintain a purposive sample.

Those who expressed interest in the study were sent an email with study details and the consent form. Potential participants who were referred by a mutual contact were

sent a copy of the recruitment flyer in addition to the consent form. All potential participants who were sent the interest email also received a link (within the email message) to the researcher's schedule via Calendly. The Calendly link allowed individuals to select a mutual time of availability for their video interview. They were encouraged to contact the researcher directly to schedule an alternative time if no times in the scheduling tool fit their availability. Once the interview was booked, a Zoom meeting link was included in the calendar invite.

Participant's email addresses were stored on a password-protected electronic spreadsheet which could only be accessed by the researcher. Phone numbers of the participants were not collected. The researcher utilized her Pepperdine University email to contact participants. The university email system is password protected and requires a two-factor authentication system for login.

Human Subject Considerations

Institutional Review Board (IRB) approval was obtained from Pepperdine University see Appendix C). The researcher filed for Expedited review which includes email and internet communication as well as data collection via video and voice recordings. Participants were informed that their participation in the study was voluntary. The researcher sought permission from the recruitment site, LinkedIn, but was informed that it was not a requirement for posting on the platform.

Risks of participation were minimal and may have included the potential for participants to recognize disadvantages due to race/ethnicity and gender. Additional risk included fatigue experienced during the overall study and time commitment of the interview. Participants were made aware that there were no correct answers and that

they could withdraw at any time. Specifying this information provides a precautionary measure to “ensure informant honesty and the involvement of genuinely willing participants” (Samuelson & Litzler, 2016, p. 99).

Benefits of participation may have included the potential for participants to recognize advantages due to race/ethnicity and gender. The benefits to research science and society may include better understanding of how to support female identifying individuals pursuing degrees in computer science and related fields. An additional benefit may include a better understanding of the role of cultural capital (i.e., familial and social support systems) in the educational journeys of female individuals pursuing degrees in computer science and related fields.

There was no perceived deception in this study. Also, there was no anticipated risk of harm associated with this study. Participants received minimal monetary compensation in the form of a $15 Starbucks gift card for beginning the interview. There were no potential conflicts of interest to the researcher’s knowledge.

An informed consent form for the study was approved by the university IRB. The consent was sent to subjects via email. They were asked to return the completed electronic copy prior to their interview. The informed consent described the nature of the study, benefits of participation, and confidentiality. Participants were also made aware of how their information will be retained. The researcher collected consent forms electronically via direct email with each participant. Participants were also given the option to sign the consent form (see Appendix D) via e-sign. An e-signature formatted document was sent via Adobe Acrobat upon request.

Participants' names have been changed in the study to keep their identity confidential. The risk of a potential breach of confidentiality was minimized by the researcher through ensuring that only she had access to all files containing identifiable information of the participants. The researcher's computer is protected by a facial recognition system, ensuring that only the researcher was able log into the computer to access data collected for the purposes of this research study.

Instrumentation

Instrumentation for this study involved interviews to collect data.

Interviews

Data collection for the current study was gathered from semi-structured interviews. Virtual interviews consisted of fourteen open-ended questions adapted from the Gonzalez (2019) research study. The researcher began by verifying the informed consent of each participant. Once consent-related questions were reviewed and confirmed by the participant, the interview began with five introductory questions. Eight CCW-related prompts followed, covering the various areas of capital examined in the study. The interview concluded with an open-ended question inviting participants to share any additional information that was not discussed in response to the interview prompts. Confidentiality was maintained for the interview by setting up each interview with a password protected Zoom link.

Validity and Reliability

Validity and reliability are central to the foundation of sound research studies. Creswell and Poth (2018) have presented validation in qualitative research as "an evolving construct [which utilizes] a broad understanding of both traditional and

contemporary perspectives [as] essential for informing the work of qualitative researchers and readers of qualitative research" (p. 254). The ENA webtool allowed for validation through the thick, rich descriptions provided by (see Figure 9 under *Tools/Instruments* Used subsection) analysis output. The interconnected nature of constructs displayed in graph visualizations emphasize prevalent codes in the data and their relationship to one another (Siebert-Evenstone et al., 2017). Additionally, previous research utilizing ENA suggests consideration of the temporal patterns of data within various contexts (Csanadi et al., 2018). This variation supports the need for additional coders to validate the researcher's review of the data. Thus, the inter-rater reliability provided by the second and third coders allowed for external audit through the coding process.

Reliability measures were achieved through intercoder agreement (Creswell and Poth, 2018). Under this process the two coders created and revised a codebook through an iterative process based on the transcript content. Triangulation of data in this study were evaluated through the sources of a codebook (as defined by the two coders), interview transcripts, and thick, rich descriptions provided by ENA figures indicating connections between constructs.

Data Collection

The anticipated response rate was 75% which accounted for a minimum sample size of fifteen respondents for interviews. Email reminders were sent directly to individuals who agreed to participate in the study. The recruitment timeline was extended to obtain the minimum sample size.

Interviews

Interviews were utilized for this study with the purpose of accounting for the culturally significant lived experiences of female learners in their educational endeavors in computer science and related fields. Interviews were conducted across the span of 14 weeks.

Procedures for Interview

The researcher scheduled interviews via email with a Calendly link for participants to select from a list of day and time options. Each interview lasted for approximately one hour but varied depending on participants response time to each prompt. Each participant met with the interviewer via the Zoom online meeting platform. A Zoom account is provided by the researcher's institution. Participants were made aware that interview audio was required for transcription purposes. Participants were reminded of their right to withdraw at any time and the objective nature of their responses in efforts "[t]o ensure informant honesty and the involvement of genuinely willing participants" (Samuelson and Litzler, 2016, p. 99).

A video recording was optional. Participants were provided an option on the consent form to select permission for video recording or audio only. Thirteen of the participants gave consent to be video recorded.

Participants were informed of confidentiality measures prior to beginning the interview. For instance, they were informed that they would be identified by a pseudonym in the study (i.e., "Participant 1") instead of their name. Participants were also informed that they could be provided a copy of the final study manuscript once available.

Data Management

Paper files (i.e., notes, printed transcripts, etc.) were kept in a locked file cabinet at the researcher's home. Only the researcher had access to the data. Video and audio files from the interviews were stored on the researcher's computer which is password protected and requires facial recognition of the researcher for access. Study data will be stored for at least three years by the researcher and will not be shared. After the third year, the researcher will archive the data and submit a request to the institution's IRB for the data to be reused in the future. This information was shared with participants in the informed consent.

Data Analysis

Research questions were revisited with results of network analyses showing connections between constructs. Interview data served as the source for network analysis. Participant responses that aligned with final themes supporting the research questions were utilized to support Chapter 5 discussion points. Semi-structured interviews were analyzed through discourse analysis using the QE method of analysis. Transcripts of interviews were accessed through the Zoom transcription service for the researcher to reference after the interview. Transcriptions were edited by the researcher for grammatical, translation, and other system interpretation errors. Transcript manuscript revisions were saved to a Word file.

Transcript text was imported onto an Excel spreadsheet for the three coders to analyze segments of the interviews. A separate Excel file was created for each interview. The researcher created a codebook based on Yosso's (2005) CCW model, indicating a code for each type of CCW capital evaluated in the study: aspirational,

familial, social, and navigational. Additional codes of access and equity were derived from the research questions. Three emerging codes of cultural, financial, and spiritual resources emerged from the data.

The researcher made various iterations to the codebook. Initial iterations were reviewed with an experienced researcher in effort to reduce bias and maintain neutrality with the codes. Feedback for the codebook was also provided by the second and third coder as the data continued to be evaluated. Interview data was analyzed through the ENA webtool. Embedded in the webtool is software to account for statistical procedures.

Means to Ensure Study Validity

Methods to ensure validity included interrater reliability in which coding was conducted independently by three raters. Through the process of social moderation, the second and third raters each met with the researcher (first rater) to review their interpretations of the data for their assigned interviews of review. Raters then reached a consensus on the coding of participant's utterances. This helped to mitigate any potential bias of the researcher.

Chapter Summary

Chapter 3 detailed an overview of the research study's research methodology and design, interpretive theoretical framework, participant sample information, and human subjects considerations. Validity and reliability considerations were discussed in efforts to ground the study. Implementation of Chapter 3 measures will be further discussed with the Chapter 4 presentation of findings.

Chapter 4: Presentation of Findings

Chapter Overview

Chapter 4 presents findings related to the impact of cultural capital on the learning experiences of C-STEM female learners of color and their perceived access and equity in field studies. The study includes participants in the disciplines of computer science and related fields. The researcher expanded the participant demographic to C-STEM to include the experiences of female learners in overarching related fields such as applied mathematics, engineering, learning design and technology, and physics.

Overarching research questions and the study's purpose will be revisited to indicate how the researcher's exploration of the topic evolved from the proposal stage to data collection and analysis phases of the study. Interview protocol and interviewee profile information is shared to provide context to the fifteen participants involved in the study and the discussion items that guided the researcher's semi-structured interviews with them. Chapter 4 content will explore prominent connections between codes and qualitative data as indicated by participant utterances in italics. The chapter will conclude with a summary of 5 key findings to be discussed in further detail in Chapter 5.

Context

The purpose of this research study is to explore the impact of cultural capital in the C-STEM learning experiences of female learners of color as it relates to perceived access and equity in their field studies.

The overarching research questions that guide this study are as follows:

- RQ1: What aspects of cultural capital, if any, have an impact on the perceived access of female C-STEM learners of color?

- RQ2: What aspects of cultural capital, if any, have an impact on the perceived equity of female C-STEM learners of color?

Interview Protocol

A total of fifteen interviews were conducted via Zoom. Each interview lasted between 30 and 50 minutes. The following fourteen items formed the interview protocol. Interviewees were not given the protocol in advance of the interview:

- IQ1: What has been your academic pathway since high school?
- IQ2: Tell me about the educational history of your parents/guardians (if known).
- IQ3: Tell me about the educational history of your grandparents (if known).
- IQ4: When did your computer science [or related field] learning journey begin?
- IQ5: How do you self-identify?
- IQ6: What were your hopes and dreams for your education as related to computer science [or related field]?
- IQ7: Tell me about other influences or people who had hopes and dreams for your learning journey into the computer science [or related] field.
- IQ8: How have you navigated your learning journey in the computer science [or related] field?
- IQ9: Tell me about experiences from your culture that helped you to navigate your learning journey in the computer science [or related] field.
- IQ10: What kind of support, if at all, did your family provide in the beginning of your computer science [or related field] learning journey?
- IQ11: What kind of support, if at all, did your family provide as you continued your computer science [or related field] learning journey?

- IQ12: In what ways, if at all, did your community influence or support your decision to pursue your learning journey in computer science [or related field]?
- IQ13: Tell me about any community resources that might have supported you through your learning journey in computer science [or related field].
- IQ14: Tell me about anything that we have not discussed that you would like to include.

Interviewee Profiles

Table 2 lists degrees represented in the study as connected to C-STEM disciplines and career paths. Participants self-identified in the general race/ethnicity categories of Black/African American, Hispanic, and Asian American (see Table 3). A range of familial education levels (parents/guardians and grandparents) were represented, causing the participant pool to range from first-generation to third-generation college students.

Table 2

Degrees/Career Emphases Represented in Study

Degree Type	Total
Bachelor's Degrees	
Computer Science	6
Computer Information Systems	1
*Engineering	4
Physics	2
Non C-STEM	3
Graduate Degrees	
Computer Science	3
Technology Focus	2
Learning Design and Technology	1
Organizational Leadership Focus	3
Business Administration	2
Non C-STEM	2

Table 3

Race/Ethnicity Breakdown of Study Participants

Race/Ethnicity	Total
African American/Black	11
Latinx/Hispanic	3
Korean American	1

The U.S. Department of Homeland Security (DHS) STEM Designated Degree Program List was utilized to guide qualifying degree selection for the study (DHS, 2022). Participants were also considered qualified if they were working in a technology career field, even if their degree was in a general discipline (i.e., organizational leadership) to provide a diverse perspective of women of color in C-STEM. The latter applied to only one participant who received additional education connected to computer information systems.

Codebook

The codebook was developed in six iterations with four aspects of the CCW model framework (Yosso, 2005) serving as a foundation. The researcher established codes and sought the support of two coders (in addition to herself as a coder) to ensure reliability and validity. Codes were continuously evaluated throughout the interview process to ensure accurate representation of the data. Two codes of access and equity were established based on the study research questions. Four codes of aspirational capital, familial capital, navigational capital, and social capital were a priori codes that stemmed from the CCW model framework.

The six prior mentioned codes were divided into promoting and limiting subcategories to account for participants' positive and negative experiences with the

codes, respectively. Three additional codes of cultural resources, financial resources, and spiritual resources emerged from the data to support connections between the research question elements of access and equity and the four a priori codes. Table 4 provides an abbreviated version of the codebook, including the definitions developed throughout various iterations of the codebook. See Appendix E for a detailed version of the codebook including examples in the participants' own words.

Table 4

Abbreviated Codebook for Wright Study: Cultural Capital and C-STEM

Construct	Definition
Research Question Umbrella Areas	
Access	Resources made available to the learner (i.e., educational/learning resources, acquired learning, early outreach programs, enrichment programs, educational organizations, etc.) for them to obtain their education.
Equity	Equality of resources and support mechanisms made available to the learner (i.e., educational, social, *gender*, etc.) for them to obtain their education.
Emerging Areas of Capital	
Cultural Resources	Established cultural groups designed to promote underrepresented groups (i.e., Black professional societies- NSBE; HBCU institutions); Communities sharing same (or similar) cultural identity.
Financial Resources	Any discussion regarding finances along the learners journey or in preparation for future career opportunities; Educational resources provided.
Spiritual Resources	Inspiration or reliance on a higher power to press toward achievement in the learning journey; Internal guidance or soul-searching.

Construct	Definition
CCW Model Areas of Capital	
Aspirational Capital	The learner's aspirations for their education or aspirations that others have for them.
Familial Capital	Family experiences, cultural beliefs, knowledge, etc. that prepare the learner as they pursue their education.
Navigational Capital	How the learner navigates their learning journey with the assistance of possible resources. Their lived experiences of the journey (positive or negative). Connecting with others to get resources or answers.
Social Capital	Social/community supports that assist the learner throughout their learning journey.

Findings

The researcher utilized the ENA webtool (refer to Chapter 3 procedures) to conduct a network analysis. Coded spreadsheets for each participant were converted into Excel spreadsheet files for data cleaning. A cleaned master file including data for all fifteen participants was uploaded into the ENA webtool for analysis. Information about the goodness of fit is included with each model in the results. The goodness of fit utilizes "a comparison of the observed data with the data expected under the model using some fit statistic" (Kéry & Royle, 2016, p.589). For this study, the statistical tests automatically run by the ENA webtool were Pearson and Spearman correlation coefficients.

The researcher will report these statistical results with the ENA models throughout Chapter 4 to illustrate how statistical measures are utilized for the reliability of qualitative data under quantitative ethnography. Each node represents a coded construct in the study. The lines linking the nodes indicate the connection strength

between each construct in the conversation. A thicker, saturated line between the nodes indicates a stronger connection. In contrast, weaker connections are indicated by thinner lines between the nodes. Lines between nodes represent the frequency between linked codes in the various participant interview conversations. For instance, constructs that were coded simultaneously at a high frequency across interviewee utterances are illustrated by a thicker, saturated connection line.

A moving stanza window of the whole conversation was utilized to capture key response data shared in each question response. Question responses were recorded by question number. This allowed for participant utterances to be examined across the entire interview as responses to various questions may have resulted in multiple codes being identified in the coding process. Note that utterances are shared in the participants' own words, some containing informal language that could be considered grammatical incorrect. The researcher is intentional about sharing utterances in the voices of participants as to not take away from their lived experiences which are vital to the study.

Overarching ENA Model

The overarching ENA model in Figure 2 indicates connections between the research question topics of access and equity compared to the four coded constructs of the CCW framework model. Specifically, the overarching model indicates the strongest connections (represented by thicker lines) between promoting aspirational capital, promoting social capital, and promoting navigational capital in connection with promoting access. Connections to promoting equity are not as apparent in the model. Hence, lines linking to equity constructs are thinner, indicating less connection. It is also

necessary to note that promoting codes fall to the right of the y-axis of the model. (See Table 5 for Goodness of Fit details.) Such could indicate the increasing trend in the promotion of access and equity as other areas are supported in an increasing manner.

Figure 2

Overarching ENA Model

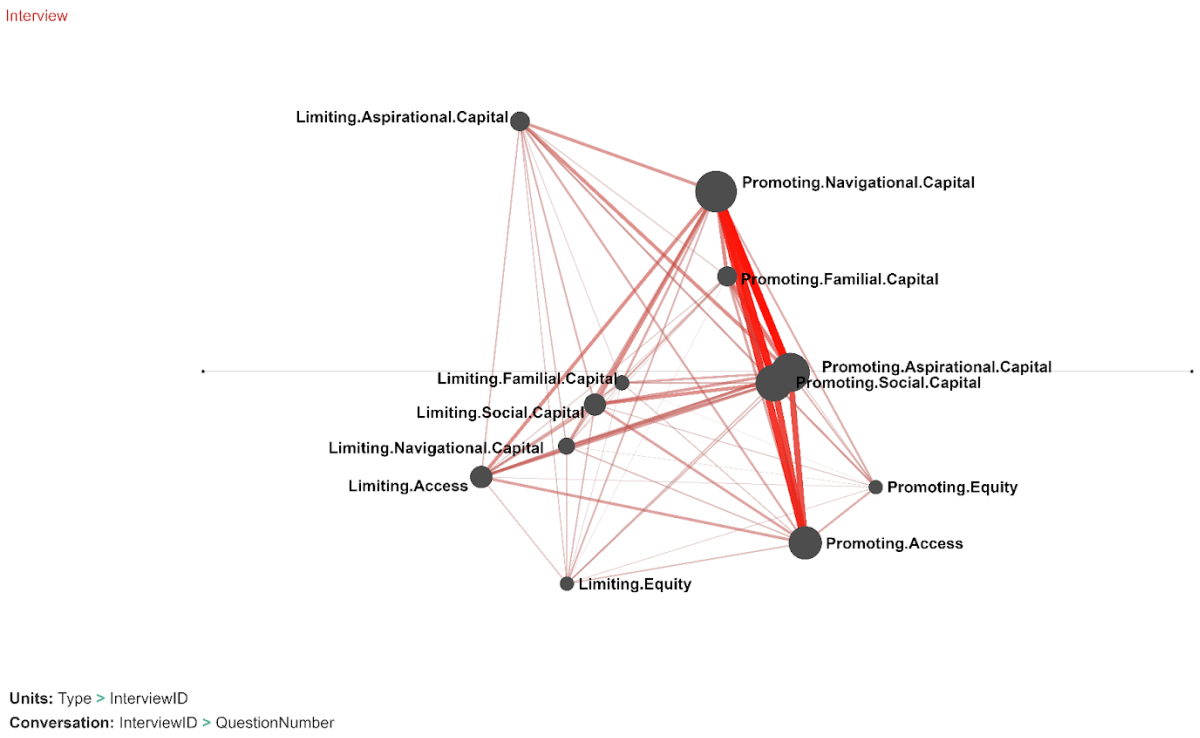


Table 5

Goodness of Fit: Access and Equity Overarching Model

Axis	Pearson	Spearman
X	1.00	1.00
Y	1.00	1.00

Access Overarching ENA Model

Under the access overarching model in Figure 3, a strong relationship between the constructs of promoting navigational capital, promoting social capital, and promoting

aspirational capital appears in connection to promoting access which is indicated by thicker connection lines. While not as strong, yet worth noting, the limiting access code shows slight connection to the same three promoting capital codes as indicated by thinner lines between the node connections. The promoting codes fall toward the right of the y-axis in this model, while limiting codes fall to the left. Table 6 notes Goodness of Fit details of the access model.

Figure 3

Access Overarching ENA Model

Table 6

Goodness of Fit: Access Overarching Model

Axis	Pearson	Spearman
X	1.00	1.00
Y	1.00	1.00

For instance, the strong connections between promoting navigational, social, and aspirational capital codes are represented in data accounting for the responses of Participants 1 and 13 when asked questions about the two construct areas. Both participants recalled how educated figures in their networks shared various information and resources contributing to access in the learner's journey. Participant 1 stated

> I don't feel like I would have been able to navigate through computing at all without the community that I did have in that bubble of a space. And so, there were many times where we were staying, spending the night in the [HBCU school] Science Center at school because we were really up like forming groups and studying for these exams.
>
> We really lean[ed] on each other a lot because with computing, it's not like natural. So, a lot of it is very abstract, and it's not second nature to understand. And I feel like the culture of computing is like: just look at this textbook that walks through these examples. But there's no substance to that, you know. So, we kinda [sic] had to fill in those gaps for each other. And so, I really, I think, in navigating I just leaned on people a lot.

Participant 1's account indicates how social and navigational capital had a positive impact on resources which provided access during her learning journey.

Additionally, the learners' encouragement of one another promoted aspirational capital for Participant 1. Participant 13 shared a similar account:

> And then, I think once it was even a neighbor to another neighbor who was in the medical field who convinced me that like no, you don't need to just stick with your same internship that you were gonna [sic] do. That I had been doing, you know, summer after summer in undergrad. But, he said, you know, I really think you should pursue this opportunity in [state] because at least it gives you a chance to do something different.
>
> And that was, of course, very pivotal, you know, for me, for me as well. So, I'll say then once I did the internship, Dr. [faculty name] ... Like, I remember him setting out like he had like a paper plate, and he drew out a map of the country… to show me where the top computer science programs were.

As illustrated by Participant 13's account of her mentor sharing his knowledge of top graduate CS programs, the learner gained access to academic resources through a social network, which encouraged her pursuit of advancing her education. Additionally, her account of both her mentor and neighbor provided examples of individuals who shared their resources because they believed in her future aspirations.

Equity Overarching ENA Model

While not as notable as is the case with promoting access, the promoting equity code does show some slight connection (indicated by thinner lines) to the promoting codes of aspirational, navigational, and social capital areas (see Figure 4). In the equity overarching model, it is more apparent how all four constructs of the CCW model have a connection to one another. The constructs of aspirational, familial, and social capital,

along with the code of equity, fall closely together under the x-axis. (See Table 7 for complete Goodness of Fit details for the model.)

Figure 4

Equity Overarching ENA Model

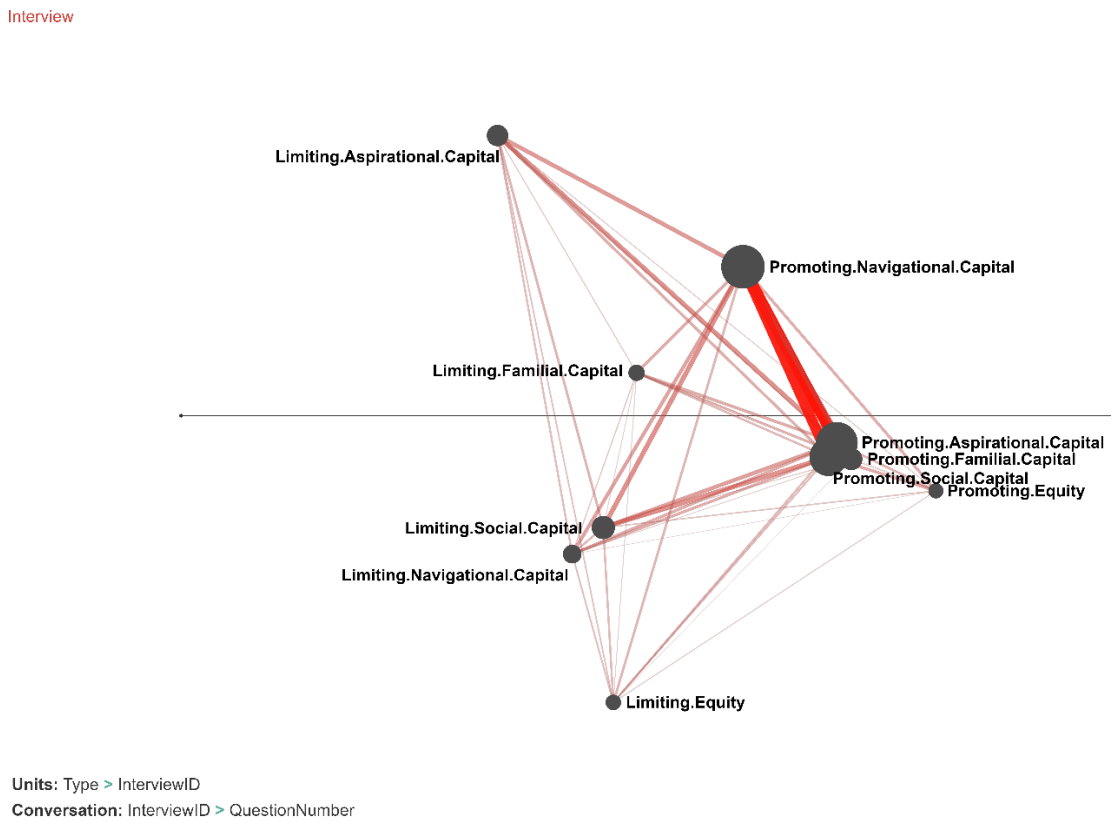


Table 7

Goodness of Fit: Equity Overarching Model

Axis	Pearson	Spearman
X	1.00	1.00
Y	1.00	0.99

For instance, the strong connection between the four capital codes is illustrated in the case of Participant 9. She discussed how advocacy and mentorship helped her to

navigate her learning journey in hopes of more equitable outcomes. She also spoke about the social support that she was able to seek out and later provide for other underrepresented minority students in her field of study. Her experiences also reflected aspirations of wanting to provide more equitable opportunities for other Black women in her department. Participant 9 shared

> So I would say that I've had to do a lot of self-advocacy. So I've had to oftentimes point to the problems that are faced by underrepresented minority students and then ask departments to address those problems. So I think that that's like one of the key components. And how I've had to navigate math and physics is I've had to like be intentional about communicating to departments and advisors and professors about my specific needs or lack of support and then being pretty aggressive at advocating for continued support for me and people who come up behind me. And that is yeah, part of it is advocacy.
>
> Part of it has been mentoring. So I've been intentional about like my first day in college, I met a woman of color physicist who ended up mentoring me until very recently, when she passed away. But basically, I've had every step of the way when I have to engage like a new department or a new system, I have to kind of pre-vet it by identifying people who will be specifically supportive of Black women. And then I identify those people and I get connected with those people. And then I, I basically end up maintaining a connection with them throughout the navigation. And so when I'm making decisions, when I am like trying to pass through all the hoops that we have to pass through for the PhD and things like

> that I am running everything by them, and also sometimes like challenging them to be more supportive, things like that.

Similarly, Participant 3 expressed reliance on social support in connection with seeking equity for herself and other women with similar identities which supports the strong connections seen between the promoting social and promoting equity codes. The pursuit she described, in reference to equity, also indicates a connection to how she navigated her pathway. Participant 3 offered

> Yeah, I really was very set on not necessarily following a career ladder within engineering. I kept my options open. And when it became evident to me, after doing engineering for several years straight out of college, and actually being in the field with a hard hat with steel-toed boots. And being one of few females and even fewer females of color. Doing it day in and day out. I was prompted and compelled to reach out to senior management within the organization that I worked at and to point out that I didn't understand why there was such a gap and the pipeline of other Black female engineers in particular. Like I didn't understand why I was one of very few. Especially when I had been exposed during college to so many organizations like I just mentioned the Society of Women Engineers, the [National] Society of Black Engineers and it was always bustling with all this great talent. I just couldn't understand why there weren't more people like myself, Black female engineers, in corporate America.
>
> So when I approached senior leadership and I posed that question to them, they turned the tables and said to me, well, [name], if you want to see something change, you go ahead and make it happen. Luckily, they also

> sponsored me to an extent in supporting me, forming a women's network at that time, which allowed me to do just that. You know, to create a network that was supportive of women and creating more of a talent pipeline for that particular organization. So that is how I navigated my journey. I just sort of listened to my passion. And followed what I thought was the right thing to do in terms of posing a challenge to the organization that I worked with. And created a different pivot in my career from me actually doing the hands-on engineering work to being able to help recruit engineers within the organization.

Participant 3's account of seeking to promote equity for other women of color also provides an example of how the promoting aspirational code connects to the promoting equity code. The hopes that she shared in the discussion were driven by her desire to see more equitable representation in her work environment, displaying a discourse pattern reflective of the connections indicated in the equity overarching model.

Emerging Code ENA Models

The following three models (Figures 13-15) indicate data reflecting the emerging codes of cultural resources, financial resources, and spiritual resources in connection with the construct of access. Note that the construct of equity was not included in the emerging code models due to the results not being as prominent as access construct connections. Due to the researcher's necessity to report key findings of the study, the following emerging code models will focus on the access connections most relevant to codes that emerged through study data. Similarly, the familial capital code appeared far less frequently in connection with emerging codes than the other areas of capital. Thus,

reporting will highlight the more frequently appearing codes (indicating key connections) of aspirational, social, and navigational capital.

The emerging codes were developed as coders noticed trends in the discourse of participant interviews. For instance, many participants shared how organizations based on common racial/ethnic identities served as a key source of support along their learning journeys. The National Society of Black Engineers (NSBE) was a frequently credited organization amongst Black-identifying participants, especially those pursuing computer science and engineering fields of study. Other participants shared about how they developed their own support networks among colleagues of the same race in their professional environments. The frequency of these findings in the interview discourse led to the emerging code of *cultural resources*.

While the theme of cultural resources was very prominent in the data and established as a code, the code of *financial resources* also held a strong presence. Coders noted participants' frequent mention of financial resources that were recommended to them or monies that were received to advance their learning journeys. In the initial phases of coding the data, mention of financial resources was coded under the access code. However, the researcher found that the topic was mentioned so frequently in that data that it warranted its own code.

Likewise, the code of *spiritual resources* was established as some participants shared how their spiritual practices and faith journeys kept them grounded throughout their learning experiences in C-STEM. Conversations around spirituality evolved within the context of aspirational and social capital but participants who shared the significance of a higher power in their lived experiences provided unique perspectives

that could not be captured by the priori codes alone. The three emerging codes provide additional context as to how community cultural wealth is represented by the women in this study. As a result, connections were made between the three emerging codes, the two research question codes (access and equity) and three of the priori codes (aspirational, social, and navigational) which were developed from the CCW model.

Access, Aspirational, and Financial Connections

Prominent connections were found between promoting access and promoting aspirational capital as connected to financial resources for the learner, as displayed in Figure 5. The thicker lines between the promoting aspirational capital and financial resources constructs above the x axis, then financial resources and promoting access constructs falling just below the x axis, both indicate strong associations between the emerging and priori codes. (See Table 8 for Goodness of Fit details.)

Figure 5

Emerging Code ENA Model 1: Access, Aspirational, and Financial Connections

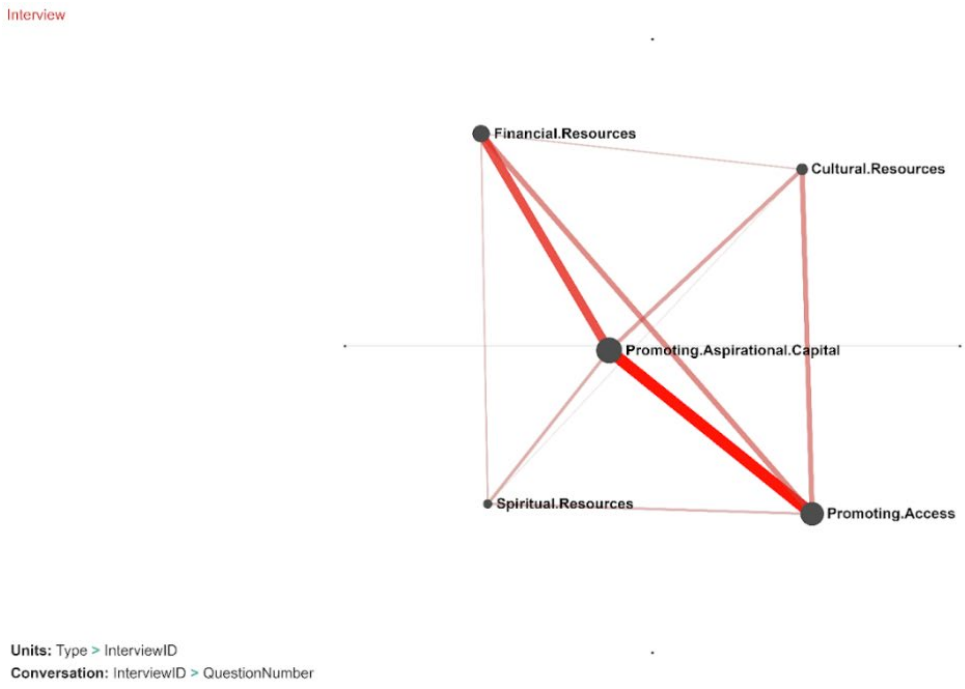


Table 8

Goodness of Fit: Emerging Code ENA Model 1

Axis	Pearson	Spearman
X	0.97	0.97
Y	0.99	1.00

For instance, a strong connection between promoting access and promoting aspirational capital is characterized through utterances shared by Participant 8. She credited her parents as individuals who aspired for her C-STEM studies. In addition to the hopes they shared for her career trajectory, they also encouraged her to identify resources to advance her journey. She later connected with a mentor who provided her with access to such resources which included financial means to pursue her studies. Participant 8 shared the following while reflecting on her journey:

> My parents, for sure, because even when I sat down to choose a major in college, I remember my dad was like, what do you want to do? And I said, I think I want to do psychology because that has to do with at least people and you know, helping people and learning about them. And he was like, that's not going to make you money unless you go to school for a lot of years. He was like, you're going to be a STEM major, pick something in STEM. And I initially picked chemistry, chemical engineering.
>
> But then, when I got into Timbuktu academy, and they gave me the scholarship, the director, Dr. [name], was like we have more money for physics. If you want to stay an engineering major, we might run out of scholarship money for you. But if you come to physics, we have all the money. And that switched me over to physics because he also made a good argument. He was like, it's the

> basis of everything, you could pretty much get a job in any type of STEM with a physics degree. And he was right. So he kind of pushed me too.

In continuing the discussion of strong connections between the promoting access and promoting aspirational capital codes, Participant 14 also shared how the promotion of financial resources shaped her journey in field studies. However, in her case, she was provided less access initially as related to where to obtain financial resources. Her mentors recognized her aspirations in the field and encouraged her to seek out her own funding to pursue her research interests. Participant 14 provided the following account regarding her path to financial access as a learner:

> And so when I went to grad school, my advisors try to like, put me on to like all these different projects. But I care about like outreach and doing this stuff. [They were] just like, yeah, yeah. Like, I don't care what you do as long as you get your own funding, right. Or she's like, if you get your own funding, I don't care what you do. And so that really encouraged me to go find my own funding. And that's when I started doing the [technology corporation] research stuff and the [funder] fellowships because, like I honestly, she kept giving me all these different projects like I'd be good at them. But like I just didn't care about them. And so then, once I got my own funding then I was like because even in my essay to the [funder], I was doing the evaluation of [educational level] outreach.

The above participant utterances also begin to touch on connections to the promotion of social capital and connections to emerging codes. This will be further explored in the following model.

Access, Social, Financial, and Cultural Connections

In Figure 6, the data illustrates strong ties between promoting access and promoting social capital in connection with the emerging constructs of financial and cultural resources. The thickest line between the promoting codes of access and social capital support findings that indicate connection between the learner's social network and the resources they were able to obtain (namely educational resources accounted for in the access code) from this network. Table 9 indicates Goodness of Fit details in connection to this model in which the constructs displayed indicate a central connection to the promoting access code.

Figure 6

Emerging Code ENA Model 2: Access, Social, Financial and Cultural Connections

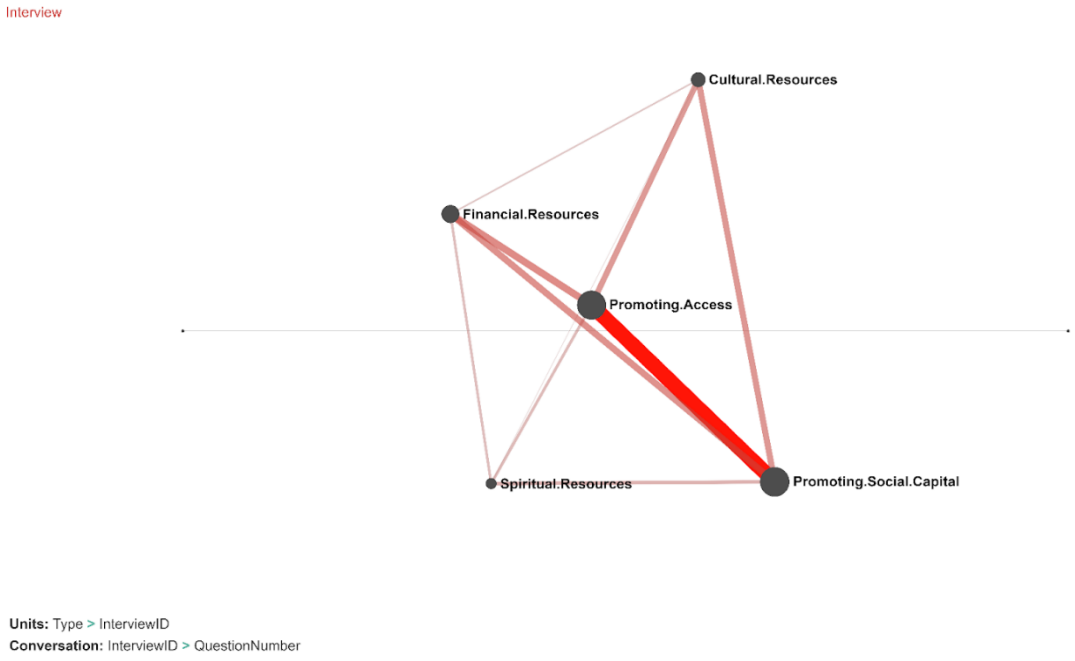


Table 9

Goodness of Fit: Emerging Code ENA Model 2

Axis	Pearson	Spearman
X	0.99	0.97
Y	1.00	1.00

For instance, Participant 2 described how members of her cultural group helped her to gain access and mobility in post-degree career pursuits. These results support the strong connections between the promoting access and promoting social capital codes seen in Figure 6. Participant 2 offered the following:

> And so then I ended up at [tech employer]. And so far, I've really leaned on the Black community within [employer]. So, thankfully in my first position, the senior engineer in the area was a Black man. And he mentored me through and like really taught me the ropes. It was a completely new technology prior to [what] I was doing… So it's, actually there were two Black men in that department who really helped me out.

Throughout her interview, Participant 2 continued to account for how members of her cultural community provided resources supporting her academic and professional advancement. Her story provides one example of similar findings among multiple participant interviews in that social networks created within members of the same culture fostered access to various financial resources.

In the case of Participant 15, she recalled how minority enrichment programs in STEM provided funding for students' work while also providing a supportive community of individuals with similar cultural backgrounds. She also described how the community

continues to rely on one another for access to resources and support in the advancement of their research careers. Participant 15 shared the following:

> And then support systems outside of that, I had a similar type of cohort programs when I started at [former university] for the PhD which had turned into the Masters. The NSF [National Science Foundation] bridges to the doctorate program through LSAMP [Louis Stokes Alliances for Minority Participation], like a minority participation program. That was super helpful because I had a cohort of people who came in with me…And we still keep, well for the most part, we also keep in touch with one another, which is nice. If we have questions about where to submit this paper, we want someone to review this, etc., we'll still tap into that network.

Data from Participant 15's interview also supports the notable connections between the promoting access and promoting social capital codes in Figure 6. Accounts from both Participants 2 and 15 also indicated the importance of cultural communities in connection with how they navigated their learning and early career journeys. This is described in further detail in the next ENA model.

Access, Navigational, Financial, and Cultural Connections

The following model in Figure 7 indicates how the constructs of promoting access and promoting navigational capital indicate strong connections to the emerging codes of financial and cultural resources in the data. (See associated Table 10 for Goodness of Fit details of the model.) While the thickest connection line in the model is illustrated between the access and navigational codes, it is necessary to note that the emerging codes of financial resources and cultural resources help to tell the story of why this

strong connection is the case. Many participants in the study reflected upon how they relied on peers within their cultural groups for various resources which included access to academic and career resources in addition to the presentation of financial support.

The concept of mentorship in connection with social networks was discussed earlier in this chapter. Specific to navigational capital, access, and financial resources, mentors from similar cultural backgrounds as the learner often encouraged them to pursue opportunities which the learner may have not realized was at their disposal had it not been for the mentor's exposing the mentee. While most participants described specific mentors who were influential in providing resources for academic and financial access in their journeys, some participants described how they were inspired by key figures who may not have provided direct mentorship but played a key role in their aspirations as women of color.

Figure 7

Emerging Code ENA Model 3: Access, Navigational, Financial, and Cultural Connections

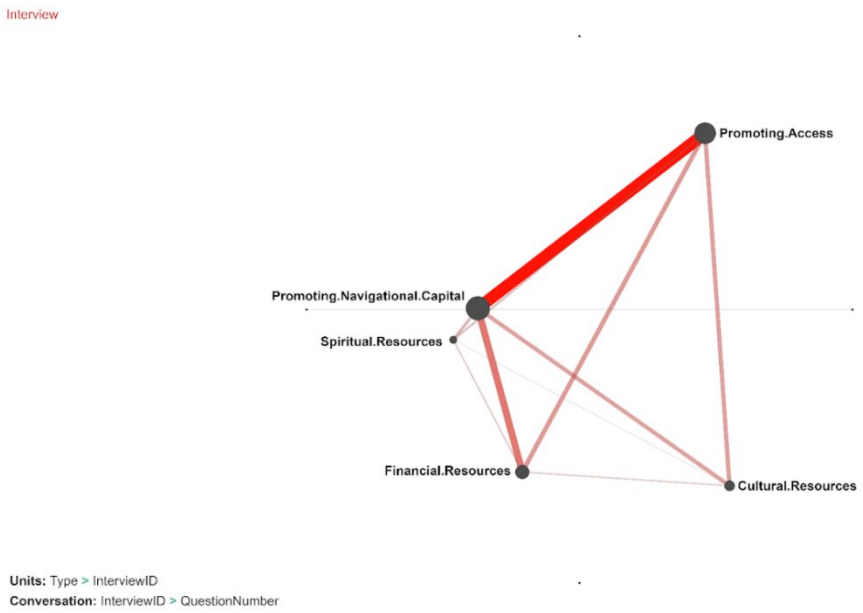


Table 10

Goodness of Fit: Emerging Code ENA Model 3

Axis	Pearson	Spearman
X	0.99	0.99
Y	0.98	0.98

For instance, Figure 7 displays the connection between the promoting codes of access and navigational capital as the most prominent linkage between codes displayed in the model. Data from Participant 4's interview narrative illustrates this exceptional connection. When asked about experiences from her culture that helped her to navigate her learning journey, Participant 4 shared defining points in which she gained inspiration from professionals and historical figures in her community. Below Participant 4 describes influential members in her journey.

> Growing up in an all Black city with all black teachers and Black doctors and Black churches, and Black well-educated parents. And being at an HBCU with Black professors, I never ever, ever had to face racism. I never ever ever [sic] was told I couldn't. I never was told that I was stupid. And so I was only told that I could, and that I should. And that the world was my oyster to accomplish whatever I wanted to accomplish. And so I was my high school valedictorian. My boyfriend was his class's valedictorian. We just egged each other on it's just like, you know, iron sharpens iron and so you just keep going.
>
> And so other things that helped were our high school principal was a Tuskegee Airman. We just, there are just role models all around us. So there was never a thought that you could not. My godfather was the first Black optometrist to graduate from [university]. My aunt was the first Black woman to graduate from

> [medical school] with an MD. I mean, just why not? Yeah. So I think that attitude of never ever being a victim and you just have whatever you need to do, whatever it is you want to do. I think that was the biggest help.
>
> And then also that was doubled by going to an HBCU and meeting Coretta Scott King and realizing that she is just a person. Meeting Edwin Moses and having Jesse Jackson register us to vote and meeting, you know, famous people. And just Black excellence was [city of university] and [HBCU schools]. And you just expected to rise to the top. So that, I think, was the environment that I grew up in, and then going down to [city of university] in the early eighties. That was just the Black mecca of achievement and elitism that was not there where I grew up. But both places where you can, you shall, you must.

In her interview, she went on to speak of how such inspiring social figures motivated her own career pursuits and how she wanted to be seen as a professional in her community. The above quote mentions how, in addition to indirect mentorship through key figures in her community, she also credited her partner at the time as a strong social collaborator within her cultural group. Participant 4's account supports results showing strong connections between access, social, and cultural elements. In terms of connection to financial resources, much of the access and inspiration gained from her community helped her, as well as other participants, advance in her.

Chapter Summary

Chapter 4 summarized the results of the study according to the two overarching research questions. The context and interview protocol sections revisited the study purpose and questions that the researcher asked of participants. A codebook for the

study was included to display definitions of each of the nine main codes utilized to analyze study data: access and equity; promoting and limiting codes for four areas of cultural capital- aspirational, familial, navigational, social; and three emerging support based codes- cultural, spiritual, and financial resources. Participant utterances were included to share qualitative data in support of the study findings. The following key findings have been selected for analysis. Study data indicate the following key findings (labeled numerically as F1, F2, etc.) as a result of interviewing participants:

- F1: There is a notable promotional (or positive) impact on the perceived access of female C-STEM learners of color in association with the promotion of aspirational, social, and navigational capital areas.
- F2: There is a low promotional impact on the perceived equity of female C-STEM learners of color in association with the promotion of aspirational, familial, social, and navigational capital areas.
- F3: There is a notable promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of aspirational capital as connected to reported financial resources.
- F4: There is a distinguished promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of social capital as connected to reported financial and cultural resources.
- F5: There is a distinguished promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of navigational capital as connected to reported financial and cultural resources.

These key findings will be discussed in Chapter 5.

Chapter 5: Discussion of Findings

Chapter Overview

Chapter 5 focuses on deep analysis of five key findings of the study. The conclusions and implications section steers the direction of future research for the researcher. Study limitations and recommendations are shared to provide insight into the existing literature and practitioner work in the study area. The researcher concludes with a reflection on the overall study to include an evaluation of her work and research journey.

Introduction

The purpose of this research study was to explore the impact of cultural capital in the C-STEM learning experience of female learners of color as it relates to perceived access and equity in their field studies. The overarching research questions that guided this study were as follows:

- RQ1: What aspects of cultural capital, if any, have an impact on the perceived access of female C-STEM learners of color?
- RQ2: What aspects of cultural capital, if any, have an impact on the perceived equity of female C-STEM learners of color?

The researcher utilized CRT (Crenshaw, 1988) as the conceptual framework for the study. Such allowed for the CCW model (Yosso, 2005), derived from CRT, to highlight the experiences of learners of color from an assets-based approach.

Findings

Five key findings were selected for analysis in this chapter. Key findings are labeled in numerical order as F1, F2, etc.

F1: Promotional Perceived Access and Cultural Capital

There is a notable promotional (or positive) impact on the perceived access of female C-STEM learners of color in association with the promotion of aspirational, social, and navigational capital areas.

Regarding the strong connection between access and aspirational capital, mentors were credited frequently when participants were asked who had hopes and dreams for their educational future. Specifically, many primary and secondary school teachers were celebrated for nurturing learners and providing advanced learning opportunities based on the abilities they displayed. Other mentors such as bosses, educated family friends, and professors challenged learners to pursue the C-STEM fields they excelled in while sharing supplemental resources to encourage their pursuits. Such resources included information about enrichment programs, financial opportunities (scholarships and grants), and access to internships.

It is also essential to note that most lines coded for aspirational capital in this study were due to the aspirations that others had for the learner. A heavy influence of others' encouragement and motivation (as noted in codebook definition) in addition to their own aspirations was noted in responses to the interview question asking specifically about the aspirations of others in their learning journey. In many cases the aspirations that others had for the learner were stronger than those in which they had for themselves.

In addition to mentors, family members also shared high aspirations for learners. Their shared encouragement was also accounted for in the promoting aspirational code. When speaking of emotional support provided by family members, many participants

described them as “cheerleaders” throughout the journey. In reference to familial capital, which addressed resources provided by the family to advance the learner’s education, many parents ensured that the learner received proper educational resources to advance in their journey. This was the case even when the family was not as knowledgeable about or experienced in the learner’s C-STEM discipline of study.

Parental advocacy in early education was also a common theme in the data. This tied back to aspirations in that many of the learners who may not have had early exposure to C-STEM fields initially were supported to pursue the pathway by others, such as mentors and parents, who had high aspirations for them. This finding is supported by Frazier’s (2020) research which emphasizes the increased self-efficacy of students who had early exposure to CS education. Higher self-efficacy was reported as well as more interest in continuing pursuit of the field as compared to peers who may have reported a lower self-efficacy in Frazier’s study.

In support of the increased access and aspirational capital findings, literature highlights the significance of teacher support for underrepresented CS learners. Ryoo et al. (2015) emphasize that teachers play a vital role in driving cultural change in educational institutions. Lehman et al. (2016) speak to how teacher support can encourage career possibilities for future educators in the CS space specifically. Yuen et al. (2016) emphasize the partnership between families and schools in which schools can provide families with tools for cultural capital in digital learning.

The examination of strong connections between access and social capital further emphasizes the presence of mentors also seen in the aspirational capital connection. Researchers such as Eyo-Idahor (2022) have found mentorship to have a notable

impact on social capital in particular which is consistent with the results of this study. Furthermore, social capital was coded frequently in connection to networks made with peers within and beyond the learning community. This finding indicates the ways in which peers can promote access for one another through their social networks. This point will be further discussed in finding four which examines strong connections between perceived access, social capital, and financial and cultural resources.

F2: Promotional Perceived Equity and Cultural Capital

There is a low promotional impact on the perceived equity of female C-STEM learners of color in association with promoting aspirational, familial, social, and navigational capital areas.

Less equity challenges were shared since the group of participants had high support and encouragement in their learning experiences overall. This indicates a connection to the literature in which Koch et al. (2019) found that high parental support specifically has been indicated to have a correlation with high persistence of female learners in STEM and for their developing a growth mindset in the field. Many learners in the study referred to parents and other family members as “cheerleaders” throughout their journey, championing them as females pursuing an education in C-STEM fields. Additionally, learners that reported more cultural support may not have needed equity from external sources to move forward because they had strong support systems within their cultural groups.

For instance, when asked about how she navigated her learning journey in C-STEM, Participant 10 responded with the following:

> So I didn't have to navigate anything. I was in a nurturing environment. I was in a nurturing environment with full scholarships. I [had] more scholarship money coming in than my schooling my tuition because every scholarship I applied for in college, I got. So I lived comfortably. I had amazing professors. I was in a tremendously nurturing environment because I was at an all-Black school…Oh, and I can say this. So when you say with me going to a Black school, that was intentional because I wanted to live and be educated in a black environment, period. Not even knowing that when I got there, how nurturing, and kind and respectful and fun, and just fantastic. And you were never a number. You were a name.

Her response supports the finding of CCW model-based codes having a minimal impact on equity because the learner's being was affirmed in her environment. Specifically, she was affirmed by being a part of an established cultural group (attending an HBCU institution) that placed a high value on her cultural background and surrounded her with learners of similar identities pursuing similar studies.

Participants who share examples of equity were coded most frequently with access and financial support codes. Therefore, direct connections were not made to the four areas of capital. It is also vital to note that the CCW model is formed upon an assets-based approach. Considering this, the presence of equity may be limited because the learner's assets are highlighted in the framework. Interview questions based on the CCW model may consider that equity is promoted for the learner through the various forms of capital, and any challenges faced along the journey could be overcome by the promotion or positive examples of these four elements. This

observation supports Morales-Chicas et al.'s (2022) research speaking to the way Yosso's (2005) CCW model framework "challenged [an existing] deficit lens by, instead, identifying the cultural strengths of nondominant groups and the multiple skills, abilities, and cultural knowledge they bring while resisting oppressive barriers" (p. 2).

Results indicating the low connection between equity and aspirational capital link to the consideration that most aspirational responses were tied to family and social support where there were positive connections and indicated strong access. This was also the case for low connections between equity and familial capital, as few connections were made between the two codes. In instances when equity was coded for, connections existed primarily in the social and navigational codes, linking back to reports of more positive experiences. Some participants shared specific recollections of collaborating with other women through professional organizations and academic groups to navigate through their journeys. For example, Participant 12 detailed the ways in which she and other women in her major encouraged and provided accountability for one another:

> And then connecting with like other a lot of women. Not a lot of women, but like there were so few of us that, like we kind of got to know each other. And would you know, encourage each other. Or, not like the soft, like huggy [sic] encourage, but like did you do that paper, you know. Did you get that project done like kind of that checking in, I'll say on each other. So even in those small exchanges is just like, okay, you see me, I see you.

She and other women in the study expressed fewer inequities because they were engaging with individuals of similar identities who affirmed and supported their existence in their C-STEM fields of study.

While equity had a low promotional impact in connection to the other constructs, some participants did express the challenges they faced with equity as women of color in C-STEM. For instance, Participant 1 shared the disconnect she felt from colleagues at her industry internship, which starkly contrasted the supportive, affirming environment she experienced as a Black woman at the HBCU school she attended.

> So I feel like, especially that's the culture [HBCU school] too. Like we're very Black women centric. Like you can do it sis. You're smart. You're brilliant. Your voice should be heard. So, I think that was definitely a cultural experience or a space that really helped me feel comfortable. But it was a real contrast to what tech is like outside of that bubble. So I would say it helped us and it hurt us because being wrapped in a culture that really affirmed you in most ways and then going to a summer internship, or an emerging program, or whatever at a company and feeling like the zoo animal. It's a very weird juxtaposition I would say.

Additionally, Participant 5 shared about the learning obstacles she faced in being one of the few women in her major.

> But I remember the only time I feel like I got [practical learning] to some extent in school was like the last year before we graduated. [It] was like a practicum class where we could like kind of choose whatever we wanted and work with the team to build something that we came up with an idea for. And that was the first time I

> really felt a level of passion in what I was doing. And I wish I had more of that like from the beginning because I feel like so many women dropped out of the program like every single semester. I would look around, and it would be less and less and less. And I wish that we got a taste of that in the beginning because maybe it would connect with more people other than the one subset of people that seem to get a degree.

The account shared by Participant 5 supports the literature that indicates the male-leaning learning preferences in computing education and how such departments could be more inclusive in their pedagogy to retain more female students in C-STEM majors (Kulturel-Konak et al., 2011). These examples of Participants 1 and 5 illustrate that though the assets-based framing of the study framework displays more positive results around equity, there are still considerable challenges that these women face in their lived experiences.

F3: Promotional Perceived Access, Aspirational Capital, and Financial Resources

There is a notable promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of aspirational capital as connected to reported financial resources.

This finding is consistent with Yosso's (2005) framing of aspirational capital through the asset's promotion of encouraging future hopes and dreams of the learner despite barriers. Specifically, in connection with the findings between access, aspirational capital, and financial resources, Yosso's (2005) framework supports that "[t]his resilience is evidenced by those who allow themselves and their children to dream of possibilities beyond their present circumstances, often without the objective

means to attain those goals" (pp. 77-78). It is necessary to note that many of the individuals in this study who shared the hopes and dreams that others had for them, in response to aspirational capital questions, reported such support to come from immediate family members such as parents and siblings. Further supporting Yosso's (2005) highlighting of parent's high aspirations for their children despite any limitations of resources early in the learner's journey.

In the cases in which the learner's reported other's aspirations for their C-STEM learning journeys tying to increased earning potential, there is alignment with Goode's (2010a) observations of the "tremendous costs to not being fluent with technology". She goes on to share that there is a necessity to expose students to "technology-rich environments" in the computing space prior to college entry, providing them with greater access to such educational opportunities (p. 588). Findings could suggest that other's aspirations for the learner were intentional in not only encouraging C-STEM learning, but also pushing these women in a direction in which they could later enjoy financial stability. The knowledge of these supporters, many being parents/guardians, made it so that the participants could gain access into the C-STEM space. Such was reported to be the case even when the supporters may not have had direct access themselves but were enthusiastic about strategically identifying resources to advance the learner in their pursuit.

Further connection to the literature on familial support of the learner's career aspirations highlights ways in which parents' own challenges with career trajectories could encourage perseverance for first-generation STEM learners (Morales Chicas et al., 2022). Some participants shared ways in which their parents provided early

exposure to STEM topics despite their own lack of familiarity with the topics. These actions reflect the high aspirations of parents for their learners as shared previously in this discussion. Furthermore, family members and mentors who shared high aspirations for the learners demonstrated an investment in their technological identities. This is particularly the case for learners whose families or mentors provided them with early exposure to the field.

Literature from Goode (2010b) stresses the significance of students' establishing a strong technological identity as it has a direct impact on academic and career trajectories. Additionally, Brock et al. (2010) speak to how social mobility can be impacted by one's technological identity. The researchers in Brock et al.'s study highlight technological capital as a form of capital in informational and communication technology fields, which serves as a "power resource" and "accrues through education, economic means, and social networks" (Brock et al., 2010, pp. 1042-1043).

F4: Promotional Perceived Access, Social Capital, Financial Resources, and Cultural Resources

There is a distinguished promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of social capital as connected to reported financial and cultural resources. This finding supports the literature on computing education and social identity. Specifically, Michell et al. (2017) stresses the importance of technology learning creating a sense of belonging by catering to students' social identity, fostering inclusive environments. The responses of participants in this study emphasized the importance of the learner's social identity being affirmed in a holistic manner, not just in the classroom, to encourage the learner's

full potential. Mentorship, by both formal and informal means, played an essential role in shaping the learner's social identity.

Mentors appeared as key educators, supportive bosses, and knowledgeable community members who centralized the learner's success in their work together. Many of these individuals provided access to financial resources, academic programs, internship opportunities, and other sources that would benefit the learner's journey in C-STEM. In connection to other findings shared in this chapter, the mentors (in addition to parents and other key figures) felt it necessary to support these women because they believed in their potential to pursue their fields of study. Also, mentors saw it necessary to connect the learners with other students and like-minded professionals through providing access to internships and other social networking opportunities.

Aside from traditional academic and professional circles, the learner's social identity was also affirmed through spiritual sources such as communities of faith practice. Some participants shared how gathering with their faith communities during their academic programs helped encourage them as they navigated the rigors of their studies and faced career decisions. Others shared how their personal faith, often established early in their upbringing, helped them to endure challenges faced during the journey. For instance, Participant 8 expressed the importance of her faith community not only providing spiritual and emotional support throughout her journey but also providing financial resources when needed. Participant 8 shared the following:

> But the church when I got to LA and was working in [C-STEM field], that church, that you know, because there was no preconceived notion of politics with family, they were so helpful. Like to this day, so [many] people were like taking me in

> and helping me out. And you know, helped [with] whatever it took [for] me to get my master's degree. And they gave me a scholarship like every year I was in my program. It was [church name]. And I sang in the choir. And when I talk the choir directors to this day, and the praise and worship leader, they check on me. They come to my birthday parties. Like they pour into me as a community. And I think that's beautiful, knowing that I'm from a different place. And that they just know, they know what I do. And they feel like it's important.

Furthermore, she shared that her church community had a direct connection to her cultural group causing them to affirm her to go beyond spiritual means but also linking to her identity.

In connection to the learner's upbringing, participants who mentioned the most impactful connections between access, social capital, and financial and cultural resources shared how early outreach programs shaped their foundation in C-STEM disciplines. Those who detailed their participation in these programs were often placed in programs by their parents who had knowledge of the resources or other community members (i.e., educated neighbors and family friends) who shared early outreach resources with the learner's families. Additionally, a number of the programs detailed by participants of their experiences, were held at college campuses where they were able to connect with other STEM learners of similar identities.

In terms of peer support, the existence of strong community networks helped learners to persist and succeed. Many of the African American participants from a range of C-STEM fields (i.e., computer science, engineering, etc.) credited the National Society of Black Engineers (NSBE) as a key organization in their journey. The

organization provided various academic and career resources but expanded beyond the learner's exclusive university communities. Learners were able to collaborate with students from other institutions and create professional relationships which often led to internships and exposure to a variety of post-degree opportunities. George et al.'s (2022) study results support this finding in that student groups in computing fields were found to be a positive predictor of maintaining interest in computing career possibilities. The research indicated that the social support fostered through field related organizations and professional development opportunities encouraged students to persist in pursuit of career pathways.

Participants who credited the NSBE community as a key resource in their journey intentionally shared how the group provided them with a sense of belonging and promoting their identities when they often felt marginalized at their institutions. This was particularly the case for those who attended predominantly White institutions (PWIs). Those who were a part of organizations like NSBE who attended HBCUs shared how connections to this larger cultural network enhanced their learning experiences and the promotion of social identity which they were already experiencing at their schools.

F5: Promotional Perceived Access, Navigational Capital, Financial Resources, and Cultural Resources

There is a distinguished promotional impact on the perceived access of female C-STEM learners of color in association with the promotion of navigational capital as connected to reported financial and cultural resources. In terms of financial support, some participants reported having to "figure it out" on their own due to limited family resources. Though this scenario may seem to have presented various challenges for

learners, it became a navigational task that helped them persist and develop skills in resourcefulness as a result. This led to participants identifying scholarship opportunities and other financial resources to advance their education. Upon the mention of financial resources to promote their learning (i.e., scholarships, grants, funded research), coders also coded access as the financial means described were helping the learner to advance in their academic journeys. Some participants also mentioned paid internships that they were able to obtain, also speaking to their navigational skills, which provided them access to career resources in their disciplines.

Specific to cultural resources, connections to the codes of access, navigational capital, and financial resources were highlighted by the cultural communities that affirmed the work of the learners who shared promotional or positive experiences. This finding connects back to Michell et al. 's (2017) discussion of social identity and inclusive learning environments as referenced in the community support focus of finding four earlier in this chapter. Many participants credited their peers in assisting them to navigate their learning journeys. They described how they leveraged their learning through peer groups who utilized each other’s knowledge to enhance their classroom learning. The strong prevalence of navigational capital in finding 5 also connects to prior research studies in which navigational capital was identified frequently in a STEM study examining data based on the CCW framework (Samuelson & Litzler, 2016).

Interview items in the study centered on participants’ educational journey as learners (pre-career) in their C-STEM disciplines. However, many of the women in the study shared experiences of their career trajectory, particularly in response to interview items asking about navigational capital. One reason for this result could be that some

participants pursued advanced degrees or promotional opportunities in the field along the way, causing overlap in their recollections of navigating their learning journey. Another reason for this outcome emphasizes the idea that other participants may have found the navigational and social aspects of their journey, and aspirational, to be a bridge from their undergraduate education to early career opportunities. For instance, Participant 4 shared the significance of her cultural community in helping her navigate internships and her early career roles in computer science.

> So I had to make a new community because my community I grew up in had absolutely nothing to do with computer science. But after my freshman year, I got a summer internship at a company called [corporation] and I had a summer internship there after my freshman year, after my sophomore year, and after my junior year at the same location. And this company recruited students from the [university area] because they were trying to have more Black engineers, Black software engineers…So in that process, we all were part of a cohort.
>
> And we would be up there during the summer together. And we met Black students from other schools. And we would have picnics and we would have things like that. And that became my community. So we had a technical community of those of us that came from [undergrad city], and I was the only female. And of those guys, I'm still in touch with those guys…We clumped together and made our own Black [company group], because the company's nickname…[That's] how [group name] became my community.

It is also vital to note that Participant 4 established a continuous connection to her peer community, particularly those who shared her cultural background. This also connects

to finding four discussion points of strong ties between social capital and cultural resources in which communities are formed and safe spaces created for underrepresented learners to navigate their journeys in C-STEM.

Conclusions

To conclude the study findings, the researcher discovered that C-STEM female learners of color can be encouraged (aspirational), can navigate (navigational), and affirmed in communities of similar identities (social) as a result of access to financial & cultural resources. Financial resources increase equity & participation for these learners. Cultural resources, as defined in this study, indicated that participants whose backgrounds and race/ethnicity were affirmed & celebrated generally seemed to report more support as they moved through the journey. This was particularly the case for those who connected with communities through established professional organizations such as NSBE and HBCU institutions. The study emphasized an impactful focus on social, navigational, and cultural codes which will be discussed further in the following implications, limitations, and recommendations sections addressing future research.

Implications

From an organizational change perspective, findings of this study indicate current practices that may require further development, as opposed to the implementation of large-scale change. Specifically, participants credited C-STEM enrichment programs with providing a foundation for their studies. In cases where supplemental programs are already successfully placing value on learner identities, such programs could focus developmental efforts on targeting parental and community groups to increase their reach of marginalized students. These programs create a safe space for traditionally

minority learners who may have varying experiences in the classroom depending on where they are being educated.

Potential implications for policy reform at the school level were alluded to in Chapter 1 and briefly reviewed in the Chapter 2 literature review. While associated points are vital in discussing access and equity in C-STEM education, results from this study present an opportunity to examine what has successfully shaped the educational experiences for minority learners in these fields. The enrichment programs and professional organizations reported to have a positive impact on participants, especially those that celebrated learners' cultural identities, serve as an effective bridge to fill the gaps that K-16 institutions are often challenged with in C-STEM educational representation.

Limitations

Various limitations existed in the current study, making it ripe for continued research in the field. One limitation was the challenge of finding women of color with C-STEM degrees specifically in CS. The researcher set out to make participants with CS degrees the focus of the study but degree types were expanded. This practice was beneficial to the current study but the recruitment challenges indicate potential limitations of these women as represented in the field which points back to challenges indicated in Chapter 1 of the study. Furthermore, the indication of C-STEM majors/degrees are broad in this study. While CS degree holders are the participant majority in this study, a future study in which all participants are CS degree holders may yield different results. Due to the small, purposive sample size, generalizability is limited in comparison to a larger population of female learners of color in C-STEM fields.

It is also important to note that the participants in this study achieved success in their journeys despite any challenges along their pathways. Therefore, the outcomes of the results reflected in a more positive direction as opposed to learners whose challenges may have taken them off the path. The women in this study defied the odds, so more elements of success are highlighted through the promoting codes shared in the results. In terms of timeframe, researchers and consumers of the literature should consider the time span since Yosso's 2005 CCW model article. Perhaps there are unaccounted nuances in modern society, particularly for women of color.

Recommendations

The researcher recommends that scholars continue to increase studies specific to marginalized learners in CS, especially women of color. Issues of accessibility of diverse CS learners may be further highlighted considering challenges the researcher experienced with gathering a robust sample for CS learners alone for the current study due to inaccessibility. Such challenges connect back to the literature gaps & limitations shared in Chapter 2 of the study. Previous research indicated gaps in the literature as related to under researched participants of color due to sampling convenience as many participants being studied are college students representing male dominated, non-diverse backgrounds who are easier for researchers to access (Wofford, 2021).

Studies aimed at making further comparisons across C-STEM fields may also be of value should sampling issues continue to present challenges in the field of computer science learning, specifically. Such interrelated research could explore additional means in which female CS learners of color can be supported in their educational journeys. Utilizing a different conceptual framework, such as the intersectionality of their

experiences may shed light on layered areas of necessary support (Hill Collins & Bilge, 2016; Rankin & Thomas, 2020; Rankin et al., 2021). Also, examination of the areas of the CCW model not covered in this study, such as resistant and linguistic capital, could also be researched in efforts to support learners in this group.

The connections between social capital, access and cultural resources in this study indicated a prominent impact of HBCUs on positive outcomes for Black C-STEM learners who were educated in this system. HBCU's ability to incorporate pedagogical practices which encourage retention and foster mindsets of student success regardless of academic background has been highlighted in previous STEM-related studies on Black female learners (Rankin & Thomas, 2020; Rankin et al., 2021). Additional studies further examining women who have navigated C-STEM learning at HBCUs specifically would be beneficial in the literature. Lastly, the researcher would encourage other scholars to explore the lived experiences of diverse women who had challenges completing a degree in C-STEM fields, specifically computer science and engineering, due to racial and gender related barriers in their learning environments.

Reflection

In reflection of what was learned through the process of this dissertation, many points lead back to research planning and design more than the content of the study itself. The researcher was reminded that while research can be rewarding, the iterative nature of collecting data and analyzing (i.e., codebook development) requires great commitment to formulate a strong study. Hence the significance of research design planning. It is valuable to allow the data to tell the story which is one reason why utilizing interrater reliability through the coding process was essential in this study.

Incorporating interrater reliability improved the rigor of the data collection process due to the multiple iterations reviewed with other coders.

In retrospect, there were various aspects of the in which the researcher would have conducted the study differently. Establishing a strong research design in the planning phase would have provided a stronger starting point for reviewing results. Specifically, data analysis could have benefited with enhanced alignment between the research questions and interview questions/prompts. In connection with the interview questions/prompts asked of participants, a future study may involve asking less of the introductory prompt questions and focusing more on questions about participants' culture as this was of greatest interest to the researcher. The interview questions were more focused on CCW model areas than actual aspects of access and equity, so there could be some aspects of those umbrella topics that were not covered in depth because of the CCW focus. Further reflecting upon the research design, the researcher would work to better streamline participant demographics in future studies by reviewing potential sampling limitations pre-study. This work gives the researcher an advantage in continued work due to now being aware of sampling challenges and having an established sampling pool in which to grow from.

Lastly, in reflecting upon the study findings, the researcher was surprised by the prevalence of emerging codes. The positive implications of access and financial aspects were especially surprising considering how the literature tends to highlight challenges faced by marginalized learners. This takeaway also highlights the necessity of continuously developing coding iterations and memoing data observations when crafting

a qualitative research project. The researcher's discovery in this area emphasizes the significance of allowing data to speak for itself and tell the story in a research study.

Additionally, the researcher expected to find a higher report of equity challenges faced by the women in the study, producing in less favorable results around equity, due to these barriers being frequently reported in the literature. However, the more positive associations found in equity-related can be attributed to the study's assets-based framework which speaks to the significance of selecting a framework that will complement a research study. The researcher found the CCW model to be a strong framework, supporting the study results and highlighting the unique contributions participants in the study have made in their respective C-STEM fields.

Closing Summary

In conclusion, this study highlights the relevance of cultural assets for female C-STEM learners of color. It is imperative that consumers of research note the unique needs of this group of learners and the ways in which their lived cultural experiences shape their educational and career journeys. Findings answer the research questions in that cultural capital, as framed by the CCW model (Yosso, 2005), do have an impact on perceived access and equity for female C-STEM learners of color. Elements of aspirational, familial, navigational, and social capital were indicated in the overarching exploration of access and equity. While access did have a more influential impact than equity, it is important to note the role that both played in the experiences of participants. Furthermore, emerging codes of cultural, spiritual, and financial resources accounted for why access had such strong connections to the various CCW elements.

To provide a high-level overview of the study, it was determined that the access provided by social support systems, through financial and community (including cultural and spiritual) resources, most influenced the fifteen participants' ability to successfully navigate through their learning journeys in C-STEM. Through the researcher's utilization of semi-structured interviews, she was able to gather information pertinent to participants' lived experiences which appropriately suits the sensitive nature of the data collected.

In contribution to the literature on this topic, this study provides a space for the stories of female C-STEM learners of color to be shared. However, the broad pool of participants represented in terms of specific C-STEM fields of study indicates the need for more diverse representation in the literature which supports suggestions for future research made by previous researchers (Eyo-Idahor, 2022; McCall, 2017; Wooford, 2021). Such challenges also connect back to points posed in Chapter 1 regarding how diversity concerns in C-STEM learning can impact the technological workforce. Through an organizational change lens, consumers of the research can continue to examine how changes in the learning environment, such as celebrating marginalized learners for their assets, may lead to advances on a global scale as we continue to embrace a technologically advanced society. The narratives in this study speak to the ways in which the women interviewed, as well as their peers that share similar identities as women of color, can influence large scale change in C-STEM learning and career outcomes.

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APPENDIX A

Interview Script

Thank you for participating in this interview today. My name is Tiffany Wright and I am a doctoral learner at Pepperdine University. This interview is for my doctoral dissertation research study. The interview process will include a video recording so that the data can be transcribed. You may be audio recorded only (without video) as an alternative. Do you give consent to be video or audio recorded during this interview session?

Thank you, I will begin recording now.
(Begin recording)

Thank you for participating in this interview today. Before we begin, I just have some consent verification questions:

1) Have you received and signed your consent form?
2) Would you like for me to read the consent form to you?
3) Do you have any additional questions about the consent form or your rights as a study participant?

(Begin interview)

Thank you for your participation in this study and your willingness to complete the interview process. Each response will be kept confidential. In the study manuscript, participants will be referred to as Participant 1, Participant 2, Participant 3, etc. to ensure the identity of each participant remains confidential and that confidentiality guidelines are reinforced.

The purpose of this interview is to explore the phenomenon of how female learners of color use community cultural wealth (cultural capital) to navigate access and equity throughout their computer science [or related fields] learning journey. There are no incorrect answers, and answers can be as short or long as desired. Based on your responses to the interview prompts, I may ask additional clarification questions. If at any time you would like to stop the interview and terminate your participation in the study, please let me know and the interview will be stopped immediately. The interview will be video (or audio) recorded, and is expected to last approximately 60 minutes, depending upon your response time for each prompt.

After the interview, you will receive a summary of your responses and you will have the opportunity to ensure that I have accurately documented your responses.

Do you have any questions before we get started?
We are ready to begin.

Introductory Prompts
IQ. 1: What has been your academic pathway since high school?
IQ. 2: Tell me about the educational history of your parents/guardians (if known)?
IQ. 3: Tell me about the educational history of your grandparents (if known)?
IQ. 4: When did your computer science [or related field] learning journey begin?
IQ. 5: How do you self-identify?

Aspirational Capital
IQ. 6: What were your hopes and dreams for your education as related to computer science [or related field]?
IQ. 7: Tell me about other influences or people who had hopes and dreams for your learning journey into the computer science [or related] field.

Navigational Capital
IQ. 8: How have you navigated your learning journey in the computer science [or related] field?
IQ. 9: Tell me about experiences from your culture that helped you to navigate your learning journey the computer science [or related] field.

Familial Capital
IQ. 10: What kind of support, if at all, did your family provide in the beginning of your computer science [or related field] learning journey?
IQ. 11: What kind of support, if at all, did your family provide as you continued your computer science [or related field] learning journey?

Social Capital
IQ. 12: In what ways, if at all, did your community influence or support your decision to pursue your learning journey in computer science [or related field]?
IQ. 13: Tell me about any community resources that might have supported you through your learning journey in computer science [or related field]?

Closing Prompt
IQ. 14: Tell me about anything that we have not discussed that you would like to include.

APPENDIX B

Recruitment Flyer

Volunteers Needed for Research on Females of Color in Computer Science Education

I am conducting a research study in which I examine the educational pathways of female learners of color in computer science as it relates to various aspects of their culture. Participants meeting all inclusion criteria are eligible to receive a $15 gift card. Your assistance would be greatly appreciated in my research endeavors. Referrals are also welcome.

Participants may qualify if they:

- Identify as a female of color (as defined by Black, Indigenous, People of Color)
- Are over the age of 18 years old
- Have obtained a Bachelor's degree or higher in computer science (or a related field) at a U.S. based institution

Participation involves:

- Completion of a study consent form
- A one-time, 60-minute interview
- Email correspondence with the researcher

Please contact the study Principal Investigator, Tiffany Wright, via LinkedIn Messaging for email contact information.

APPENDIX C

IRB Approval Notice

Pepperdine University
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Date: March 10, 2023

Protocol Investigator Name: Tiffany Wright

Protocol #: 22-12-2036

Project Title: Examining the Role of Cultural Capital in Access and Equity for Female Computer Science Learners of Color

School: Graduate School of Education and Psychology

Dear Tiffany Wright:

Thank you for submitting your application for expedited review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. As the nature of the research met the requirements for expedited review under provision Title 45 CFR 46.110 of the federal Protection of Human Subjects Act, the IRB conducted a formal, but expedited, review of your application materials.

Based upon review, your IRB application has been approved. The IRB approval begins today March 10, 2023, and expires on March 09, 2024.

The consent form included in this protocol is considered final and has been approved by the IRB. You can only use copies of the consent that have been approved by the IRB to obtain consent from your participants.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Please be aware that changes to your protocol may prevent the research from qualifying for expedited review and will require a submission of a new IRB application or other materials to the IRB. If contact with subjects will extend beyond March 09, 2024, a continuing review must be submitted at least one month prior to the expiration date of study approval to avoid a lapse in approval.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph.D., IRB Chair

cc: Mrs. Katy Carr, Assistant Provost for Research

APPENDIX D

Consent Form

PEPPERDINE
UNIVERSITY

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION STUDY

IRB #:

Participant Study Title:

Navigating Access and Equity in Computer Science Education: A Phenomenological Study of Female Learners of Color and Their Use of Cultural Capital

Formal Study Title:

Examining the Role of Cultural Capital in Access and Equity for Female Computer Science

Authorized Study Personnel

Principal Investigator: Tiffany Wright, M.A. tiffany.wright2@pepperdine.edu
Secondary Investigator: Martine Jago, Ph.D. martine.jago@pepperdine.edu

Key Information:

If you agree to participate in this study, the project will involve:

- ☐ Female identifying people of color (as defined by Black, Indigenous, People of Color) over the age of 18 years old
- ☐ Participants will have obtained a Bachelors degree or higher in Computer Science (or related field) at a U.S. based institution
- ☐ Procedures will include a one-time interview in which participants will be asked about their experiences navigating access and equity through their educational journey in Computer Science
- ☐ One virtual interview (via Zoom) is required
- ☐ The interview will last for approximately 60 minutes
- ☐ There are no risks associated with this study
- ☐ You will receive a $15 gift card for your participation provided that all inclusion criteria are met prior to the start of the interview
- ☐ You will be provided a copy of this consent form

Invitation

You are invited to take part in this research study. The information in this form is meant to help you decide whether or not to participate. If you have any questions, please ask.

Why are you being asked to be in this research study?

You are invited to participate in a study conducted by Tiffany Wright, doctoral candidate in the Ph.D

APPENDIX E

Codebook for Wright Study: Cultural Capital and C-STEM

Construct	Definition	Examples
Research Question Umbrella Areas		
Access	Resources made available to the learner (i.e., educational or learning resources, acquired learning, early outreach programs, enrichment programs, educational organizations, etc.) for them to obtain their education.	Promoting Example “And then, when I went to my first job actually, [I] got my first job through a recommendation from someone who had graduated, maybe two, with 2 years before me. So he was instrumental in getting my first position. It was a different location, but it was the same company, so that was really helpful. So he was my mentor.” (Participant 2) Limiting Example “Man, it's been tough. It has been really, really hard. I would say at first, when I first started in the major it was very discouraging because it felt as if everyone around me knew about computer science. Knew what it was, had a past with it, had either gone to a coding camp or had done it in high school, and I had never even seen it before. And so, at [school] is one of like the largest universities in the country. So, the classes I was in were huge. Everybody knew what they were doing. It felt like I couldn't really talk to my professors because it wasn't a comfortable environment for me. They were all male. They were all older. They were all, you know, gave you 5 minutes of your time, and if they didn't feel like you were smart enough kind of blew you off.” (Participant 5)

Construct	Definition	Examples
Equity	Equality of resources and support mechanisms made available to the learner (i.e., educational, social, *gender*, etc.) for them to obtain their education.	Promoting Example “And then once I did get into engineering with all boys, you would think they would have treated me terribly, but they didn't. The boys that I went to school with a lot of them knew that I was sharper than they were. And they grew up with me. So they didn't treat me bad. They really didn't treat me bad. They grew up with me. They knew, growing up already because I didn't spend much time as a kid in class with the regular students, with the normal students. Because I would my, I couldn't do the work they were doing it was too easy…So they didn't give me I went to class with all White boys. They didn't give me grief. They knew I was smart. So they would ask me for help, and the teacher would get mad. And I didn't have problems with the kids in [home state] with the guys in class in [home state] because they were my friends from childhood. So they had already experienced life with me.” (Participant 10) Limiting Example “So that's what I mean, like, I've had to really kind of go out of my way to make sure that 1) I'm getting the same support as other people, and then 2) that I get additional support that is needed for Black women to actually survive.” (Participant 9)
Emerging Areas of Capital		
Cultural Resources	Established cultural groups designed to promote underrepresented groups (i.e., Black professional societies-NSBE; HBCU institutions); Communities sharing same (or similar) cultural identity.	“I've mentioned it a few times, but just kind of reiterating like NSBE also was a really big part of my journey through engineering. Like the camaraderie, and like the support. And like knowing that, you know, I'm not the only Black person doing this, you know. And like having that community where it was like, we can work hard and study and stuff together. And we can just have fun together. And like, you know recognizing like, engineering doesn't have to look a certain way or like we don't have to whitewash our engineering experience, right. Like I can still have fun and like be me in the way that I have been me and want to be me. And be an engineer.” (Participant 12) “Growing up in an all Black city with all Black teachers and Black doctors and Black churches, and Black well-educated parents. And being at an HBCU with Black professors, I never ever, ever had to face racism. I never ever, ever was told I couldn't. I never was told that I was stupid. And so, I was only told that I could, and that I should. And that the world was my oyster to accomplish whatever I wanted to accomplish.” (Participant 4)

Construct	Definition	Examples
Financial Resources	Any discussion regarding finances along the learners journey or in preparation for future career opportunities; Educational resources provided.	“Yeah. I think, I think that you know you mentioned like capital from a social perspective. But then there's also like real financial capital. And I think that's been the one thing that my family hasn't been able to support me in. That's been pretty difficult compared to a lot of my peers. But then, also, as we talked about earlier, has been like a really strong motivator. So I feel like I have a lot of incentive to work harder than some of my peers, because I have to make up like I need to, I have like a financial incentive.” (Participant 9)
Spiritual Resources	Inspiration or reliance on a higher power to press toward achievement in the learning journey; Internal guidance or soul-searching.	“Another community that I can think of is, you know I have my faith community like my church community. That was very much, it was interesting, because at first they were kind of like, oh, well, like you're going back to school? Like, what does [husband] think about that?...But you know, aside from the initial like questions they were, they're also like very supportive. And like expressing to me like, hey, like, I'll pray for you during this journey. Like it's gonna be good. And I think it always gives me time to kind of catch up with them. And whether it's like a praise session, or like venting session, or just getting through during times of like the highs and the lows like they're there for me.” (Participant 7) “But also, I don't know if this helped me navigate or not, but I think, sticking to my own feelings about what I didn't want to do. Sort of helped me as well. So there was some like self-realization or soul searching, going on as I was just looking at the culture around me, and seeing that it wasn't fun to me to like, just go code for a company like I like to code. But I want to do it for fun. I want to do it on my own… I knew that I didn't want to just do that, you know. I want to have my hands in a bunch of different things. And so, knowing what you don't want to do, I guess, can help you navigate or pivot, or move around certain things, or go for this opportunity instead of that one. So, I think a lot of listening to myself to help me navigate.” (Participant 1)

Construct	Definition	Examples
CCW Model Areas of Capital		
Aspirational Capital	The learner's aspirations for their education or aspirations that others have for them.	"Yeah, so definitely my stepmom. She is very supportive. Although, like of course, I grew up around her spending summers with her and my dad, I didn't really know what she did for work, really. I just know she was always tapping away on the computer. But I never, I didn't know what it was. I had no idea, not the slightest. Until undergrad, when she is like, switch your major to computer science. And so, she was very encouraging. I don't think she like told me enough about like how hard it would be, or how weird it would be in the tech industry. But maybe, since she's in Fintech, it's kind of different. I don't know. But she was definitely one of the people who really encouraged me to stick with it." (Participant 1)
Familial Capital	Family experiences, cultural beliefs, knowledge, etc. that prepare the learner as they pursue their education.	"Hmm. Well, again, I mentioned, you know my father was just a pivotal figure. And giving me that early exposure to even making the connection of housing conditions being able to be improved by engineering skills being applied. I should say too that when I was still in high school, I was volunteering with Habitat for Humanity. And they were, they had a really big presence in [city]. Where again, I was able to like apply engineering skills to actually help build houses. And get the immediate gratification of seeing the families that were helping to build those same houses side by side with me. And these were the folks that would be eventually living in those houses. Like it just touched me profoundly." (Participant 3) "So I would have to add the cafeteria plan to my tuition because my mother felt I needed the cafeteria plan. Yes, Lord Jesus. So I and it was a blessing actually. Even though I've complained because I kept looking at how much it costed. But the truth is, when you live off campus, but you have a plan on campus in between classes you can actually just stop at the cafeteria, eat, and keep going. You know, it actually makes it more convenient. You don't have to leave campus…And so that was, it was a blessing to eat on campus because it made life easy. You didn't have to drive. We went to school in the middle of nowhere. So it's not like, if you got on the road, you were going up the street. So having food at your doorstep was a blessing." (Participant 10)

Construct	Definition	Examples
Navigational Capital	How the learner navigates their learning journey with the assistance of possible resources. Their lived experiences of the journey (positive or negative). Connecting with others to get resources or answers.	"We really lean on each other a lot, because with computing, it's not like natural. So, a lot of it is very abstract, and it's not second nature to understand. And I feel like the culture of computing is like: Just look at this textbook that walks through these examples. But there's no substance to that, you know. So we kinda had to fill in those gaps for each other. And so, I really, I think, in navigating I just leaned on people a lot." (Participant 1) "So, it's just like [my manager] and I started to kind of outgrow that role. And thankfully, my relationship with my supervisor was so strong that I was telling her like, this is what I'm doing day to day. And I'm not, it's not fulfilling. And she introduced me to her husband, who is a CIO. And that's how I got into technology…Yeah, it was not a direct path by any stretch of the imagination. But it's been, it's been nice. It's been good." (Participant 11)
Social Capital	Social/community supports that assist the learner throughout their learning journey.	"I think, related to cultural capital we covered, you know, so many things. And I think it's interesting to see it in like a family community. You know, [a] colleague type of way. But I can definitely say, like, during this program, like, you know, the line definitely blends. You know, like colleagues and friends, and like classmates, like start to feel like family. And you know there's uhm, and I do see like such a big importance in having multiple like dimensions of that. You know like, not just having like one, you know. Like it's really helpful to have that great friend to like push you through. But it's also like equally important to have that mentor that you know, like your boss and your colleague, you know. I think it's all kind of like webbed together. So that's like one thing, I would add. But there is definitely a blend in the support systems." (Participant 7)

Note. Examples of definitions are shared in the participants' own words.