UNIVERSITY OF CALIFORNIA SAN DIEGO

CALIFORNIA STATE UNIVERSITY SAN MARCOS

Cooperative Coding:

How Underrepresented Students Perceive Collaboration in Computer Science

A dissertation proposal submitted in partial satisfaction of the

requirements for the degree of Doctor of Education

in

Educational Leadership

by

Devon Senneseth Marano

Committee in Charge:
University of California San Diego

Beth Simon, Chair
Amy Eguchi

California State University San Marcos

Rong-Ji Chen

2022

The Dissertation of Devon Senneseth Marano is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

University of California San Diego

California State University San Marcos

2022

DEDICATION

To my husband, for taking his patience to new levels and bringing an unparalleled amount of thoughtfulness into everything our family needed along this journey.

To my son, for greeting me after many long days with a big smile, hug, or some much needed cuddles.

To my dad, for instilling in me a strong sense of both work ethic and humor.
To my mom, for truly making me believe that I can move mountains.

To my siblings, for reminding me to push pause every once in a while.

Thank you for your unwavering support and endless encouragement. Without you all, I wouldn't be where I am or who I am today.

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ACKNOWLEDGEMENTS

With an abundance of respect and appreciation, I would like to thank Dr. Beth Simon, my chair, for her guidance and support that extends far beyond the scope of this project. As one of my earliest mentors within Computer Science education, she has helped to inform and inspire my teaching, my research, and my "big picture" for what this field can do for our communities. Her enthusiasm and expertise are unparalleled and I feel truly grateful to have had this opportunity to learn from her. I would also like to acknowledge my committee; Dr. Rong-Ji Chen and Dr. Amy Eguchi for sharing their time and wisdom. Their thoughtful questions and critical feedback provided many opportunities for reflection and, in turn, opportunities to grow as both an educator and researcher.

To my Cohort 16 colleagues, thank you for the encouragement and compassion that was expressed through every step of this journey. You each bring humility and humor into the often daunting task of being an educational leader and I'm so grateful for that.

Lastly, I would like to thank the many students who I have had the privilege of working with throughout my career. For every one lesson I plan, there are a dozen that they are waiting to teach me. Through these I have been able to develop and continually deepen my "why".

VITA

EDUCATION

2022	University of California San Diego, San Diego, CA California State University San Marcos, San Marcos, CA **ED.D in Educational Leadership**
2014	National University, San Diego, CA **M.A. in Education**
2012	San Diego State University, San Diego, CA **B.A. in Mathematics**

PROFESSIONAL EXPERIENCE

2022	Teacher on Special Assignment (TOSA) Sweetwater Union High School District
2014 - 2022	Math and Computer Science Teacher Sweetwater Union High School District

AWARDS

2021	CSTA National Teaching Excellence Award
2019 - 2021	College Board AP Computer Science Female Diversity Award

ABSTRACT OF THE DISSERTATION

Cooperative Coding:
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by

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Doctor of Education in Educational Leadership

University of California San Diego, 2022
California State University San Marcos, 2022

Beth Simon, Chair

Computer Science is one of the most rapidly expanding career fields and high schools across the country have responded by increasing access to programming courses by over 300% in the last decade (College Board, 2020a; College Board, 2020b; U.S. Bureau of Labor Statistics, 2020). However, as job openings and course access increase, racial and gender gaps within tech industries continue to present an array of problems that range from stifled creativity to racially biased software (Bobb, 2016; Hoever, Van Knippenberg, Van Ginkel, & Barkema, 2012; Lee, 2018; Rock & Grant, 2019; Sandvig, 2016; Stevens, 2008; U.S. Bureau of Labor Statistics,

2020). Thus, as access to Computer Science in secondary schools increases, so must educator understanding of how to support underrepresented students within these courses.

Collaboration is widely recognized as an instructional strategy that supports both social emotional and academic success. However, the specific role this strategy plays in CS classes has primarily been explored through quantitative research efforts with minimal focus on the lived experiences and perspectives of these underrepresented students. The research presented in this dissertation contributes to this growing understanding by using a primarily qualitative lens to examine the impact that structured collaboration has on the experiences of underrepresented students in high school CS courses. Building upon existing research, this study provides additional support for the use of accountability structures as a means of transforming peer interaction into Cooperative Learning. By amplifying the voices of Black, Latinx, and female students within high school CS classes, this study provides a better understanding of how instructional strategies can be leveraged to support these students.

The results of this research capture the strengths and shortfalls that students perceive when engaging in Cooperative Learning activities. Key findings include student concern over how effort *and* voice are distributed during collaboration, individual increases in content confidence and creativity attested to the exchange of ideas, and an intrinsic need to feel connected and comfortable with their peers. Through these perceived relationships between collaboration, academic growth, and social emotional well-being, this study highlights several opportunities for educators to better engage and support underrepresented students within high school CS courses.

Chapter 1: Introduction

Female, Black, and Latinx students have been historically underrepresented in Computer Science (CS) courses at all levels of education and in professional environments. Although gender and racial gaps have existed in virtually all science, technology, engineering, and math fields (referred to as STEM) the representation of these individuals in CS is significantly lower than in the remaining areas of STEM (Griffith, 2010; Milesi et al., 2017; Syed & Chemers, 2011; Whittaker & Montgomery, 2012; Women in Science, 2020). Approximately 40% of non-CS STEM professionals are female while less than 20% of CS professionals are women, and similar incongruencies reveal themselves when we look at the proportion of minorities in these fields (Women in Science, 2020). While the underrepresentation of females, Black, and Latinx individuals in any STEM field is a problem deserving of a solution, the inherent interconnectedness of CS poses unique implications warranting even more urgent attention and interventions. Computer Science is one of the fastest growing industries in the world, and according to Moore's Law, processing speeds and computing power double almost every year (Palem et al., 2009; U.S. Bureau of Labor Statistics, 2020). However, if society expects technology to continue improving at its current rate, interventions must be taken to broaden the participation of female and minority individuals in CS. The current lack of diversity in CS organizations and departments is not conducive to the technological progress society yearns to make (Bobb, 2016; Hoever, Van Knippenberg, Van Ginkel, & Barkema, 2012; Lee, 2018; Rock & Grant, 2019; Sandvig, 2016; Stevens, 2008). Thus, the commonly accepted factors of underrepresentation, such as gender stereotypes and societal pressures, must be reexamined, and educators must begin to approach the disparities within CS from angles as unique as the root causes themselves.

While CS has existed as a discipline for over 50 years, as a high school course it is still a fairly new concept. As recently as 2010 Advanced Placement CS courses and exams were being offered at fewer than 14% of high schools across the country (College Board, 2020a). These Advanced Placement (AP) courses are classes designed and provided by the College Board. A school can begin offering these courses after submitting an approved course description and syllabus, and schools are highly motivated to do so since data has repeatedly shown that students who participate in these courses experience greater success in their first year of college (Murphy & Dodd, 2009). Over the past several years, districts and communities have been working to broaden availability, and in 2019 the number of schools offering an AP CS course had risen to approximately 50% (College Board, 2020b). While this increase in access can be seen as a major triumph, there is still a great deal of work that needs to be done in order to close the gender and racial gaps by increasing female, Black, and Latinx enrollment in these courses.

In order to quantify the progress made towards closing these gaps, educators must consider what ideal enrollment demographics should be. Equal Female Representation (EFR) would mean approximately 50% of students in a CS class are female, while Equal Black and Latinx Enrollment (EBLE) would ideally mean the number of Black and Latinx students in a CS class is roughly proportional to the racial makeup of the community served by school. However, when looking at high schools in the US currently offering a CS course, less than 8% of schools have achieved EFR within their CS courses, meaning the overwhelming majority of these courses still have less than 50% female enrollment (College Board, 2020b). Further, these CS courses are far from achieving EBLE, with less than 6% Black and less than 17% Latinx students, both well below their numbers represented in the population at large (College Board, 2020b).

Closing these gaps will require systemic change, likely in the form of policy reform at the state and district level. While undoing centuries of gender and racial stereotypes is a daunting task, research has shown that there are many small steps that districts, school sites, and educational organizations as a whole can take to help create CS courses that support equal representation of female, Black, and Latinx students. These steps include increasing awareness of what CS courses actually aim to teach (Carter, 2006; Goode, 2008; Goode & Margolis, 2011; Margolis et al., 2015; Zimmerman et al., 2011), developing and adopting more inclusive curriculum (Aharoni, 2000; Buck & Stucki, 2000; Carter, 2006; Goode, 2008; Goode & Margolis, 2011; Guzdial & Forte, 2005; Kirk & Zander, 2002; LaForce et al., 2016; Margolis et al., 2012; Margolis et al., 2015; Treu & Skinner, 2002; Varma, 2006; Zimmerman et al., 2011), providing math or science credits as opposed to merely elective credits for students who take CS courses (Cuny, 2011; DeClue, 2008; Goode & Margolis, 2011; Wang et al., 2016; Zimmerman et al., 2011), and reimagining current courses to allow for interdisciplinary approaches (Carter, 2006; Chen et al., 2013; DeClue, 2008; Ge & Sun, 2000; Goode, 2008; Goode & Margolis, 2011; Montag et al., 2016; Ramesh et al., 2004; Treu & Skinner, 2002; Zimmerman et al., 2011). The list of excuses for why educational organizations cannot support inclusivity within their CS programs is quickly dwindling. By implementing any or all of these interventions, districts across the country stand to make great progress towards rewriting the narrative regarding who belongs in CS and consequently help close the gender and racial gaps that permeate this field.

District and state policy change plays an integral role in any equity initiative, and CS education reform is no exception. However, the benefits of the aforementioned interventions are limited if the teachers working first-hand with students are unprepared for the unique challenges presented by CS courses (Gal-Ezer & Stephenson, 2010). Thus, it is becoming increasingly clear

that some of the most influential participants in this reform process are the teachers in these classrooms. Teachers have a seemingly endless bank of strategies to deploy for any given learning objective, but understanding how different strategies impact different students is the key to building an inclusive classroom. In order to support underrepresented students in CS, teachers will need to gain a deeper understanding of the intentional and unintentional consequences their pedagogical decisions have on the classroom experiences of female, Black, and Latinx students. In doing so, CS teachers can begin to distinguish between practices that support and practices that hinder the success of those who have been historically excluded.

There are countless ways that pedagogical decisions impact student experience within classrooms, however research surrounding these experiences is typically broken into two primary categories: Academic Experiences and Social Emotional Experiences. Academic Experiences include opportunities for students to make explicit cognitive gains and are characterized by a student's performance on assessments, both formal and informal, and their self-perceived ability to comprehend and apply the content at hand. Social Emotional Experiences include opportunities for students to build relationships and manage emotions. These experiences are characterized by the extent to which students feel like they belong or feel as though they have a safe space to share their voice. Understanding the role that both types of experiences play on female, Black, and Latinx perceptions surrounding CS appears to be another highly effective strategy to help close the representation and retention gaps (Anderson & Ward, 2014; Barker, Garvin-Doxas, & Jackson, 2002; Cutts et al., 2011; Ericson et al., 2014; Goode & Margolis, 2011; Grossman & Porche, 2014; Hamner et al., 2008; Horwitz et al., 2009; Kirk & Zander, 2002; LaForce et al., 2016; Lau & Yuen, 2010; Margolis et al., 2012; Margolis et al., 2015;

McDowell et al., 2006; McGill et al., 2019; Milesi et al., 2017; Okebukola & Woda, 1993; Treu & Skinner, 2002; Wilson, 2002; Zimmerman et al., 2011).

The relative novelty of CS access at the high school level presents educators with limitations when it comes to making research-based pedagogical decisions. Fortunately, several applicable themes emerge when looking at the available research related to university level CS education and general best practices in non-CS content areas. Existing research acknowledges that CS environments have a tendency to overemphasize competition, devalue the social benefits of computing, and favors individualistic culture (Barker et al., 2002; Carter, 2006; Kirk & Zander, 2002; Lewis, Bruno, Raygoza, & Wang, 2019). While each of these tenets unconsciously contribute to feelings of isolation and unwelcomeness exhibited by Black, Latinx, and female students, existing research also provides insight into how teachers can combat these negative classroom cultures through peer interaction (Gray, et al., 2019; Horowitz, 2009; Kirk & Zander, 2002; McDowell, 2006; Nosek, 1998; Werner, et al., 2004; Yadav, Mayfield, Moudgalya, Kussmaul, & Hu, 2021). As CS pedagogy continues to evolve, educators must work to understand the role that collaboration plays in supporting the success and retention of underrepresented students.

Statement of the Problem

The glaring underrepresentation of females, Latinx, and Black students presents lasting problems for local communities and society as a whole, but the relative novelty of CS at the high school level presents educators with a unique opportunity to rewrite the narrative of what CS is and what type of students belong in CS learning environments. Acknowledging the unique experiences and perspectives of students with different genders and ethnic backgrounds doesn't just promote inclusivity within the classroom, it destigmatizes what types of individuals can be

successful programmers and thus encourages a broader range of individuals to pursue degrees and careers in technical fields.

Increasing the participation and success of Black, Latinx, and female students in high school CS courses will undoubtedly require district and policy reform, and research has shown that simply enrolling in CS classes in high school contributes to a student's long-term success in CS (Milesi et al., 2017; Taylor & Mounfield, 1989; Wilson, 2002). However, ensuring that Black, Latinx, and female students have a *positive* experience in these high school courses is likely to have an even bigger impact on these students' willingness to continue within the field. While positive classroom experiences encompass a wide variety of characteristics, it's important to note that they include not only content acquisition but also the degree to which an individual feels they belong and can be successful. Countless factors contribute to students having these kinds of classroom experiences; however, a teacher's instructional decisions are perhaps the biggest factor.

Leveraging instructional strategies to support all learners is the epitome of effective teaching; understanding why and how certain strategies can be used to support at-risk or underrepresented students is at the core of inclusive teaching. One of the most widely explored strategies related to inclusivity is collaboration. Having students work together to complete a project, brainstorm ideas and explanations, or engage in general problem solving has been shown to be an effective means to support academic and social emotional gains in virtually all subject areas and educational levels (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Gillies, 2019; Gray, Haynie, Trees, Astrachan, Uche, Cooney, & Kick, 2019; Jensen et al., 2002; Klein, 1975; Mabry, 1985; McDowell et al., 2006; Nosek, 1998; Porter et al., 2011; Shelly & Troyer, 2001; Walker & Crogan, 1998; Werner, Denner, & Bean, 2004). When we narrow our focus to CS

education, we see similar findings. Collaboration is believed to support fluency with technology, increase participation, challenge the notion that programming is a solitary field, highlight the social value of coding, and increase quality of work (Gray et al., 2019; Horowitz, 2009; Kirk & Zander, 2002; Lewis et al., 2019; McDowell, 2006; Nosek, 1998; Werner et al., 2004; Yadav et al., 2021). Pair Programming, for example, is a widely used strategy that allows two students to work together to complete a program and has been shown to increase course satisfaction and willingness to take more CS courses (McDowell, 2006). Pair Programming incorporates Positive Interdependence and places approximately equal value on the skills and ideas that each partner brings into the relationship. Additional Cooperative Learning strategies have been deployed successfully by researchers and additional benefits such as increased scores on multiple choice assessments (Porter, Bailey Lee, Simon, & Zingaro, 2011) and increased sense of efficacy (Werner, et al., 2004) have been uncovered. However, not all collaborative opportunities are created equal (Gray, et al., 2019; Gillies, 2003). The current research involving collaboration in CS provides little to no insight into the specific role that accountability structures, such as Positive Interdependence, play in achieving these outcomes.

There are fundamental differences between Collaborative Learning and Cooperative Learning (Gray, et al., 2019; Ghaith, 2007; Gillies, 2003; Klein, 1975) but the weight of these differences when applied to high school CS classrooms remains unclear. When students are given the opportunity to work with another student and there are no specific roles, time guidelines, or other structures to encourage an equitable distribution of learning opportunities, there is less accountability and it becomes easier for students to "hide" within a classroom. Black, Latinx, and female students are already predisposed to avoid participating, and thus it stands that the individual accountability structures that distinguish Cooperative Learning from

Collaborative Learning could improve the overall experiences of these underrepresented students. However, as the literature review will reveal, this relationship has received insufficient attention. By developing a better understanding of this relationship and the connections that exist between Cooperative Learning and classroom experiences for Black, Latinx, and female students, teachers can begin to provide more targeted interventions and in turn provide these underrepresented students with more positive experiences within high school CS classes.

Definition of Terms

Collaborative Learning is considered any unstructured activity that involves two or more students working together. The key here is the "unstructured" nature of these activities. Students engaged in Collaborative Learning have no additional incentive or accountability to cooperate or contribute to the completion of the task equally (Gray, et al., 2019).

Cooperative Learning is an elevated form of Collaborative Learning where several key components are in place to provide structure and equal distribution of learning opportunities. These components include, but are not limited to positive interdependence, shared products, explicit roles, individual accountability, equal participation, and additional structures may be present. Through this form of collaboration individual members develop a sense of responsibility for contributing to the success of the whole group (Gillies, 2019). Figure 1 provides further clarification on the relationship between Collaborative and Cooperative Learning. While any form of group work can be viewed as collaboration, not all collaboration qualifies as Cooperative Learning.

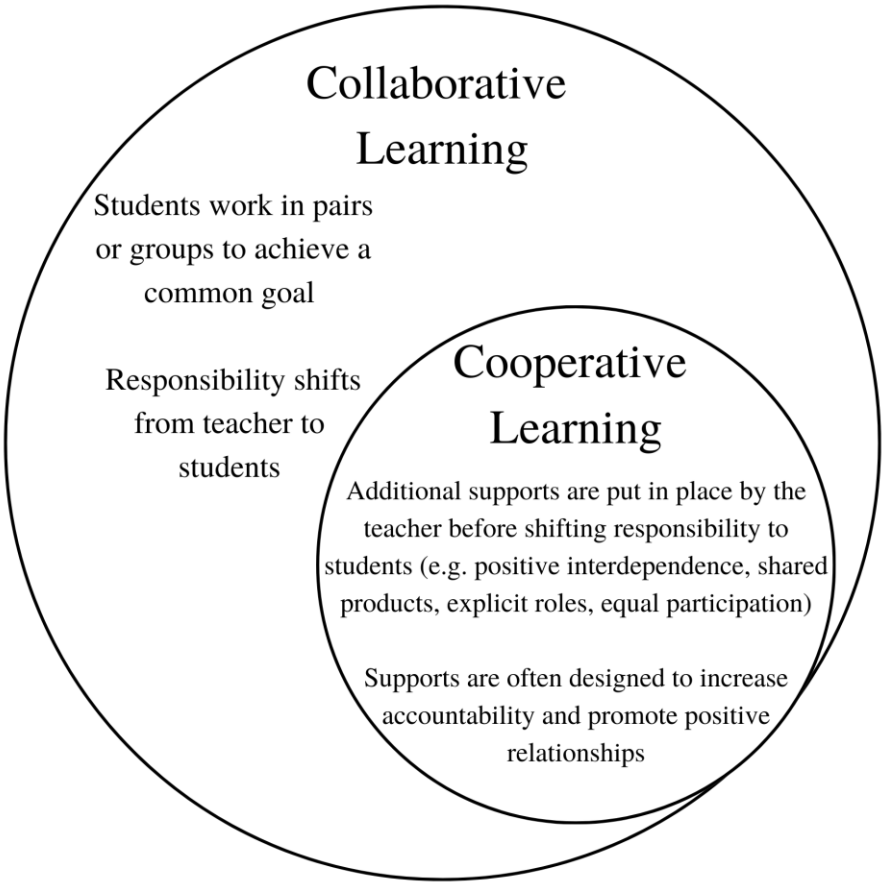

Figure 1: Collaborative vs Cooperative Learning Diagram

Positive Interdependence exists when a group of two or more students collaborate and members perceive the success of one student as obtainable only if the entire group succeeds. When this characteristic is present in collaborative activities, "gains for one imply benefits for the others, and cooperation replaces competition" (Gray et al., 2019, p. 1191).

Academic Experiences refer to all opportunities for students to make cognitive gains and demonstrate proficiency in regards to the content objectives of a specific class. Examples include completing assignments, projects, or assessments, engaging in small or whole class discussions, etc.

Social Emotional Experiences encompass the opportunities students are given in a classroom to build relationships and practice managing emotions. These opportunities contribute to a student's sense of belonging, freedom from anxiety, and safety within a classroom. It is important to note that various instructional activities can present students with Academic and Social Emotional Experiences simultaneously.

Sense of Identity within a Computer Science setting describes an individual's awareness of themselves, their feelings, and their beliefs. This also connects to the extent that an individual feels engaged and as though they have a place within Computer Science (Ryoo & Tsui, 2020).

Sense of Efficacy refers to the extent an individual feels in control of achieving a desired outcome. Within Computer Science, this often connects to how deeply a student feels capable of succeeding and persisting in the future (Doyle, Stamouli, & Huggard, 2005).

Purpose of Study

Teacher communities and policy makers alike focus a great deal of energy on enrolling underrepresented students in Computer Science courses, but less is known about the instructional strategies that support their academic and social emotional gains once these students have been successfully recruited. This study hopes to broaden educator understanding of how these underrepresented students, once enrolled in a CS course, construct their sense of belonging, develop content skills, and ultimately build their understanding of what CS is and who can succeed within this field. The purpose of this study is to explore how various forms of collaboration in CS classrooms shape student experiences. Specifically, this study seeks to understand how collaboration with and without the presence of Positive Interdependence impacts the social emotional and academic gains of Black, Latinx, and female students.

Current research provides ample support for the use of collaborative activities to support student learning at virtually all levels of instruction (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Gillies, 2019; Gray, et al., 2019; Jensen et al., 2002; Klein, 1975; Mabry, 1985; McDowell et al., 2006; Nosek, 1998; Porter et al., 2011; Shelly & Troyer, 2001; Walker & Crogan, 1998) but the majority of these studies are lacking student voice and direct consideration of how students perceive cooperative instructional strategies. An inherent characteristic of these strategies is the shift of responsibility from the teacher to the students. When these strategies are deployed in a classroom, the responsibility of problem solving, communicating, and building relationships is of course facilitated by the teacher but is carried much more heavily by the students themselves. Thus, it is imperative that the implementation of these strategies is accompanied by a deeper understanding of how students perceive these peer interactions. By building upon educator knowledge of how students perceive the benefits and obstacles associated with collaboration, this study aims to illuminate the extent to which these types of activities can be leveraged to support Black, Latinx, and female student success.

Research Questions

This study addresses the effect of Cooperative Learning on the Social Emotional and Academic Experiences of underrepresented high school students enrolled in a CS course. In order to address these issues, the following research questions were developed:

1. What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?
    a. To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?

b. To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?

2. What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?
    a. Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?

Theoretical Framework

This study explores the role that Cooperative Learning opportunities play in underrepresented student experiences in high school CS classes. Working with partners or teams is a fundamental element of K-12 classrooms, and learning to work *well* with others is a fundamental goal of education. While a teacher's motivation for implementing collaborative opportunities can vary, the goals typically connect to the content learning objectives at hand. However, through Situated Learning Theory (SLT) we see that the byproducts of peer interaction extend far beyond the academic learning objectives and can have lasting impacts on social emotional factors as well. Thus, both explicit and implicit learning occurs through these peer interactions. When working in a collaborative setting, students build and modify the frames by which they participate and behave, and "the development of knowledge is constrained by every individual's conception of what [they] are supposed to be doing" (Clancey, 1995, p. 49). As students enter a new classroom, the development of these new frames is likely informed by the frames they brought with them. Thus, although female, Black, and Latinx students who enroll in a CS course may enter with preconceived beliefs or frames, the peer interactions they experience inside these classrooms will contribute to the new frames they build.

These frames that students construct within a CS classroom will guide their behavior and beliefs moving forward within that environment and thus it follows that one's identity within a community begins to shape as a result of these interactions. Thus, when considering the experiences of Black, Latinx, and female students, collaborative opportunities may have short and long term effects on an individual's sense of efficacy, belonging, and overall comfort within CS environments. Our current understanding of how this frame development and social emotional factors for Black, Latinx, and female students are influenced by peer interactions is extremely limited. Thus, this study applies the fundamental tenets of SLT along with a Narrative Inquiry framework to explore how peer interactions shape the frames and social emotional beliefs of Black, Latinx, and female students within high school CS classrooms.

Through SLT, any interaction that includes listening, speaking, collaborating, or otherwise working with another individual is considered a social interaction, and these interactions are used to shape an individual's sense of belonging and identity within a greater setting or community (Lave & Wenger, 1991). Over the course of an entire school year, students enrolled in any course will naturally become part of a "community of practice" (Clancy, 1995, p. 51). The recent expansion of CS within high schools means that our understanding of these communities is still developing. Within K-12 classrooms, collaboration typically falls into one of two categories: Collaborative Learning and Cooperative Learning. Each of these two approaches vary in both their implementation and their impact on student experiences. While the implications for each have been explored in non-CS classrooms and within CS classrooms at the post-secondary level, our understanding of how these two forms of peer interactions impact Black, Latinx, and female students is still developing. Thus, using our existing knowledge of SLT, this study uses a Narrative Inquiry framework to unpack the perceptions that these students

have related to peer interactions so that educators may continue to unpack the implications of Cooperative Learning.

Narrative Inquiry allows educators to understand problems and relationships through the lens of the individual that experiences them firsthand (Connelly & Clandinin, 1990; Creswell, 2008). Individuals are given a chance to narrate or recount their interactions in a way that preserves their unique experiences and typically focuses on individual voices that are often unheard or silenced (Creswell, 2008). This approach was especially important given the historical exclusion of Black, Latinx, and female voices. This study implements this framework through the inclusion of three, qualitative phases that each prioritize the lived experiences of the participants. These phases included a focus group and two individual interviews that allowed the researcher to prioritize the direct voice of the participants and the semi-structured nature of each phase allowed the unique experiences to guide the unpacking of each individual narrative.

Methodology

This study explores the perceived connections that students form between peer interactions, their sense of identity, their sense of belonging, and their social emotional well-being within their CS class. In addition, the study will examine the differences that students discern between peer interactions in CS classes vs non-CS classes. These relationships and differences will be investigated across four phases. In the first phase, a survey will be administered to all students enrolled in a CS class at two different high schools. Using the results of the survey, 3 - 4 participants will be selected from each school so that the remaining qualitative phases will include the voices of students who have been historically excluded from CS. In phase two, this subgroup of approximately 8 participants will engage in a semi-structured focus group. The last two phases will include two individual, semi-structured interviews with

each of the participants. Each of the phases will be spaced approximately three weeks apart to allow the principal and secondary researchers to revise the instruments for subsequent rounds based on the findings that emerge from preliminary rounds of analysis after the focus group and initial interviews.

Significance

This study seeks to build upon the limited existing knowledge of best practices for CS high school teachers. Access to CS at the secondary level is expanding faster than ever, and curricular packages are being developed to allow teachers of all comfort and experience levels to facilitate these courses. However, educators and researchers must not overlook the need to properly prepare teachers so that they may facilitate these courses in a way that supports and includes underrepresented student populations. Collaboration and group work are some of the most basic instructional practices a teacher can carry into a classroom, but how these interactions contribute to a sense of belonging and identity, especially for Black, Latinx, and female students, is something that must be understood at a deeper level in order to better retain these students and begin to close the gaps that exist at the postsecondary and professional levels.

Additional significance of this study lies in the extensive look at student perception of these classroom experiences. The vast majority of our current understanding of best practices stems from quantitative data. Student voice, as examined through three rounds of qualitative data collection, will provide much needed insight into the understanding that students build surrounding teacher facilitation of collaboration. Current CS research focuses heavily on data related to enrollment, persistence, academic achievement, and general demographics related to each of these measures. By taking a closer look at the student perspective, the existing research

will be supplemented by a better understanding of how to build positive experiences for students and promote inclusivity within the classroom and greater CS community.

Chapter 2: Literature Review

Overview

Computer Science education is experiencing unprecedented growth: more states are making CS a graduation requirement, more universities are accepting high school CS courses as a math or science credit, and more students are enrolling in these classes and taking advantage of this rapidly expanding field (Code.org, 2020; College Board, 2020a; College Board, 2020b, Wang & Moghadam, 2017). This growth presents our education system a unique opportunity to develop this subject area so it not only includes all students but supports them through the use of research-based curriculum and instructional practices. Although CS as a field has been around for decades, access is only recently becoming widespread, which means there is an insufficient pool of trained teachers, thus many CS teachers are inexperienced with the content. Luckily for these educators, what CS programs across the country need more than content masters are advocates for traditionally underrepresented students. The number of female, Latinx, and Black students enrolled in high school CS classes is staggeringly disproportionate, and the gaps only grow bigger when looking at rates of persistence within CS college majors and hiring statistics (Alvarez, Burge, Emanuel, Gates, Goldman, Griffin, & Washington, G. 2020; Andersen & Ward, 2014; Camp, 2012; Goode, 2008; Goode & Margolis, 2004; Grant, 2019; Holman, 2019; Landivar, 2013; Margolis & Estrella, 2017; Sandvig, 2016; Teresa, 2018; Toldson, 2018; Treu & Skinner, 2002).

Although best practices for CS education at the secondary level are still being explored, by examining instructional strategies already proven to be successful at increasing diversity at other grade levels and within other content areas, educators can better understand how pedagogical decisions can directly support closing the aforementioned gaps. This strengthened

understanding can inform the way teachers across the country approach the development of stronger site-based programs and a sustainable increase in female and minority participation in high school CS by developing inclusive classroom cultures. This literature review provides a deeper examination of the underlying causes of underrepresentation, the long-standing stigmas and obstacles standing in the way of creating diverse environments, and the importance of increasing the number of female, Latinx, and Black individuals within CS classrooms. A review of existing interventions is provided and leads into a discussion surrounding the general pedagogical practices that have proven effective in a variety of CS classroom settings. Peer interaction emerges as a common thread amongst these interventions, and a closer examination of these types of instructional strategies is provided. These findings reveal several key differences in the way peer interaction is facilitated specifically related to structured and unstructured interactions. This review examines the beneficial and harmful effects that various accountability structures can create before examining the specific differences between Collaborative Learning and Cooperative Learning. Using a variety of subject area and grade level contexts, this review addresses the relationship between Cooperative Learning, Collaborative Learning, and varied student outcomes. This analysis provides support for the eventual claims surrounding the use of Cooperative Learning to support female, Black, and Latinx experiences in CS classrooms.

Causes and Effects of Underrepresentation

When a creative work environment includes individuals of a wide variety of perspectives and experiences, it is more likely to develop newer, more efficient products and ideas because a diverse work setting provides individuals with a chance to focus less on fears surrounding inclusion and more on the innovation at hand. This environment is more conducive to creativity,

free exchange of ideas, and ultimately allows the members within it to reach their most effective state of problem solving (Stevens et al., 2008). However, the homogeneity plaguing the tech industry seems to contradict this very idea. If CS departments and companies remain primarily White and male, the racial and gender uniformity can lead to device discrimination and, at best, creative stalemates (Bobb, 2016; Hoever et al., 2012; Lee, 2016; Rock & Grant, 2019; Sandvig et al., 2018; Stevens et al., 2008). Despite the historical connotation that computers are inherently objective, creativity and subjectivity are integral parts of CS since the capabilities and beliefs of the computers in question are limited to those of the programmer. Thus, the industries striving to produce smarter, better, faster pieces of technology could benefit greatly from including diverse voices and, consequently, more diverse ideas throughout the development process. After considering the industrial and societal implications of allowing this underrepresentation to persist, it becomes increasingly clear that educational leaders at all levels must begin taking more serious action to close the racial and gender gaps in CS.

Before school district and industry leaders can begin to remedy the underrepresentation of female, Black, and Latinx individuals in CS, they must first understand the factors allowing the issue to persist. Researchers have often attributed the existence of these gender and racial gaps to the limited access students have to these courses at the secondary level (Cuny, 2011; DeClue, 2008; Ericson et al., 2014; Goode, 2008; Goode & Margolis, 2008; Google, 2015; Margolis et al., 2012; Margolis et al., 2015; Wang et al., 2016). Although it is unclear what age or grade level serves as the ideal point of representation intervention, it is well-documented that exposure to CS courses before entering college greatly increases a student's chances of succeeding and persevering within the field (Milesi et al., 2017; Taylor & Mounfield, 1989; Wilson, 2002). Thus, researchers believe that by strengthening opportunities for CS at the high

school level, increased participation will follow naturally, and gaps in the number of female, Latinx, and Black students who earn Bachelor's degrees in the field and, consequently the gaps existing in professional spaces, will begin to close. One study found students enrolled in an undergraduate, introductory programming class who had high school coding experience were almost twice as likely to pass the college course compared to their peers who had no experience (Wilson, 2002). There has been a great deal of progress at the secondary level with regards to accessibility; the number of U.S. high schools offering CS courses saw a nearly 300% growth in the last decade (College Board, 2020b). Yet, amongst these courses, less than 30% of students are female and less than 25% are minority students (Code.org, 2020). Thus, access alone cannot be accepted as the sole obstacle to underrepresentation.

Since access does not appear to be closing the gaps at a significant rate, researchers have also turned their attention to the factors that determine why students do (or do not) opt to enroll in these courses. Researchers at various levels of education have concluded that student interest and willingness to enroll are largely connected to long-standing social stigmas that affect students differently based on gender and race (Andersen & Ward, 2014; Giannakos et al., 2016; Grossman & Porche, 2014; Wang et al., 2016). Gender stigmas manifest in a widely held belief that males are better suited for STEM careers while their female counterparts are better suited for careers in humanities or in positions where they can better serve their families and their communities (AAUW, 2010, Brickhouse et al., 2000; Carter, 2006; Grossman & Porche, 2014; Hartman & Hartman, 2008; Kirk & Zander, 2002; Leaper & Brown, 2008; Lewis et al., 2019). One researcher conducted a study across nine diverse high schools to gain insight into the barriers preventing students from pursuing a future in CS. A survey was designed to collect data regarding student perceptions surrounding CS and their motivational factors, or lack thereof, for

pursuing this field as a major or eventual career. The survey was administered to 828 students and, despite having similar aptitudes, as measured by performance in math courses, the females in this study were significantly less likely to consider a future within CS. The results revealed more than 25% of females claimed a significant deterrent was that the field was not "people-oriented" enough (Carter, 2006, p. 30). The belief that females should pursue careers that help others or society at large is a stereotype that appears to significantly contribute to the underrepresentation of females in CS (Carter, 2006; Kirk & Zander, 2002; Werner et al., 2004).

Stereotypes such as these prevent females from confidently pursuing careers within many areas of STEM. In an interdisciplinary effort, a gender studies professor and a CS professor teamed up to further understand why females seem to opt into the soft sciences (e.g. psychology, sociology) as opposed to careers within STEM (Kirk & Zander, 2002). In their study, they consider the word pairs concrete vs abstract, logical vs intuitive, domination vs submission, and they subsequently assert that men correlate with the former and females more so with the latter. The traditional socialization occurring throughout a female's life leaves many of them without the proper epistemologies to succeed in overly competitive, male dominant settings, thus hindering both their confidence and sense of efficacy (Kirk & Zander, 2002). While females have historically been excluded from STEM, they are excluded at nearly twice the rate when researchers turn their attention to CS (Women in Science, 2020). Unique elements of CS appear to amplify the issues that permeate other female-lacking fields. One example of this was found through the basic language deployed by CS teachers "such as 'boot', 'crash', 'abort', and 'kill', which implicitly support themes of violence and domination" (Kirk & Zander, 2002, p. 121). These terms can contribute to an already masculine and competition-driven environment yet there exist several neutral terms (e.g. "start" and "end") that can easily be used in place of their

violent counterparts. Computers and software are constantly going through updates, yet a typical CS classroom is "not attuned to the emerging needs of students and lacks new ways to make use of diversity" (Varma, 2006, p. 130). The way that females view CS and the way that educators view females within CS appear to be key perspectives to take into consideration as researchers continue to develop interventions to increase female enrollment.

Societal biases and outdated stereotypes play a significant role in the persistence of CS racial gaps as well. It is important to note females who also identify as Black or Latinx experience unique, negative effects of stereotypes; however, most research approaches racial stigmas from a solely race-based perspective. While issues related to intersectionality often require separate exploration, this literature review chooses to focus on how racial stereotypes generally affect Black and Latinx interest and motivation to enroll in CS courses. Studies indicate that both systems and individuals within education threaten the success of Black and Latinx students most often by unjustly lowering expectations for the intelligence, motivation, and general ability for success of these individuals (Eccles et al., 2006; Fisher et al., 2000; Grossman & Porche, 2014; Neblett et al., 2006). Teacher expectations of students are deeply related to the development of each student's expectations of themselves, their self-esteem, and their sense of efficacy but can have an even bigger effect on minority students (Cherng, 2017). These stakeholder beliefs and systemic biases can lead to a sense of fear within Black and Latinx individuals; fear that the individual will prove these negative perceptions to be true and thus contribute to their group's stereotypes. Over time, this fear translates into decreased confidence and likeliness to enroll in advanced courses (Grossman & Porche, 2014). Similar to the effects stereotypes have on females, these social and institutional biases present deeply rooted

challenges to solving the underrepresentation epidemic that has plagued CS education since its inception.

Instructional Strategies That Support Equal Representation

As educators, policy makers, and district administrators become increasingly aware of the causes of underrepresentation, an increasing amount of energy is directed towards increasing the number of Black, Latinx, and female students enrolled in CS courses. This is undoubtedly an area worthy of attention; however, once students are enrolled, how does the education system support the long-term retention and success of these students? Creating an equitable system and supportive pipeline for underrepresented students begins with the classroom teachers who welcome these students into their first CS course. Thus, the teachers who work firsthand with underrepresented students must begin addressing the covert obstacles that exist within the classrooms themselves. Computer Science classrooms often identify as having "communication patterns which can be characterized as engendering a defensive climate" (Barker et al., 2002, p. 43). These researchers attribute this to the informal hierarchy and inherent competition between students consistently working to 'out smart' one another. While competition can serve many purposes in other areas of education, it presents unique issues to CS due to the varied levels of experience students enter the classroom with. One national study included a survey of more than 1,600 high school students and found males were over 30% more likely to feel confident in their ability to learn CS when compared to females, and white students were 24% more confident than their Latinx counterparts (Wang et al., 2016). This significant difference in confidence levels, mixed with the competitive nature of CS classrooms, is one possible factor contributing to the widespread anxiety exhibited by female and minority students in CS classrooms (Barker et al., 2002; Lau & Yuen, 2010; Okebukola & Woda, 1993; Treu & Skinner, 2002; Varma, 2006;

Wilson, 2002). The accompanying defensive behaviors that anxious students exhibit allow these students to remain anonymous and socially distant from their peers in these CS classes, further alienating these underrepresented groups.

The overall culture of a classroom is developed by the teacher's facilitation of various Academic and Social Emotional Experiences and it is widely accepted that academic success and perceived ability to learn CS are proven indicators of underrepresented student persistence (Anderson & Ward, 2014; Ericson et al., 2014; Milesi et al., 2017). One study at a large, midwestern university surveyed 105 students enrolled in an introductory programming course and found that the factor with the strongest ability to predict student success in the CS course was their comfort level (Wilson, 2002). In this study, a student's comfort level was measured by their level of anxiety, willingness to ask questions in a variety of settings, perceived difficulty of the content material, and perceived skill level relative to their peers. Interestingly enough, this factor had more predictive power than a student's previous programming experience, general computer skills, and math abilities. This finding supports the need to combat the inherent competitiveness educators find in CS classrooms but also highlights the importance of creating a question friendly culture (QFC) or one where students feel comfortable and confident enough to seek clarification and support openly (Kirk & Zander, 2002; Treu & Skinner, 2002; Wilson; 2002). A QFC can help "counter the 'weed-out' culture" that can occur when underrepresented students fall victim to the "every man for himself" mentality that often plagues advanced courses. (Kirk & Zander, 2002, p. 121). There are many steps educators can take that don't involve redoing their entire teaching style to build a QFC such as intentionally incorporating time into lessons to genuinely seek questions from students, incorporating humor, and increasing willingness to re-explain concepts (Treu & Skinner, 2002). Teachers must also become more

aware of personal biases and how that affects which types of students a teacher calls on, interrupts, or elicits feedback from (Kirk & Zander 2002; Treu & Skinner, 2002).

In addition to encouraging classroom teachers to develop a QFC, researchers have found certain instructional strategies can help reduce the competition and subsequent alienation of underrepresented students. Instructional interventions are especially important to consider given that most CS courses offered at the high school level are classified as advanced, and that tends to carry a certain level of pressure on the teacher to perform. Luckily, there are strategies to support general class culture as well as more traditional measures of student achievement. Inquiry Based Learning (IBL) has long been touted as a superior strategy when supporting student engagement with rigorous academic content (Friesen, & Scott, 2013; Margolis et al., 2012; Panasan, & Nuangchalerm, 2010). This approach, also referred to as Project Based Learning (PBL), requires students to grapple with a real-world problem that relates to the content at hand and through the solution process, students demonstrate various learning objectives (LaForce et al., 2016). This approach relies heavily on Piaget's theories surrounding Constructivism which, at its core, views "the learner as an active entity, and [views] knowledge as being constructed in the learner's mind, rather than being transmitted from teacher to the learner" (Aharoni, 2000, p. 26). When students work together through PBL, IBL, or similarly designed activities that support a Constructivist approach, the responsibility to solve problems, communicate, and build relationships inherently shifts from the teacher onto the students (Margolis et al., 2012; Treu & Skinner, 2002; Wadsworth, 1996). When CS students are given the opportunity to arrive at learning objectives on their own or through peer collaboration, it's been proven to increase both student engagement and achievement (Aharoni, 2000; Ben-Ari, 2001; Goode & Margolis, 2011). Increased engagement combats feelings of anxiety and isolation, while increased student

achievement combats fear of failure and decreased confidence, all of which are feelings that disproportionately affect underrepresented students (Barker et al., 2002; Grossman & Porche, 2014; Lau & Yuen, 2010; Okebukola & Woda, 1993; Treu & Skinner, 2002; Varma, 2006; Wilson, 2002). Not only does this approach stand to support underrepresented students' confidence and sense of self-efficacy in CS classrooms, but the open-ended nature of IBL and PBL allows students to integrate their "cultural wealth" and diversity into the subject matter (Goode & Margolis, 2011; Margolis et al., 2012). Thus, these instructional approaches, or certain components embedded within these approaches, provide underrepresented students with increased opportunities to feel represented and supported within these historically alienating classrooms.

The undeniable interconnectedness of technology with nearly all aspects of society lends itself not just to the use of IBL, but also to the use of Hands On Learning (HOL). This category of instructional approaches is characterized by any opportunity for students to apply abstract concepts to a tangible learning environment and again utilizes Constructivism to give the student more control over their own learning. In the case of CS classrooms, this can take the form of animation, simulation, rocketry, robotics, and electronics tinkering (Buck & Stucki, 2000; Guzdial & Forte, 2005; Hamner et al., 2008; Zimmerman et al., 2011). Similar to PBL, these HOL opportunities allow students to incorporate their unique prior knowledge and experiences, which can increase engagement, confidence, and achievement. In one study involving Georgia Tech students, an introductory class with a previous pass rate of 66.4% was redesigned to incorporate more HOL opportunities and as a result the success rate rose to 90% (Guzdial & Forte, 2005). Additional studies have shown these HOL experiences have statistically significant impacts on the achievement of Latinx and female students, and the general effects of these and

other Constructivist strategies have been found to greatly improve Black student outcomes as well (Hamner et al., 2008; Washington et al., 2020; Zimmerman et al., 2011). As CS course offerings continue to expand to more high schools across the country, it's vital that teachers running these programs utilize instructional strategies that are inclusive of all races and genders. Moving beyond implementation, educators must also work to understand the elements present in these strategies that contribute to their effectiveness.

It is well-documented that having prior experience with CS before entering college greatly increases student chances of succeeding and persevering within the field (Milesi et al., 2017; Taylor & Mounfield, 1989; Wilson, 2002). One study found that students enrolled in an introductory programming class who had high school coding experience were almost twice as likely to pass the college course compared to their peers that had no experience (Taylor & Mounfield, 1989). A more recent study found that self-perceived confidence and skill level of college women was significantly and positively correlated with their likeliness to continue taking courses in CS (Milesi et al., 2017). However, teachers must be cognizant that offering a CS course does not automatically equate to a supportive CS experience. Thus, when discussing and selecting instructional interventions, it's important that the teachers who are steering these classrooms head in a direction that is inclusive by utilizing instructional strategies that support female, Black, and Latinx students. By doing so, there stands to be an increase in the number of female and minority students who feel capable and confident in pursuing CS at the university level, which will subsequently increase diversity at the industry level.

Collaboration as an Intervention

Although the relative novelty of CS in high schools leaves educators with limited knowledge of best practices, key themes emerge from the existing research. Classrooms that

employ Question Friendly Cultures, Hands On Learning, Project Based Learning, or Inquiry Based Learning have been shown to reduce feelings of anxiety, isolation, fear of failure while increasing confidence, academic achievement, and cultural relevance (Aharoni, 2000; Ben-Ari, 2001; Goode & Margolis, 2011; Guzdial & Forte, 2005; Hamner et al., 2008; Kirk & Zander, 2002; Margolis et al., 2012; Treu & Skinner, 2002; Washington et al., 2020; Wilson; 2002; Zimmerman et al., 2011) By providing students with an opportunity to engage with the content while engaging with their peers, teachers allow students to construct their own understanding of the explicit learning objectives as well as their understanding of where they belong within a given learning environment. Each of these aforementioned strategies support the shift from a teacher-centric classroom to one that is more learner-centric. A key tenet of learner-centered classrooms is that individuals must first feel safe before they can be expected to begin developing knowledge either independently or with the support of peers (Combs, 1976; Bransford, Brown, & Cocking, 2000; Turner, 2011). While classroom safety is imperative for students of all ethnic and gender identities, it is well documented that gender and ethnic minority students have an increased likelihood to report feeling unsafe (Voight, A., Hanson, T., O'Malley, M., & Adekanye, L. 2015; Williams, Schneider, Wornell, & Langhinrichsen-Rohling 2018). These decreased feelings of safety correlate with decreased connectedness, quality of relationships, and perceived opportunities for participation (Williams, et al. 2018). Thus, establishing safety within a CS classroom as a means of supporting student-centered learning also stands to support the overall feelings of connectedness and confidence that these underrepresented student groups require.

Student-centered learning takes many different shapes and forms but virtually all of them rely on peer collaboration (Combs, 1976; Bartko & Eccles, 2003; Bransford et al., 2000; Ghaith

et al., 2007; Gillies, 2003; Horwitz, 2009; Lau & Yuen, 2010; Treu & Skinner, 2002; Turner, 2011). While the focus shifts from the teacher onto the students, it is important to note that students must be provided with proper guidance, coaching, and instructions in order for these strategies to be successful. Collaboration must be carefully structured in a way that is mindful of varying levels of expertise as well as the varying needs of underrepresented students. When implemented without fidelity, peer interactions can not only fall short of providing these opportunities for academic and social emotional growth but actually increase the negative emotions and experiences that are attributed with the persistence of underrepresentation within CS (Bartko & Eccles, 2003; Ghaith et al., 2007; Gillies, 2003; Jensen et al., 2002; Mabry, 1985; Shelly & Troyer, 2001; Walker & Crogan, 2008).

Varying Levels of Collaboration and Varying Student Outcomes

As educational leaders continue to uncover best practices for inclusive CS programs, the relatively new expansion of this field at the high school level will place certain limits on the amount of research available. Given these high school CS classes are new environments for most teachers and most students, better understanding of how to support content mastery and develop confidence and efficacy within students will often stem from the existing research from higher education CS courses and secondary, non-CS courses. One instructional intervention that repeatedly emerges within research at all educational levels and content areas is the use of collaboration to improve student experiences. Research suggests various peer-to-peer instructional strategies can benefit both the Academic and Social Emotional Experiences of students in a wide array of educational settings (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Jensen et al., 2002; Klein, 1975; Mabry, 1985; McDowell et al., 2006; Nosek, 1998; Porter et al., 2011; Shelly & Troyer, 2001; Walker & Crogan, 1998). This implies that part of the solution to

underrepresentation lies in supporting teachers as they select and facilitate opportunities for student interaction. Since research shows the persistence of female, Black, and Latinx students in CS is strongly related to both a supportive classroom environment (Barker et al., 2002; Cherry, Cummings, Moon, & Gosha, 2020; Kirk & Zander, 2002; Lau & Yuen, 2010; Toldson, 2018; Treu & Skinner, 2002; Varma, 2006; Wilson, 2002) and also content confidence (Andersen & Ward, 2014; Ericson et al., 2014; Giannakos et al. 2017; Milesi et al., 2017; Wang et al., 2016), any strategies that appear to influence both stand to make an even more powerful impact on supporting these underrepresented students.

While the aforementioned novelty of CS in high school settings limits the research surrounding best practices, a great deal of research exists surrounding the effects of collaboration on university students taking introductory programming courses. While some of these studies have focused on uncovering the shortcomings and obstacles standing in the way of female and minority persistence, many others have quantified the success of collaboration (Barker et al., 2002; Milesi et al., 2017; Taylor & Mounfield, 1989). One notable strategy is Peer Instruction which involves a specific structure for students to respond to content questions and collaborate with peers between questions (Porter et al., 2011, p. 45). This instructional strategy begins with a question that all students answer independently; next they take turns sharing their reasoning with a predetermined peer group, and then students respond individually to a second question measuring the same skill. Researchers used two introductory CS courses to measure the effects of this strategy and found students who missed the first question were significantly more likely to answer the second question correctly after being provided with a chance to collaborate with peers. This strategy was tested using a range of question difficulty, and interestingly, the rates of student improvement were most significant with questions assessing the most challenging

concepts (Porter et al., 2011). While this study did not address the implications of this strategy on a student's Social Emotional Experiences, increasing content confidence is a well-established intervention for Black, Latinx, and female students in CS (Andersen & Ward, 2014; Cherry et al., 2020; Ericson et al., 2014; Giannakos et al. 2017; Milesi et al., 2017; Toldson, 2018; Wang et al., 2016).

Collaborative problem-solving is a recurring theme in many research studies involving CS students at the college level. At the University of California Santa Cruz, researchers carefully designed a controlled, experimental study examining the impact of "Pair Programming" on student pass rates, student persistence into the next level programming course, and student commitment to CS as a major (McDowell et al., 2006, p. 90). Pair Programming is a strategy that involves two individuals sharing a device to complete one task; individuals alternate between giving guidance and carrying out instructions until the task is complete. In this experimental study, students were either enrolled in the course that used the Pair Programming structure or were enrolled in the course that served as the control group where students completed assignments independently. The researchers found that females who were in the Pair Programming course were significantly more likely to enroll in the next level programming course, more likely to pass that course, and more likely to declare CS as their major when compared to females in the control group (McDowell et al., 2006).

While the general success of Pair Programming has been further supported through numerous additional studies, there is very limited data for the effects of this strategy on ethnic minorities (Werner, Denner, Campe, Ortiz, DeLay, Hartl, & Laursen, 2013). The underrepresentation of Black and Latinx students in CS courses often leads to underrepresentation in the research efforts of CS educators. Although many of these studies

provide little to no explicit data for racial subgroups, separate studies found that developing support systems, in the form of study groups or other classroom networks, are a critical part of supporting Black and Latinx student achievement (Ericson, Engelman, McKlin, & Taylor, 2014; Zimmerman et al., 2011). Thus, if this Pair Programming dynamic can serve as a support system, it stands to be as effective at closing the minority CS gaps as it proved to be at closing the gender CS gaps in McDowell's study. Beyond educational contexts, this Pair Programming strategy has also proven to increase confidence, enjoyment, program readability, and program functionality in professional settings, which further supports the usefulness of this strategy for a student's social emotional growth, academic gain, and eventually their contributions in a professional collaborative setting (Nosek, 1998).

In addition to Pair Programming and Peer Instruction, Process Oriented Guided Inquiry Learning (POGIL) is a Cooperative Learning strategy designed to support both content acquisition as well as soft skills such as communication and teamwork (Yadav et al., 2021). This strategy utilizes an "Explore-Invent-Apply" routine and explicit student roles that lets teams navigate through complex programs in a constructivist, student-centered manner. POGIL is designed to increase student ownership of their learning while also increasing the sense of community and quality of peer relationships within a classroom. These benefits are especially important when working to support Black, Latinx, and female students as numerous studies and the key tenets of culturally responsive teaching repeatedly confirm that these student groups thrive when social connectedness and community are valued over competition (Abacioglu, Volman, & Fischer, 2020; Gray et al., 2019; Horowitz, 2009; Kirk & Zander, 2002; McDowell, 2006; Nosek, 1998; Phalet, Andriessen, & Lens, 2004; Werner et al., 2004; Yadav et al., 2021). While this strategy has been shown to increase engagement, it has also been met with some

resistance when students push back against the roles and structure of the activities (Hu, Kussmaul, Knaeble, Mayfield, & Yadav, 2016). In a study of nearly 700 students enrolled in introductory college courses that were each taught by POGIL trained instructors, researchers sought to better understand how students perceive these collaborative activities and what relationships exist between teamwork perceptions, self-efficacy, and performance. Using a survey and end of course learning assessment, the researchers found that the vast majority of students viewed these collaborative activities favorably and also believed that they positively impacted their individual learning outcomes. Additionally, these opportunities for teamwork were shown to improve general teamwork skills such as respecting peer opinions and thinking through complex problems. While subsets of data were not provided for Black, Latinx, and female students, the large sample size of this study did afford a relatively large number of responses from each of these demographic groups. This study provides endorsement for the use of POGIL and collaborative learning as a means of supporting underrepresented students, but the purely quantitative nature of the study does pose limitations on what educators can discern about student perceptions and lived experiences surrounding POGIL and collaboration.

These results support the findings of aforementioned research efforts that carefully designed peer interaction can greatly benefit student attitudes and academic growth (Aharoni, 2000; Ben-Ari, 2001; Goode & Margolis, 2011; Guzdial & Forte, 2005; Gray et al., 2019; Hamner et al., 2008; Kirk & Zander, 2002; Margolis et al., 2012; Treu & Skinner, 2002; Washington et al., 2020; Wilson; 2002; Yadav et al., 2021; Zimmerman et al., 2011). While these findings yields a great deal of promise and insight for high school CS leaders, it is important to consider the wide variety of collaborative strategies and adopt only those that are supportive of inclusion efforts. Collaboration has been shown to be a key ingredient to the

success of college CS students (McDowell et al., 2006; Porter et al., 2011); however, without considering the role each student plays within a collaborative setting, the effects can have a negative impact on female and minority students (Ghaith et al., 2007; Gillies, 2004; Walker & Crogan, 1998). In a controlled, randomized experiment of 168 undergraduate students, participants were randomly assigned to a group that was either homogeneously female, predominantly female, predominantly male, or homogeneously male and were then given either a high or a low structure task. Those groups predominantly or homogeneously male were more likely to exhibit acts of dominance, and this increased further if the task was high structure (Mabry, 1985). This could mean that within a high school CS classroom where most groups will logistically be primarily male, female students could feel less confident and less likely to share ideas even if the teacher had provided structure for students to follow.

To further complicate the idea of providing structure to peer interactions, another controlled, randomized experiment involving over 200 undergraduate students was conducted where researchers had multiple groups work through a common problem; however, before beginning, the researchers arbitrarily selected a group leader (Shelly & Troyer, 2001). The researchers then proceeded to falsely inform each group that the leader had been selected based on either skill, leadership aptitude, or popularity, and when this happened the group dynamic quickly turned negative when compared to the control group where there was no designated leader. The groups who had been falsely informed that their leader had more skill or leadership aptitude demonstrated significantly different speech ratios, with the leader dominating most of the conversation. Interestingly, all members of the group with a supposedly popular leader had significantly shorter speech durations than individuals in all of the other groups. While it is common for collaborative groups to have a leader or facilitator, this experiment highlights the

negative impact that haphazard collaborative structures can create. Thus, educators must not assume that merely providing a group with a common goal will inherently lead to equal contribution from each member or equal feelings of belonging (Bartko & Eccles, 2003; Ghaith et al., 2007; Gillies, 2003; Jensen et al., 2002; Shelly & Troyer, 2001; Walker & Crogan, 2008) and furthermore cannot assume that providing a group with superficial structure will generate the support needed for students to learn collaboratively (Shelly & Troyer, 2001). These studies serve as precautions to educational leaders that not all collaboration is beneficial, and more specifically, not all structured collaboration is fair and supportive to non-dominant groups present in a classroom.

From Collaborative Learning to Cooperative Learning

The insight provided by these studies suggests there are significant benefits to providing students with opportunities to collaborate at both the university and professional level. This same pedagogical approach has demonstrated remarkable success within K-12 education as well. Peer interaction in K-12 environments is usually generalized into two categories: Collaborative Learning and Cooperative Learning. Cooperative Learning usually involves explicit roles for students to follow, the presence of Positive Interdependence, and approximately equal participation. In contrast, Collaborative Learning is more open, involves less teacher guidance, and students determine how much or little cooperation will actually occur. When comparing the effects of these two approaches, researchers have found that Cooperative Learning and explicitly structured peer interactions "can produce significant improvements on measures of academic performance, liking of peers, and racial prejudice." (Walker & Crogan, 1997, p. 381). One possible explanation for these differences is that students participating in unstructured interactions, or Collaborative Learning opportunities, experience an increase in anxiety and

"associated ego defensive behavior" stemming from being uncertain of how to contribute to a group's efforts and whether or not their contributions are even necessary in the first place (Klein, 1975, p. 286). Computer Science classrooms are already predisposed to be highly competitive and contribute to feelings of defensiveness amongst underrepresented students (Barker et al., 2002) thus these unstructured peer interactions stand to disproportionately threaten the experiences of Black, Latinx, and female students. The few key components that transform Collaborative Learning into Cooperative Learning are purported by researchers as being an integral part of successful peer interaction: Positive Interdependence, explicit roles that support individual accountability, and equal participation (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Gray et al., 2019; Jensen et al., 2002).

Positive Interdependence is present in a group when one member believes that they can be successful if and only if their teammates are successful as well (Ghaith et al., 2007). In one experiment, this dynamic was tested by randomly assigning one undergraduate science class to be the control group: during tests they could talk to each other and provide all the help they wanted to, but they would be given a score based solely on the work they turned in. The experimental group was given the opportunity to talk and provide help, but they were told one of the group members' tests would be randomly selected and everyone in the group would receive that score. The success of each member of the experimental group was contingent on the success of their collaborators, and researchers found this group not only communicated more frequently, they also scored significantly higher on the final exam than their counterparts in the control group (Jensen et al., 2002). Similar results were found within a variety of content areas ranging from 1st through 8th grades (Gillies 2003). Additionally, this study showed that when students had been explicitly trained to work in Cooperative Learning groups that employed Positive

Interdependence, students “had more time to work together, they exhibited more cooperative behavior and less non-cooperative behavior” when compared to their Collaborative Learning counterparts (p. 42).

One study focused on the impacts that Cooperative Learning has on student efficacy and student achievement in AP Computer Science Principles courses (Gray et al., 2019). This course was specifically designed by College Board to appeal to a more diverse group of students but since course objectives and curriculum alone do not guarantee inclusivity, researchers turned their attention to the instructional strategies that can be leveraged in these courses. The study defined four collaborative structures and used these to distinguish between group work and Cooperative Learning. These structures included positive interdependence, individual accountability, equal participation, and simultaneous interaction. These structures, according to researchers, were put in place to decrease the chances that students could sit on the sidelines and would instead encourage students to take ownership of both their own learning as well as the collective learning of their team. Researchers trained a cohort of teachers in Cooperative Learning strategies over summer and collected a variety of quantitative data including a pre-training survey regarding each teacher’s background, a survey during the school year regarding the duration and frequency of Cooperative Learning implementation, a student survey regarding student self-efficacy, the enrollment demographics of their CS classes, individual student AP exam pass rates, and national AP exam pass rates. This process was repeated over the course of three years with three unique cohorts. Although student voice and perceptions were not captured through qualitative data collection, researchers did discover that the use of Cooperative Learning strategies, as reported by the participating teachers, was significantly and positively associated with student scores on the AP exam. Similarly, the overall pass rates for these students was

significantly higher when compared to the national pass rates. Unfortunately, this finding did not hold true when researchers examined the subset of pass rates for underrepresented students. While this study provides additional support for the use of Cooperative Learning in high school CS courses, there are still many questions educators must answer before advocating for the implementation of these strategies in all classrooms. The unique perceptions that Black, Latinx, and female students create during these collaborative opportunities must continue to be unpacked so these strategies can be leveraged in an effective, inclusive manner.

As researchers continue to narrow their findings regarding the best practices for supporting underrepresented students in high school CS courses, it's important to focus intervention efforts around strategies proven to be effective with supporting both Social Emotional and Academic Experiences. Specifically, peer interactions that incorporate some accountability structures such as positive interdependence, equal participation, or explicit roles have proven effective in improving female and minority student performance in introductory college classes (Jensen et al., 2002; Kirk & Zander, 2002; Mabry, 1985; McDowell et al., 2006; Porter et al., 2011). Additionally, peer interactions have been shown to support academic gains and promote positive Social Emotional Experiences within secondary education classrooms that involve non-CS content areas (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Klein, 1975; Nosek, 1998; Shelly & Troyer, 2001; Walker & Crogan, 1998). However, despite all of this support for the use of Cooperative Learning tenets, our current understanding of these instructional strategies lack student voice. With this in mind, educational leaders could benefit greatly from using student voice and student experiences to gain a deeper understanding of how collaboration, with and without accountability structures, affects underrepresented student in

high school CS courses as well as how these strategies may or may not affect persistence, sense of efficacy, and sense of belonging for these students.

Chapter 3: Methodology

Purpose of the Study and Research Questions

The underrepresentation of female, Black, and Latinx students in Computer Science courses contributes to limited degree conferrals, lack of diversity in the workplace, and, consequently, the stifling of technological innovation (Andersen & Ward, 2014; Bobb, 2016; Goode, 2008; Goode & Margolis, 2004; Hoever et al., 2012; Lee, 2018; Rock & Grant, 2019; Sandvig, 2016; Stevens, 2008; Treu & Skinner, 2002). Yet, increased enrollment of these student groups alone is not enough to solve these larger societal issues. A great deal of research effort has focused on the recruitment of these students, but educators must also seek to understand the experiences they have once enrolled in CS courses. Instructional strategies are among the biggest factors that contribute to student classroom experiences, and current research supports the use of collaborative activities in virtually all levels of instruction (Ghaith et al., 2007; Gillies, 2003; Gillies, 2004; Gillies, 2019; Gray, et al., 2019; Jensen et al., 2002; Klein, 1975; Mabry, 1985; McDowell et al., 2006; Nosek, 1998; Porter et al., 2011; Shelly & Troyer, 2001; Walker & Crogan, 1998). However, many of these studies are missing student voice and thus lack clarity on how collaborative opportunities contribute to a student's sense of belonging, sense of efficacy, and ultimately their understanding of what CS is and who can succeed within this field. When students work together through Collaborative or Cooperative Learning, the responsibility to solve problems, communicate, and build relationships inherently shifts from the teacher onto the students. By focusing on student perception, this study explores how this shift in responsibility directly relates to student experiences.

The causes of underrepresentation within this field are complex and deeply unique for each subgroup and even more so within intersectionalities; however, there are some themes that

remain fairly consistent. These student groups often cite feeling unwelcome, under supported, and underestimated as reasons for not enrolling in CS or not continuing in CS (Eccles et al., 2006; Cherng, 2017; Fisher et al., 2000; Grossman & Porche, 2014; Kirk & Zander, 2002; Neblett et al., 2006; Varma, 2006). Collaborative activities have the potential to target each of these areas of concern; however, not all collaborative activities are created equal. When implemented without fidelity, collaboration can actually amplify feelings of isolation or inequity amongst team members (Ghaith et al., 2007; Gillies, 2004; Shelly & Troyer, 2001; Walker & Crogan, 1998). Thus, collaboration must be approached with intentionality or educators risk doing more harm than good with regards to these vulnerable student groups.

In this study we aimed to provide educators with a deeper understanding of how students perceive various elements of Cooperative Learning activities within high school CS courses. Specifically, it explored the potential relationships that exist between components of Cooperative Learning and student sense of efficacy, belonging, comfort, and general social emotional outcomes. In order to explore these issues, the following research questions were developed:

1. What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?
    a. To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?
    b. To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?
2. What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?

a. Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?

Research Design

This study documented, described, and analyzed student experiences within a high school CS course. It implemented a four-phased, mixed methods design in order to collect data surrounding multiple aspects of collaborative experiences and corresponding student perceptions. Specifically, it used a participant selection variation of an explanatory sequential design. This approach allows researchers to collect a large amount of quantitative data and essentially build an initial profile for all participants. These profiles are used to inform the selection of participants for the subsequent, qualitative phases of the study. This allows the researchers to add an additional layer of intentionality when deciding which individuals will provide greater depth and insight into a particular phenomenon (Creswell & Plano Clark, 2011). This methodology aligned with the goals of this particular study as it allowed the researcher to build a broad, quantitative frame for the participating classrooms through the use of a survey and subsequently use that to inform the selection of student participants. This subgroup of participants then had the opportunity to provide greater understanding of how students perceive collaborative activities through a focus group and set of interviews. Thus it was important that the participant group for these phases was constructed purposefully. Table 1 provides an overview of each phase of the study and its respective contribution to the research questions.

Table 1: Research Questions Aligned to Data Collection Methods

Data Collection Methods	RQ1: What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?	RQ1a: To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?	RQ1b: To what extent are student experiences with Cooperative Learning related to their Social Emotional experiences in Computer Science?	RQ2: What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?	RQ2a: Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?
Phase One: Student Survey	x	x	x		
Phase Two: Focus Group	x	x		x	x
Phase Three: Individual Interview #1	x	x			x
Phase Four: Individual Interview #2	x		x		x

The first phase of the study began in mid-March and included the administration of a survey to two high school CS classrooms. As a fellow CS teacher in the district where the study was conducted, I've worked closely with both of the participating teachers over the past several years. I leveraged these relationships and convenience sampling to determine which school sites would be most compatible with the research goals. Once the two school sites were selected, each of the corresponding teachers provided approximately 20 minutes of class time for students who consented to participate to complete the survey. The survey consisted of questions drawn from

two separate, validated instruments. The questions addressed the following themes: Cooperative Learning, student performance, self-efficacy, student grouping strategies, student contribution to small group work, student engagement in discussion, CS identity, attitude/motivation for the class, and sense of belonging. The survey was designed to build a larger picture of the current state of collaboration at each school site as well as student perception of their participation within these collaborative settings. This survey was also used to screen and select participants for the remaining three phases of the study.

The second phase of data collection included a semi-structured focus group of 3-4 students at each of the two school sites. Using the data collected from phase one, participant selection was completed in such a way that underrepresented groups were oversampled. This decision was made to ensure that the qualitative data was rich with voices from historically excluded groups. This allowed the qualitative phases to focus solely on the perspectives of underrepresented students and ensured a wider variety of attitudes towards collaboration would be included. Specifically, the focus group participants were selected so that each group included voices of students who perceived collaboration both favorably and unfavorably. This phase used a narrative inquiry approach which focuses on unpacking and understanding participant experiences rather than using participant responses to explain a particular phenomenon or preconceived hypothesis (Clandinin & Caine, 2008). This approach places additional emphasis on the voice of the participants as they express their beliefs and perceptions. Narrative inquiry was selected because it is especially useful in supporting participants who are traditionally marginalized as it allows the researcher to collaborate with the participants to capture stories and experiences (Clandinin & Connelly, 2000).

Using the responses from the survey, all efforts were made to accommodate student schedules and arrange a time and day that was convenient for each member of the focus group. At Valley High, all four participants had an agreeable time and thus met together for this phase. However, at Center High, three participants had a common availability and one did not. Thus, the decision was made to hold the focus group with the three participants who could attend and the fourth participant engaged in an individual, semi-structured interview to ensure that this participant's responses to these questions were collected.

The questions in the focus group provided students with opportunities to recall positive experiences with collaboration in both their CS and non-CS courses. These questions were developed by examining the validated instruments used to generate the survey questions used in phase one. Through multiple rounds of reflection and discussion, the principal researcher and a secondary researcher identified topics from the survey that deserved a deeper look and a series of open-ended questions was generated to provide participants with a chance to elaborate on their positive and negative collaboration experiences in their CS class, positive and negative experiences in a class other than CS, and the general elements of collaboration that they value. For example, the first question on the survey asked students the extent to which they agree with the following statement: "I found working as part of a team in this class to be a valuable experience." In order to gain a richer understanding of their numerical response to this survey question, the participants were asked to "Tell me about a positive experience you've had while collaborating in your Computer Science class" during the focus group.

Additionally, the questions posed during the focus group provided the researcher with an opportunity to introduce three tenets of Cooperative Learning and gain insight into how students perceive the presence or absence of these tenets within their CS classroom. Students were

provided with a handout that defined the three primary tenets of Cooperative Learning: positive interdependence, equal participation, specific roles. This handout can be found in Appendix C. The semi-structured nature of the focus groups allowed the researcher to explore student perceptions more authentically by providing the flexibility needed to add or modify questions based on the group's specific language usage and shared responses. This also aligns with the Narrative Inquiry framework which seeks to understand participant experiences by allowing them to narrate and unpack their interactions in a way that preserves their perceptions. The list of questions used in this phase of the study can be found in Appendix B and a preliminary analysis of the responses to these questions was used to inform additional questions and modifications to existing questions in the subsequent phase.

The third phase of the study included a semi-structured, individual interview with each of the focus group participants. Unlike phase two, these interviews provided each student with a chance to reflect on their experiences without influence from the responses of others or fear of judgment from their peers. The questions used in this phase addressed the components of Cooperative Learning that were explored in phase two but built upon student reflections and sought to gather insight into how these components related to the participant's sense of efficacy and identity within CS. Similarly to phase two, an initial analysis of the results from these interviews was used to inform additional questions and modifications to existing questions in the subsequent phase.

The fourth and final phase of the study began in mid-May and included a semi-structured interview with the participants from the previous two phases of the study. The procedures used in this phase mirrored that of the initial individual interview; however, the questions posed sought to explore potential relationships between student perceptions of Cooperative Learning

experiences and components and their sense of belonging within their CS class. This phase of the study also provided the researcher with an opportunity to seek clarification and elaboration on any previous responses that had been provided.

Once all phases were completed, the data was interpreted using an "analysis of narratives" (Polkinghorne, 1995). This approach acknowledges the unique experiences expressed by each participant at each phase but focuses instead on the similarities and differences revealed across these narratives. By shifting our focusing on the commonalities found across many experiences, our interpretations were able to better inform our recommendations for CS educators. Figure 2 provides an illustration of the methodology and analysis used in this study.

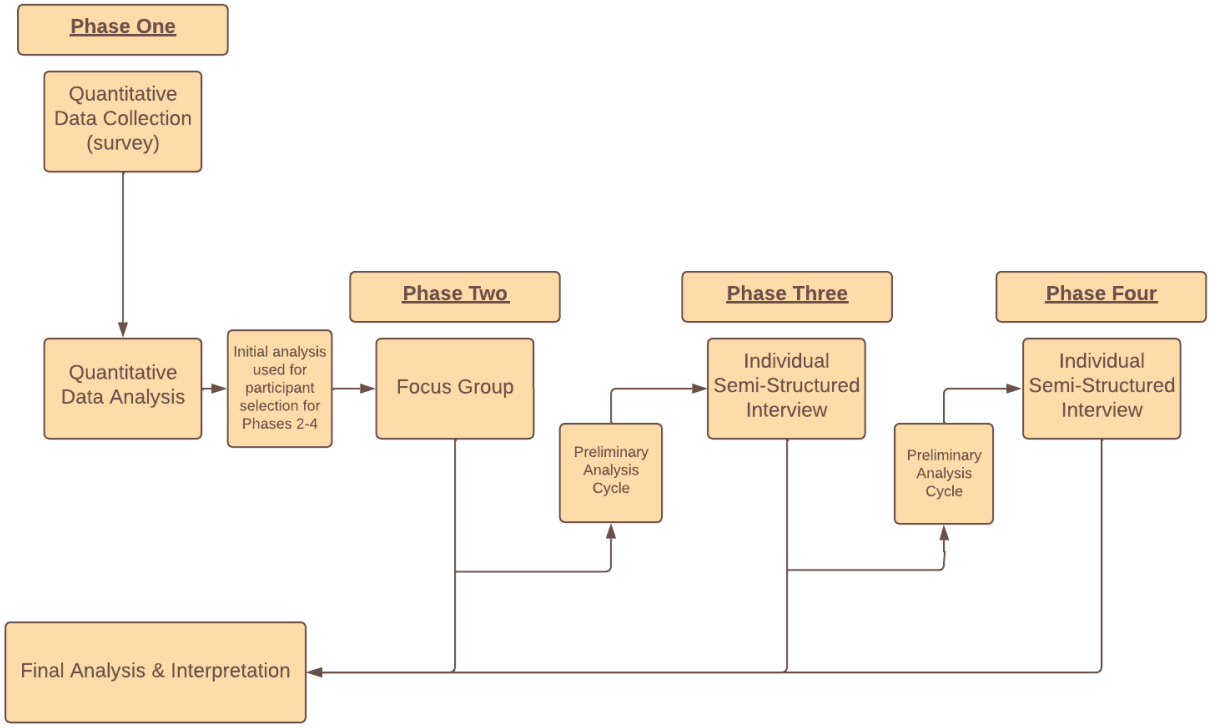

Figure 2: Diagram of Methodology Illustrating Participant Selection Variant of an Explanatory Sequential Design

Recruitment and School Contexts

Recruitment began by sending an email to all high school CS teachers in the Community Union School District[1] (CUSD). This district serves a large community in California with over 36,000 students, over half of which speak a language other than English at home, and over the last seven years it has created CS programs at almost all middle and high schools. The recruitment email explained the purpose and components of the study. This email went out to a total of eight teachers and they were invited to have their classes participate if they felt they used an above average amount of structured collaboration. The principal researcher has over six years of experience working with this group of teachers. Thus the collegial relationships between them allowed for two different teachers to respond saying they didn't feel their level of classroom collaboration would be compatible but two other teachers responded that they would be willing to participate. Both of these teachers were selected to participate based on their informal self-assessment that they each consider their classrooms to use an above average amount of collaborative activities. The principal researcher, through several years of working with the participating teachers, agreed with these assessments and thus their students were deemed to be good fits for the study. Each of the participating teachers has at least 10 years of teaching experience and at least 6 years of experience teaching a CS course.

The participating teachers work at two different high schools: Center High and Valley High. Both schools are classified as Title I and the demographic makeup is fairly similar at each site. Center High has roughly 90% of students who identify as Latinx and less than 2% of students who identify as Black or African American while Valley High has roughly 85% and 1.7%, respectively. Approximately 79% of students at Center High are socioeconomically

[1] Pseudonyms have been used for all organizational names and specific locations

disadvantaged and 74% of students at Valley High have the same classification. Although the survey provided to students in this study acknowledged the existence of more than two genders, current, public records for these schools do not provide information regarding the distribution of student gender identification.

Participants

All students enrolled in AP Computer Science Principles at the two schools were invited to participate in the study. Center High offers three different CS courses: AP Computer Science Principles, AP Computer Science A, and Exploring Computer Science. In addition, Valley High offers two different CS courses: AP Computer Science Principles and AP Computer Science A. Despite the various course offerings at each site, the decision was made to include only students from AP Computer Science Principles for several reasons. At Center High, due to low enrollment, there are only 3 students currently taking AP CSA and while their participation could add value to educator understanding of student experiences in very small CS classes, the opportunities for collaboration are too small and the Center High teacher did not believe the amount of collaboration aligned with the study. In addition, AP CSA is traditionally a more challenging course and consequently, the Valley High teacher expressed concerns over taking class time to recruit students or administer a survey. As for the Exploring Computer Science course that is offered at Center High, since a parallel course does not exist at the second participating school the decision was made to only include the shared course to reduce the possibility of course type as a confounding variable.

AP Computer Science Principles was introduced by College Board in 2016 as a way to increase engagement and enrollment in CS. It is classified as an “Advanced Placement” course but it is designed to be an introduction to the foundations of CS. Students spend a majority of the

year learning how to program; they are introduced to variables, conditional statements, loops, lists, procedural abstraction, and more. The remainder of the course is focused on building a basic understanding of how the Internet works, an introduction to data and cybersecurity, and an exploration of the global impact of computing innovations. There are no formal prerequisites for students to enroll in this course and teachers have the unique opportunity to select which programming language(s) they would like to introduce in their classrooms. Many teachers, including the two participants for this study, opt for a block-based language, as opposed to text-based, which further increases the ability for novices to find success in this course.

Once the schools and the courses had been selected, students were informed of the study overview and requirements. Of the 82 total students who were invited to participate, 23 completed the consent forms. However, in an effort to increase validity, one question was included in the survey to reduce the possibility that students were selecting random answers to the Likert scale questions. The question simply prompted students to select the value two on the scale. Thus, once all responses were submitted, the researcher determined that anyone who responded with a value other than two was not reading the prompts thoroughly enough to provide genuine responses and thus all of that individual's responses were removed from the data set. One student at each school responded with a number other than two and thus we were left with 21 students who completed the survey. Once all survey responses were received, the principal researcher engaged in a brief round of data clean-up to provide additional validity to the results of the study.

In order to best address the research questions and uncover student perceptions and experiences, the majority of the data collected was qualitative. Thus, the subsequent phases of the study involved a significantly smaller number of participants. The primary goal of the survey

was to provide a general categorization for each student's views towards collaboration. This allowed the qualitative phases of the study to be driven by the voices of students who have both favorable and unfavorable opinions towards teamwork. Thus, the remaining 21 responses were analyzed and used to create a diverse group of eight participants for the three interview phases of the study.

Using the results from the survey in phase one, the principal researcher categorized all students who responded that they were interested in being interviewed into three general groups based on their survey response patterns (SRP). These general SRPs were classified as negative, neutral, and positive. Using the summary statistics from the survey data set, the negative SRP emerged as a group of students who were low outliers for one or more questions but were at or above the mean response for the remaining questions. This group represented students whose responses suggested more negative views towards collaboration, lower tendencies to participate, and/or lower senses of belonging or identity. A similar approach was used to identify positive SRPs amongst participants. Any student who did not demonstrate positive or negative SRPs was classified as having a neutral SRP.

Once these two subgroups had been established, each was further split into groups based on responses to the gender identity question. It is important to note that the survey included a "non-binary/third gender" option for the gender question however only one student responded with this option. Furthermore, none of this particular student's responses were determined to be a low or high outlier and they were consequently categorized as having a neutral SRP. Table 2 represents the number of students that were placed in each group, at each school site.

Table 2: Survey Response Patterns by School and Gender

SRP	Negative		Positive		Neutral	
Gender[2]	Male	Female	Male	Female	Male	Female
Center High	3	0	2	2	6	2
Valley High	0	3	0	2	0	2
Total that consented to be interviewed	1	2	0	3	6	3

In an effort to reduce bias, the researcher sought to include an approximately equal number of participants who held generally negative views and participants who held generally positive views of collaboration. While most students had positive SRP, the summary statistics revealed a small subset of three students who were low outliers on at least one question and had also indicated willingness to participate in the interviews. Thus, all three of these participants were selected. To create a more balanced representation of student experiences, the study sought to include the voices of those with boldly positive views as well. When looking at high outliers, once again there were three students who were high outliers on at least one question and had also indicated willingness to participate in the interviews.

With six participants selected, the researcher next sought to fill any potential gaps and balance the quantity of participants at both sites. Only one student on the survey had identified as non-binary and they were subsequently selected to be the seventh participant. Although this participant demonstrated neutral SRPs, their experiences were determined to be aligned with the

[2] While the survey included in phase one provided students with an option to select non-binary, the number of students who selected that option and opted to be interviewed was too small to be included in the stratification by SRP. Thus, the one student who identifies as non-binary, regardless of SRP, was selected to participate.

purpose of this study: to amplify voices of underrepresented students and understand their lived experiences. This left four students from Valley High and only three students from Center High. The interviewer hoped to reduce the potential risks that arise if students drop out or are unable to complete each interview and thus the decision was made to randomly select one final student from the remaining willing participants at Center High. Table 3 provides a summary of the participants, their school, their SRP, and a brief justification of how they were selected.

Table 3: Outlier Summary and Participant Selection Justification

Name	School	SRP	Selection Justification
Nemo	Valley	Positive	Teams worked well - *high outlier*
Jaky	Valley	Positive	Teams enhance my sense of who I am - *high outlier*
Bubbles	Center	Positive	Teams improve critical thinking skills - *high outlier*
Danisha	Valley	Negative	Teams enhance my sense of who I am - *low outlier* Teams helped me better problem solve - *low outlier*
Zoe	Valley	Negative	Teams worked well - *low outlier*
Alex	Center	Negative	Teams helped me develop people skills - *low outlier* Teams enhance my sense of who I am - *low outlier* Teams improve my critical thinking skills - *low outlier*
Moscow	Center	Neutral	Identifies within underrepresented, intersectional subgroup
Eduardo	Center	Positive	Randomly selected from remaining participants that had indicated willingness to be interviewed

Less than 2.5% of each school's population identify as Black and unfortunately across all CS courses and both sites, there was only one student who identifies as Black enrolled and this student did not consent to participate. This underrepresentation has many implications for CS education but for the purposes of this study, it led the researcher to focus their attention on the

experiences of the underrepresented students who did consent to participate. Table 4 provides a summary of interview participants' relevant demographic information as well as each individual's SRP categorization.

Table 4: Interview Participant Summary

Name	School	SRP	Grade Level	Ethnicity	Gender
Jaky	Valley High	Positive	11	Latinx	Female
Nemo	Valley High	Positive	10	Latinx	Female
Danisha	Valley High	Negative	11	Latinx	Female
Zoe	Valley High	Negative	10	White	Female
Alex	Center High	Negative	9	Latinx	Male
Bubbles	Center High	Positive	12	Latinx	Female
Moscow	Center High	Neutral	11	Latinx	Non-binary
Eduardo	Center High	Neutral	11	Latinx	Male

Procedures

Phase One: Student Survey

After receiving approval from the Institutional Review Board (IRB), the researcher distributed parental consent and participant assent forms in both English and Spanish to all of the students enrolled in a CS course at the two participating schools. These forms can be found in Appendix G. The teacher for each of the participating classrooms collected these forms from students over the course of one week and subsequently administered the student survey during a regularly scheduled class period. The survey included validated questions from Yadav's Collaborative Learning, Self-Efficacy, and Student Performance in CS1 POGIL survey (2021)

and UChicago STEM Education's Basics Study Student Questionnaire (2017). The first of these instruments was validated using Crohnbach's alpha ($\alpha = 0.95$) and thus suggested appropriate internal consistency (Yadav et al., 2021). The second instrument was validated through several goodness-of-fit indicators including a Tucker-Lewis Index (TLI = 0.96), a Comparative Fit Index (CFI = 0.97), Root Mean Square Error of Approximation (RMSEA = 0.05) suggesting an exceptional fit (UChicago STEM Education, 2017). The POGIL survey was designed for and validated with first year college students enrolled in CS1 while the Basics survey was designed for and validated with high school students enrolled in Exploring Computer Science (ECS). Both CS1 and ECS are classified as introductory programming courses. A copy of the survey used in this study can be found in Appendix A.

Phase Two: Focus Group

After the data collected from phase one was cleaned and participants were selected, the researcher reached out via text and email, based on participant preference, to arrange a date for the focus group to be conducted. At Valley High, all four participants had at least one overlap in their availability; however at Center High, Alex did not have any common availability with the other three participants at this school. Thus, after conferring with the secondary researcher, the decision was made that Alex would participate in an additional individual interview to replace his participation in the focus group. All students were asked to report to their respective CS classroom after school on the arranged date and each focus group was audio recorded so they could be transcribed and subsequently analyzed.

During this phase, the participants were asked questions that focused on research questions 1, 1a, 2, and 2b. Questions revolved around student perceptions of Cooperative Learning in their CS class, perceptions of Cooperative Learning in their non-CS classes, and

what aspects, if any, are missing from collaborative opportunities in their CS class. Question 1b, which pertained to social emotional experiences, was explored in more depth in subsequent rounds since this question was anticipated to have more sensitive responses. By deferring to a later phase, this would allow more time for rapport to develop between the researcher and the participants. Although this phase was semi-structured, the instrument used to guide the discussion can be found in Appendix B and a handout that students were provided can be found in Appendix C.

Phase Three: Individual Interview #1

Each of the participants from phase two were then invited to participate in individual interviews. The researcher asked participants at the end of phase two to select a time and day to schedule their interview. The researcher made every effort possible to accommodate student schedules; however, these interviews were all scheduled approximately three to four weeks after the conclusion of phase two. This scheduling decision was made to minimize the risk that students would withdraw from the study and preserve the general fluidity of each phase. This also provided the principal and secondary researchers a chance to reflect on the responses from each of the focus groups and modify the interview questions accordingly through a Preliminary Analysis Cycle (PAC) illustrated in Figure 3.

Students were asked once again to meet in their CS classroom, but interview times varied based on student availability. This phase once again was semi-structured which allowed the researcher to ask questions that pertained to the unique experiences being shared in real time. The questions that guided this process focused on research questions 1, 1a, and 1b. The questions asked in this phase sought to build upon the responses provided during the focus group as well as provide additional insight into what relationships, if any, students perceive between Cooperative

Learning and their sense of efficacy. These questions were informed by the PAC and the exact instrument that was used can be found in Appendix D and the handout that students were provided can be found in Appendix E.

Phase Four: Individual Interview #2

The participants from the previous two phases were invited for one final, individual interview. This phase took place four to five weeks after the conclusion of phase three to accommodate the additional time and energy the participants were exerting during a national testing window. Once again, all eight participants were able to meet to engage in a semi-structured interview that allowed for a more authentic and flexible unpacking of their individual experiences. At this point in the study, all research questions had been addressed in various ways but this phase provided additional attention to all of the research questions based on emerging understandings and PAC conversations. This final phase sought to provide an even deeper understanding of the aforementioned research goals but added a focus on the relationships that students perceive between Cooperative Learning tenets and their Social Emotional Experiences. The instrument that was used to guide these semi-structured interviews can be found in Appendix F.

Data Analysis

Preliminary Analysis Cycles

Upon completion of phase 2 (focus group) and phase 3 (individual interview #1), all of the audio recordings were transcribed verbatim using software. To increase validity and preserve the authenticity of participant responses, the researcher read through all transcripts and when unusual or unclear words and phrases were found, the researcher referred back the audio files and cleaned up the transcripts. Once this process was complete, two Preliminary Analysis Cycles

(PAC) were conducted that allowed the respective, subsequent phases to reflect the researchers' growing understanding of the research questions.

The first of these PACs took place after the focus groups. Both the principal and secondary researcher independently analyzed the transcripts from students at Center High. During this independent analysis, each researcher followed approximately the same steps for coding the data sets. While making the initial pass through any given transcript, each researcher read carefully for implicit and explicit meaning, when a novel idea, experience, or observation was found, the researcher would pause to highlight or otherwise denote the segment and use that segment to name the code. To the best of their ability, this portion followed In Vivo coding practices where the names for the codes are generated using direct language from the participants. This decision was made to place increased importance on the student's perceptions of their experiences, as opposed to merely the researcher's interpretation of those experiences. This approach is particularly helpful when research efforts want to "prioritize and honor the participant's voice" (Saldaña, 2009, p. 74). Additionally, when studies work with youth experiences, In Vivo coding provides additional strength to the analysis because it honors the often silenced voices of children and teens, preserves their exact perspectives, and consequently deepens adult understanding of their worldview (Charmaz, 2006; Saldaña, 2009). In Vivo coding is inherently inductive since the codes are identified after the themes and patterns begin to emerge from the direct voice of the participants (Saldaña, 2009). The In Vivo codes were then collectively examined and grouped based on commonalities, these groups served as guiding themes for the remaining analysis and interpretation processes. In addition, this added increased alignment between the data analysis stages and the overall purpose and research questions that were guiding the study. Once these novel codes had been named, they were subsequently used

throughout the remainder of the transcripts to identify additional excerpts that support the original idea.

The first PAC yielded a great deal of insight surrounding the initial codes. The principal researcher had identified twenty-eight unique codes while the secondary researcher identified twenty. Through discussion, the researchers realized that all twenty themes from the secondary researcher mapped onto one or more of the twenty-eight themes from the principal researcher. For example, the secondary researcher generated “reciprocation, friendship” and the principal researcher generated “reciprocity” and “new friendships”. Similarly, where the secondary researcher had identified “product - good due to role”, the principal researcher had identified “stronger product” and “explicit roles”. The discussion surrounding these shared interpretations led the principal researcher to find increased value in the separation of certain codes with the eventual goal of merging them all into larger, more comprehensive themes once all data had been analyzed.

The researchers then turned their attention to the instrument that would be used for the first interview, phase three. These questions had been drafted approximately three months prior and thus there was significant room for improvement. One observation from the PAC discussion was widespread unfamiliarity with one of the specific tenets of Cooperative Learning: positive interdependence. Thus the first question was rewritten so instead of referring to all three tenets, students would be asked questions that unpacked their specific perceptions of positive interdependence. So the prompt “tell me about a time where you felt these elements were present” was replaced with “tell me about a time where you felt positive interdependence was present”, “tell me about a time you felt your partner cared about your success”, and “tell me

about a time you felt your partner did not care about your success". Similar changes were made to several other questions to elicit more detail and insight from students.

The principal researcher then used the finalized codes to analyze the remaining focus group transcripts. This allowed an additional opportunity for any points of confusion or wonderings that emerged from the other participants to be considered in the framing of the instrument for the subsequent phase. During this process, the principal researcher identified three additional themes but felt the current instrument was designed in a way that would address them and thus no further changes were made to this resource.

Before the fourth and final phase, the researchers engaged in a second PAC. One participant at each school was selected for both researchers to code independently. The participants selected were Eduardo and Danisha. Similar to the first PAC, the principal researcher and secondary researcher discovered a great deal of overlap between the codes that they had independently identified. However, since phase three was designed to prioritize depth of experiences, less novel themes had been identified overall. The principal researcher identified six while the secondary researcher identified four. Once again, these codes had a similar nature but slight differences in label. For example, the secondary researcher identified "creating a relationship" while the principal researcher identified "bonding/creating relationships". The conversations and justifications revolving around these novel codes and those identified from the previous round of analysis were used to further refine the instrument for the final interviews.

Through these conversations, the researchers reflected on the minimal insight into research questions 2 and 2a and added two more questions to take a deeper look at the differences between CS and non-CS classes. Additionally, questions that appeared to have already been answered were removed. For example, through questions related to specific roles,

the participants had discussed multiple times their contributions and their explicit titles related to collaboration so the question “describe the role you most often play during group work” was removed from the previously drafted instrument. Following this discussion and refinement, the principal researcher then independently analyzed the six remaining transcripts using the agreed upon codes.

The principal researcher coded the phase four interviews independently but followed the same aforementioned process: read through the transcripts, pause to identify novel ideas and insights, attach labels to these using In Vivo coding, read through remaining transcripts to identify additional support for said codes. The final interview served many purposes related to the goals of the study but it was largely in place to strengthen rapport between the principal researcher and the participants and clarify any remaining wonderings that stemmed from the PACs. Thus, there were not any novel themes identified while coding the phase four data. Instead, additional evidence and greater depth was added to the codes generated in previous phases. Figure 3 provides an overview of the PAC process.

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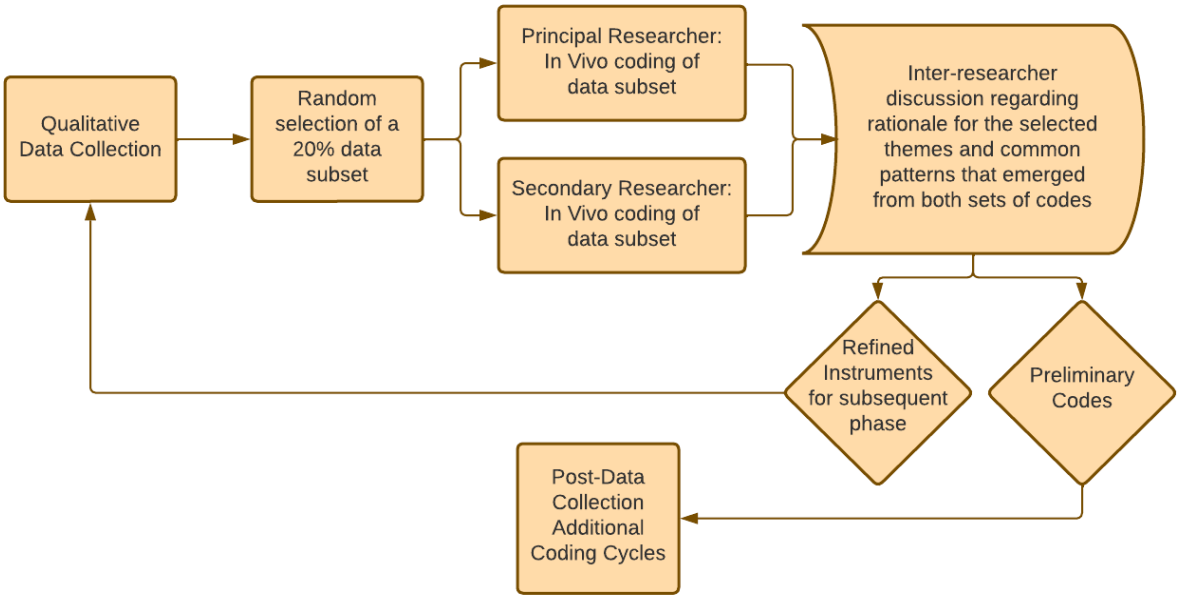

Figure 3: Preliminary Analysis Cycle

Additional Coding Procedures

Each of the preliminary data analysis cycles that were conducted after phase 2 and phase 3 added clarity and depth to the overall collection of qualitative data and they also provided a foundation for the final codes. During these cycles the principal and secondary researchers worked together to uncover and calibrate their understanding of the participants' lived experiences. However, these cycles only addressed a subset of the data collected during phase two and phase three. Thus, following the conclusion of each PAC and the conclusion of phase four, the remaining interview data went through the aforementioned transcription process. Once all audio files were transcribed, the principal researcher completed the remaining analysis independently using inductive and deductive strategies. The deductive strategy took the codes generated through the PACs and as the researcher examined the entirety of the qualitative data, additional excerpts were assigned to these codes. However, since the PACs only examined a

subset of data from phase two and three and was not applied to any data from phase 4, there was a significant amount of participant voice left to be analyzed and consequently there were additional patterns that had yet to be uncovered. Thus, this pass through the data also used an inductive approach which allowed the researcher to pause and derive novel themes. The additional coding procedures ensured that all qualitative data had been analyzed and not just the subset that was used during the PACs. This increased the evidence that was generated for each identified theme as well as allowed the researcher to identify important themes that were not present in the previously analyzed subset.

Quantitative Analysis

Statistical analysis software was used to conduct basic analysis on the data collected from the survey used in phase one. This tool was used to generate the summary statistics of the entire data. Given the relatively small number of students that consented to participate in phase one, data from both school sites were analyzed together. In addition to summary statistics, the software was used to generate calculate outliers and these were used to classify the SRP for each participant. The distribution of SRPs across gender and school site can be found in Table 2. In addition, a summary of the low outlier and high outlier responses that were used to justify participant selection for phases two through four can be found in Table 3. Given this study's focus on student perceptions and amplifying the voices of underrepresented students, this was the extent of the qualitative data analysis.

Data Interpretation

Once all four phases were complete the researcher focused on the codes and themes that emerged from the three rounds of interview data. This study sought to understand the lived experiences of underrepresented students in CS classes and thus the testimonies provided

throughout the qualitative data collection served as the focus for interpretation. Furthermore, the Narrative Inquiry framework implemented by this study placed additional emphasis on the individual experiences and unique perceptions shared by the participants.

These eight, unique narratives were then used by the researcher to conduct an analysis of narratives (Polkinghorne, 1995). During analysis, participant's data set was coded and analyzed in such a way that treated each participant's experiences as isolated. However, through analysis of narratives, these eight isolated testimonies were brought back together and viewed collectively to begin drawing connections between them. This approach preserves the uniqueness of each participant's experiences but instead of staying within a single perspective, the researcher examines the data set to look for similarities and differences. All data was looked at collectively and was analyzed as one story from eight different perspectives. The story is told through the voice of the participants but it also includes their thoughts, feelings, and beliefs connected to peer interactions. The codes and corresponding themes that emerged through this retelling of their lived experiences, allowed the researcher to view these peer interactions through the lens of the participants themselves. This lens and the themes it illuminated provided evidence of relationships between student perceptions of Cooperative Learning tenets and their individual senses of belonging, identity, efficacy, and other social emotional factors.

Positionality

As a CS teacher, the researcher has an extensive understanding of both the course context and the accompanying instructional strategies that are being examined. Additionally, the researcher has worked in the same school district as the participating teachers for eight years and has collaborated with them both for at least five years. Thus, the researcher has built strong relationships with both teachers. While these relationships allow for an increased level of trust

and familiarity, teachers who participate in research efforts have a tendency to feel as though they are being evaluated, and my existing relationship with these teachers could have increased this tendency. The CS teachers in our district meet approximately once a month as a district-wide collaborative team and during these meetings we often compare pacing, progress, and pass rates with each other. Thus, there is a natural tendency for us to compare ourselves to each other and thus there is an increased likelihood that these teachers would want their students to reflect positively on their respective courses and instructional practices. However, the use of anonymity and the minimal role that the classroom teachers played in the actual collection of data reduced the possibility that this affected the validity of this study, thus allowing the researcher's positionality to act more predominantly as a resource.

Limitations

There is a significant need for research that focuses on student perspectives of CS high school courses and while this study sought to strengthen educator understanding on this topic, it was limited in terms of both scope and context. The qualitative data focuses on the experiences of only eight students at only two different schools. However, generalizability was not the primary goal of this study. By examining the lived experiences of even a small number of students, the researcher was able to identify similarities and differences across experiences that are helpful for educators to understand. Thus, while the knowledge generated by this study is unique to these schools, students, and teachers it still provides insight that all educators, and future research efforts, stand to benefit from.

Validity

Numerous efforts were made throughout the study to maximize the validity of the findings. Before data collection began, the researcher made the decision to not use her own

students for this study. When participants, especially minors, are interviewed, there is an inherent feeling of authority placed on the researcher which can affect the authenticity of responses provided. By using students the researcher did not engage with on a daily basis, the teacher-student authority dynamic was minimized. In addition, the participating teachers were instructed by the researcher not to interact with students while they filled out the survey in phase one and were asked not to inquire about the study while phases two through four were being conducted. By doing so, the researcher hoped to solidify the message to participants that responses would not be shared with their respective teachers and subsequently encourage them to provide honest replies. Additionally, before data collection began, the principal and secondary researchers made the decision to create the survey used in phase one from instruments that had been validated through separate studies. This minimized the chances of survey questions being misinterpreted by participants and thus strengthened the validity of the quantitative data that was collected in phase one.

Once the qualitative phases had begun and the eight interview participants had been selected, students were reminded once again that pseudonyms would be used, direct responses would not be shared with their teacher, and confidentiality would be maintained throughout each phase. Additionally, since the researcher used the respective classrooms used for the focus groups and interviews, the teacher was asked to leave the room. This reinforced to the participants that this study was being conducted by a third-party and that the questions and responses were not designed to be shared with or reflective of their teacher.

Lastly, once data collection had concluded and the analysis phase had commenced, the researcher did not discuss the results during the aforementioned monthly collaboration sessions. While the study aimed to provide all educators with insight into student classroom experiences,

the researcher did not want the findings to be interpreted as an evaluation of each teacher's practices nor did the researcher want the teachers to influence subsequent phases of the study based on any details that might have been shared. During analysis, the principal researcher and a secondary researcher each went through a subset of the qualitative data to generate the initial codes. Both researchers then met to discuss the identified themes and thus allowed the principal researcher to consider multiple interpretations, minimize oversight, and provide further validation to the identified themes. These Preliminary Analysis Cycles provided the researcher with an opportunity to identify any points of confusion or novel wonderings before the conclusion of the study and thus provided additional validity to the eventual claims.

Chapter 4: Findings

Through a primarily qualitative, student perspective this study sought to unpack the experiences of underrepresented students in high school Computer Science classes. Issues related to underrepresentation have existed for decades but CS course offerings at the high school level are still relatively new. Using the existing understanding of causes, effects, and interventions related to underrepresentation, educators have the opportunity to ground these high school courses in access and equity. However, the vast majority of research efforts have held a quantitative focus. While enrollment, pass rates, retention, and similar data are valid measures of success, the lived experiences of Black, Latinx, and female students who enroll in these classes must also be understood. This study prioritized student voice and in doing so the results may provide teachers, educational leaders, and researchers with tools to better support these subgroups.

In an effort to reach these goals, this study implemented a four phase, mixed methods approach. A survey was administered in phase one with the primary goal of screening participants so that a diverse group of student voices would be included in subsequent phases. After this group was created, eight participants engaged in a focus group. The data collected here was used in a Preliminary Analysis Cycle (PAC) to identify initial codes, increase validity, and inform subsequent instruments. Participants then engaged in an individual interview, followed by a second PAC, and data collection concluded with one final interview.

As an adult who had never before met these students, the principal researcher held an inherently authoritative relationship with the participants; however numerous efforts were made to increase the comfort level of the students and subsequently increase their willingness to provide an in-depth look into their classroom perceptions. Students were given a chance to select

their own pseudonym in an effort to share ownership of the work being done and this decision, however small, seemed to make a real difference in building rapport with the participants. In addition, by meeting with students on three different occasions in their regularly used classrooms, the conversations did grow in both quality and quantity as the study progressed. As a result of these carefully developed relationships and the eight identities that shone through these shared stories, an asset-based contextualization has been provided in hopes of summarizing the participants in a way that honors their unique personalities.

Participant Summary

Jaky: "Student collaboration, like it isn't all just about just work straight through it's about like building bonds and relationships as well."

Jaky is a kind and hard-working junior who loves movies and music. She identifies as female and Latinx. As a child, her mom needed to drop her off at school early so she was enrolled in a music program. It was there she fostered a love of violin and has been playing ever since. She has a faint recollection of exploring some CS concepts in elementary school but this is her first year taking a formal CS class. She is enrolled in four AP courses and takes a lot of pride in her work. She is confident in her ability to succeed in school and extracurriculars but balances this with a strong sense of humility and humor.

Nemo: [when asked about a time her voice was included in CS] "All the time. I love, that's why I say I love being with partners cause I always get to like tell my thoughts about the program or just like in general, like anything and they'll be like, oh yeah. And then they tell me theirs. So it's like, I'm always a part of it."

Nemo is a cheerful and curious sophomore who loves manga and classic Disney movies. She identifies as female and Latinx. As a kid, she moved around a lot but is really happy in her

current city and would like to stay there even after she graduates so she can stay close to her siblings. She's been shaped by some of the strong women in her life, such as her grandma who raised her and her aunt who has inspired her to pursue a career in CS. She speaks passionately about her many varied interests and with each new interview question, she expressed genuine excitement to share about and reflect on her learning.

Danisha: "Many people struggle when they like listening to other people while they're in a group. Cause they want to do like the things their way. So like I have learned that it's better to listen to people. So things work out better."

Danisha is an outgoing and strong willed junior who seems to be involved in every club her campus offers. She identifies as female and Latinx. After moving to the US in elementary school, she learned English in one year but hid this fact from teachers to avoid being placed in certain classes. Eventually they caught on and she has been enrolled in advanced courses ever since. She is passionate about piano, Ballet Folklorico, and MECHA. She's assumed leadership roles in many different excurriculars and doing so has strengthened her confidence and determination. She is firm in her beliefs but reflective in her actions and experiences. She holds herself and her peers to high expectations but brings humor and an upbeat outlook into all that she does.

Zoe: "If you have to work with somebody you don't know and it's like someone who won't do the work, you learn that. Well, I don't know what you learned from it. Well, sometimes that just happens in like life and it'll probably happen in like the workplace and stuff."

Zoe is a quiet and compassionate sophomore who identifies as female and white. She is very focused on her academics and finds this fitting since she'll be taking six advanced courses

next school year. Once she graduates, she'd like to move to a much smaller town and work as a librarian so she can spend more time doing what she loves: reading. Although she is very soft spoken, once she's surrounded by friends she feels a lot more comfortable being her funny, sarcastic self. She is tentative when asked to speak about herself but when given a chance to talk about her classroom experiences she opens up and is very thoughtful in her reflections on who she is as an individual achiever and her roles throughout collaboration.

Alex: "I still feel really nervous cause I don't know the person. I don't know what they're like. Uh, they could be mean they could be nice. They could be whatever."

Alex is a goal-oriented and studious freshman with a very pragmatic outlook on life. He moved from out of state two years ago and while this can be a challenging time for such a major life change, he has made some connections through the school tennis team. Although he excels within his CS class, his real passion lies within the arts and he hopes to be a filmmaker someday. His experiences with collaboration are mixed but his reflections, both positive and negative, are rich. He appreciates being challenged academically and finds greater reward in trying and failing at something difficult than succeeding at an easy task.

Bubbles: "It is not always easy to collaborate or work on teams, but we usually try to make it happen. So yeah. [Teachers should] just have patience when you have a team that is not progressing."

Bubbles is a thoughtful and responsible senior who exudes kindness in all of her actions and words. She identifies as female and Latinx. She reclassified as English Proficient during her sophomore year and has been accepted into a very prestigious university. She is currently set to pursue a degree in business but has also developed a passion for Computer Science and marketing so she is keeping an open mind. She has played soccer her entire life and would like to

continue playing recreationally in college since she believes sports are an important stress reliever. She thinks carefully before speaking but brings insight and kindness into every conversation. She enjoys being challenged and drawing connections between classroom experiences and her everyday life.

Moscow: "If I was with someone who understood it too much, I get like overwhelmed cause I too am struggling sometimes. Um, but like, I don't really have a preference, but like probably someone who's struggling so that I like, I can help them learn, but also learn with them."

Moscow is an imaginative and bright junior who identifies as non-binary and Latinx. They have a wide range of hobbies that include journaling, video games, horror movies, music, and, just recently, learning to crochet and knit. They grew up locally and have an interest in moving away for college but regardless of the city they end up in, they would like to major in something related to CS. When opening up about their classroom experiences, they put a great deal of thought into their words and as ideas unravel mid-response, they do a wonderful job of pausing to really process and unpack what they're trying to say. Their ability to make connections with others and think introspectively pair beautifully with their big goals for the future.

Eduardo: "If one of our teammates are feeling down, like, no, I can't do, it's like too hard, but by pushing each other, like positivity, it gives like a boost and you seem to work better when your partners believe in you."

Eduardo is a positive and hard-working junior who loves swimming and reading. A couple of years ago, he began playing in professional video game tournaments and has already won a few. He moved to the US from Mexico in fifth grade but despite the many challenges that

accompany this transition, he felt like he adapted quickly. Eduardo seems like the type of student that a teacher could partner with the most reluctant member of a class and they would both be smiling and laughing within minutes. He believes all of his peers have unique strengths and works hard to make connections with others so that he can learn from them and their differences.

Each of the aforementioned participants met with the principal researcher on three different occasions and the semi-structured nature of these interactions allowed the principal researcher to follow each of their unique narratives. The research questions that guided this process are as follows:

1. What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?
    a. To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?
    b. To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?
2. What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?
    a. Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?

The primarily qualitative methodology aligns with the emphasis that this study placed on how students *perceive* team and partner activities within their CS classes. This chapter is framed by these research questions and explores the derived themes from various phases of the study in order to address each question in a narrative approach.

Findings

In total, phase two generated thirty-one unique codes, phase three generated six, and phase four provided additional support but zero novel codes. Once each of these codes had compiled onto a list, the principal researcher then began looking for larger patterns that connected these specific ideas. In doing so, they identified eight, larger themes that encompassed the thirty-seven subthemes. The eight themes are as follows: New Perspectives, Distribution of Effort, Pedagogical Needs, Making and Maintaining Connections, Distribution of Voice, Emotional Well-Being, Physical Obstacles of CS, and Built-In Benefits of CS. Table 5 provides a summary of these themes and their corresponding subthemes, as well as In Vivo examples from various phases and participants.

Table 5: Summary of Themes

Themes	Sub Themes	In Vivo Examples
New perspectives	• Alternative solutions • Answer/generate questions • Support with content/debugging • More comfort with peers vs teachers • Stronger product • Acknowledge individual strengths • Changed preconception • Creativity	"Collaborating with others or working with a partner or group helps to, for me to understand what I didn't understand or didn't know" "I feel stronger cause I've had many ideas suggested to me and I keep taking all of them in and I keep adding it in and we end up creating something very cool because of those ideas" "There is people that not always understands how the teacher is explaining something and I think it is more easy for them when a, a student explains"
Distribution of effort	• Disproportionate voice/effort • Reciprocity • Speed/ease • Explicit Roles • Equal Participation • Positive Interdependence • Dependable/responsible	"I was getting like frustrated them before, so when they started like listening to my ideas, it like made me more, more like warm up to them more than before" "If they did their part, they did their job and they succeeded at it and I did my part and I succeeded at it. Then we can finish the actual project. So we worked individually and then we came together and made something. So their success and my success made one big success" "I'm a very creative person. So when working with a team and they're asking suggestions, I get a sense of who I am, I'm creative"
Pedagogical needs	• Credit/grades • Student wants/needs from teacher • Creativity	"We'd all make sure that we completed our part to make sure we got our, the credit and all that" "Focus a little bit more on specific roles, more than everyone just do their own things. Since I feel like that's, it helps bring out the best best of people when have a specific thing to focus on and not just go work on all this and some people would just get lost"
Making and maintaining connections	• Social connection • Working with friends vs strangers • New friendship • Socially awkward/anxiety • Explicit roles • Not so wasted time • Bonding • Social ZPD • Social growth	"It just takes time to like speak, speak to each other. And I think it'll help if like more like students bond with each other and make sure that they have that communication." "Just observe the class, observe the students, how they're like and based on other interactions and stuff, maybe put them together with someone who's not that social and put them with someone social" "Allow them to meet new people and not just focus strictly on the work. So I think that it's really important that you just let your students work, but also know each other personally"

Table 5: Summary of Themes, Continued

Themes	Subthemes	In Vivo Examples
Distribution of voice	• Disproportionate voice/effort • Equal participation • Explicit roles • Conflict • Compromise • Acknowledge individual strengths • Self-worth • Positive Interdependence • Reciprocity	"I was like, well it's not really like me getting a good grade in this. It was like the partner." "So many people have different thoughts in their own types of ways. I think you eventually like adapt to it and you kind of like create yourself little by little into like who you are" "If you know that everyone knows what they're supposed to do, it also provides some comfort since they should. Like, they wouldn't really be like, oh, I didn't know I was supposed to do this. Cause you told them they were supposed to do this."
Emotional well-being	• Explicit Roles • More focus/less chaos • Stress • Personal growth	"[Specific roles] definitely put less stress on all of us and made it kind of fun, I guess. Cause we didn't, we weren't like all like chaotic, like, oh we have to do this, we have to do that. It was organized, um, efficient." "Relatability plays a big part in that or just joking around, you know, and then getting the job done working. She has her role. I have my role, you know, we're both, we're both doing our part, you know, and we're talking, we're joking, you know, that's, that's really the main factor that gets my nervousness down" "I get kind of nervous when I meet new people. So I was like kind of like enclosed in my own little world until I started talking to her" "Listen to others people's ideas. I think I, um, become more good at it. Like I have a open minded, I have become more open minded"
Physical obstacles of CS	• Screentime • Shared product	"It's a little bit more difficult to collaborate if you like, because we have like a computer then that's the program stays on that computer" "Maybe sometimes go outside because we're always in the computers"
Built in benefits of CS	• Creativity • Shared product	"I really enjoy talking to someone and getting to know them. Sometimes in a whole school year you just go in the class, never talk to anyone and work, but when you have a project, you need to communicate with someone." "In other classes you normally all have the same problem. Well, in computer class, you have a lot more creativity on what you need to do. So a lot of the time you end up mixing your work and get a brand new solutions. Well, in other classes, it's always like the same solution everyone got"

Many of these themes emerged across phases and across various questions. Thus, the remainder of this chapter has been organized by these eight key insights so that each may be unpacked in a way that parallels the students' willingness to unpack them across our multi-phased meetings.

New Perspectives

One core belief expressed by all eight of the participants was a deep appreciation for the exchange of ideas when collaborating. This appreciation shone through many different questions that students were asked across the study. However, it became one of the earliest patterns when students were asked in the focus group "tell me about a positive experience you've had while working with other students" and Nemo responded by saying "it's awesome that like, when you're in, like in a team, like [Danisha] said, it's more fun and also like you get to like share your thoughts with each other and you don't have to be so biased against one thing". Following this comment, Jaky and Danisha expressed feelings of agreement and Zoe gave some additional insight into what was meant by being "biased against one thing". She went on to explain that when "working with other people. Like you may be like what [Nemo] said with like on bias, you may be set on one way, but another person may have a different idea that may work better for what you're supposed to be doing and stuff". These responses demonstrate that students reflect positively on collaborative experiences when they are able to obtain new ideas and outlooks on a given task or problem. This group's responses associate different opinions or ideas from an asset-based point of view as opposed to a source of conflict.

In addition to citing reduction of "bias", the participants expressed appreciation for heterogeneity within their partnerships or teams due to the perceived strengths that each

individual brings to the table. For example, when asked to predict their success with various elements in a future CS class, Moscow had rated “thinking creatively” as their lowest skill. When asked about the role that collaboration played on that self-rating, Moscow replied with a very positive explanation that although they might not feel most confident in that area they greatly appreciate the creativity provided by their various partners. They continued to share that during one particularly important project, Moscow worked with a partner and “she was a like way more creative than I was. So the interface of the project definitely looked more interesting and like satisfying, you could say”. This response indicates this student perceives differences in abilities as a benefit stemming from collaboration. Similarly, Danisha acknowledged and expressed appreciation for the unique strengths that each student brings to a collaborative activity. She expressed struggling with the content but fortunately found support from her partner’s advanced understanding. She claimed, “I didn't like know much about coding. I was like struggling a lot and [my partner] was really good at it. So I was like coming up with the idea as of what to do and what to add to the program and she would do it, we would be like a team”. It was discovered during the focus group that Danisha and Zoe were partners for multiple units so during the final interview when all students were asked what qualities students hope their partners have, Zoe replied that “it's nice when they're, when they have more skills that I'm like weaker in, cause that way we can both just work on our strong suits”. This response was noteworthy since Zoe had been attributed with having a stronger grasp of the content but when given the chance, still expressed a preference for working with someone who has different strengths. With this response, it is also evident that these perceived strengths that each student has are not only appreciated for the sake of the current task or project but also for long-term growth.

This appreciation for different and new perspectives was not just evident when discussing peer vs peer perspectives but also peer vs teacher. When asked what aspects of collaboration students enjoy, Jaky replied that “you can get like the extra help. Like it's not just your thoughts. It's other people's thoughts. And that's not just like a teacher point of view either. Cause like if you're struggling, you ask the teacher for help… Like you can ask your friend or your partner for help and it's a different point of view”. The researcher asked for some clarification on how the student’s point of view differed from the teacher’s point of view and Jaky struggled to articulate her thought by saying “I feel like how do I say this?”, Danisha stepped in and added “[teachers] have a more complicated point of view. Like we can't understand sometimes. So if we ask like a partner, like a student who understood then he can like simplify it”. This appreciation for student perspectives over teacher perspectives was echoed at the second school site as well. When asked to reflect on how they feel when they are able to answer a partner’s questions or help them overcome a point of confusion, Bubbles shared that she wishes she had more opportunities to ask students questions or answer theirs “because I know there is people that not always understands how the teacher is explaining something and I think it is more easy for them when a, a student explains”.

This notion of new perspectives influencing individual understanding appeared across multiple participant testimonies. During collaborative activities, Jaky shared that “you can get like the extra help. Like it's not just your thoughts. It's other people's thoughts.” This perceived relationship between different thoughts and increase in content confidence was shared when Bubbles was asked to explain some of the challenges that arise when working independently in CS. She explained that “sometimes I cannot find my error or my mistakes. So it is difficult because I have to find them. And when you have a partner, he's more clear minded. So he, this

person could easily, um, located the problem". This response indicates that for this student, when different perspectives are not present, the work becomes more difficult and there is an increased risk for errors or incorrect answers. She also explained that when collaboration is not present, her overall product suffers. She elaborated by sharing "I have like, like a lot of ideas in my head of what I wanna do in a code or a app, and I don't know how to start, so I just, I don't follow. I don't follow like a plan, so it get it, it gets messed up." In this scenario, Bubbles conveys a difference between ideas and perspectives. She perceives an overwhelming feeling accompanied by having an abundance of ideas but she explains that she does not have a partner's perspective to help her navigate them and is thus left feeling less confident in her work. This perceived relationship between peer perspectives and confidence in the overall product is echoed by other students.

One of the most commonly cited side-effects of perspectives gained from collaboration was a stronger overall product. When students were asked about the impact that having specific roles had on their collaboration, Eduardo shared that "I feel like in the end it makes the design a lot better. Since in specific roles, you're putting people who are specifically good at what they're doing. And at the end result, it shows that they were, they knew what they were doing when they were making the project." This sentiment highlights the students desire to incorporate individual strengths as well as their perceived increase in the quality of the product. Nemo provided additional insight into this notion of different perspectives leading to a stronger product when she was asked what qualities she hopes her partner has. She claimed that "all partners have their own way of being" but again viewed these differences from an asset-based point of view. This was evident when she continued and added, "if you are like trying to create a really big project, it's best to have that because it enhances the ways things look or the way things are. And it'll be unique too, with both of your, like, um, joining each other to make that special project".

In addition to influencing product strength and individual understanding, collaboration and the exchange of ideas was cited as influencing conceptions surrounding CS as a field. When asked to compare and contrast collaboration in CS vs non-CS classes, Moscow opened up about how they entered this course with a preconceived idea about coding and how sharing ideas with others has impacted that. They stated "I thought like computer science was gonna be solely independent, but then the times that you, we've been partnered or put in groups, it helps either in computer science or any other class I realized. And it's similar that you...Like ideas spread out. Like instead of it being closed in, you see it, how to explain it, like your eyes open. Your eyes open. Your eyes open for me at least." While this belief is shared as a commonality between collaboration in CS and non-CS classes, Moscow explains that there was a preconceived idea specifically related to CS that no longer holds true. They highlight this individual shift in understanding by emphasizing that their eyes have been opened. Additionally, they associate instances of collaboration where "ideas spread out" with a reduction in feeling "closed in" in turn are more open to forming a new or different understanding of what CS is.

Distribution of Effort

How work is distributed, how responsibilities are shared, and how students place weight on these dynamics was a complex and recurring theme throughout the study. When completing group or partner activities, there is an inherent transfer of responsibilities from the teacher to the students. This transfer was addressed explicitly by Danisha when she was asked how a teacher could have supported her during a disagreement between her and a partner, she replied with a simple "it's on us". Zoe expressed a similar sense of responsibility for these situations. When sharing about working with partners who don't contribute, she matter of factly stated, "well, sometimes that just happens in like life and it'll probably happen in like the workplace and stuff".

A significant amount of conflict between partners stemmed from one partner doing more work than the other. When these students were asked how they handled these situations responses varied. Zoe prompted her partner to participate by asking her questions and trying to get involved. She claimed that after her partner had been distracted, the next day she "made sure like I got them to help me with stuff and if I saw it, they were like doing something else. They'd be like, Hey, and then I asked them about something on the program." Moscow took a similar approach and "would kind of trick her into helping me and be like, oh, just, just type in the stuff…I would tell her like, oh, just type in var equals or, um, putting in the, what's it called the functions, all of that. And she'd, like she started understanding it." Others resigned to just completing both shares. Bubbles frustratingly explained that she "ended up doing most of the project" and Alex shared that "they didn't do the work, but I did all the work". In some cases, the issues are perceived as unresolvable. Danisha explained how her frustration from disproportionate effort led to her ultimately confronting her teacher. She explains: " I convinced [teacher] to be with my partner. So I like negotiated."

Not every case dealt with a partner who was not carrying their weight. There were multiple testimonies that involved a student expressing frustration when their partner was doing too much of the work. Zoe explained that one of her partners did a majority of the work for a project. She elaborated by sharing that "it wasn't that the like way of doing the program was like bad or anything. It's just that they weren't taking my suggestions. So, um, the program still ended up good. It just wasn't like with the help of me". Within this partnership, one partner was completing significantly more work than the other but the frustration stems from the partner who was not contributed equally. This frustration was furthered by a reduced sense of accomplishment. She was asked how this experience affected her when she turned in the project

and replied that “it wasn't as much as my work, as it could have been, I was like, well it's not really like me getting a good grade in this. It was like the partner.” Bubbles expressed that sometimes when she works with partners she experiences a decrease in her sense of accomplishment. She shared that “if I don't know something, then my partner does it, but I don't feel anymore that I accomplish. That's how I feel.” The researcher asked if there was anything that the partner could do to restore that sense of accomplishment to which Bubbles replied “explaining it to me so that I can do it, but like with them, help. But not like they do it instead of me”. Contributing to the final product in a meaningful way was perceived as very important to multiple participants and frustration, disappointment, or isolation stemming from having that opportunity taken away was present in their responses. Jaky shared a similar scenario where her partner wanted to work independently and at her own pace. Jaky explains that she “would try to, to like chime in or like try to help in something, but she would say like, oh, it's fine. Just like, just do, um, this instead. So I would do it, but obviously I wanted to like help in the program, but I wasn't able to do that since she was doing it”. Jaky says she felt excluded despite the project being completed, she expresses a desire to help but frustration from not being given an opportunity to do so.

Moscow summarizes some of these challenges when they shared about a negative experience with collaboration. Moscow explained that “they were doing all the work themselves without like talking or anything, or they just didn't do the work. They were just sitting there. So it was like, I like felt like isolated. Left out kind of like, c'mon let's work together”. Through this testimony, Moscow explains that both a partner who does too much and a partner who does too little can leave an individual feeling frustrated and isolated. They explain the importance of an even distribution of effort and how students can associate an imbalance with negative

experiences. This expressed desire for equal distribution of effort was identified as a subtheme: reciprocity.

Many of the participants shared an eagerness to help and be helped, to share ideas and listen to a partner's ideas. When asked about a time they felt a partner cared about their success, Moscow shared about a time where "we both like kind of helped each other, like me telling, explaining, or kind of guiding them also helped me more fully understand". In this explanation, they describe helping and receiving help: their partner was given guidance and an explanation while Moscow cites that their own understanding benefitted from said explanation. This conversation took place during the first individual interview and in the second individual interview, this idea of being the partner who needs support. Moscow explained that it can leave them feeling "a little frustrated at times, but like, I feel like it also helped me to also understand the concepts". When posed with the choice of working with a partner who is struggling or a partner who has a better understanding than they do, Moscow responded with the following:

> Oh god, I feel like, if I was with someone who understood it too much, I, I get like overwhelmed cause I too am struggling sometimes. Um, but like, I, I, I don't really have a preference, but like probably someone who's struggling so that I like I can help them learn, but also learn with them. Um, yeah, cause I feel someone to experience and get like intimidated of how… not intimidated like I'm overwhelmed with how much they know. I'd feel like I'm too slow or not understanding the concepts this fast.

This response further supports their desire to experience a reciprocal relationship during collaboration. Here, Moscow views working with an advanced student as a stressor. They explain that they have a preference for working with the student who is struggling and justify this choice because they can both benefit from that hypothetical partnership.

During her first interview, Nemo expressed strong, positive associations with successful collaboration and reciprocity. When asked in the first interview how her partners have shown

that they care, she replied “all the time”. She continued by describing a time where she was struggling with a project and “she helped me out and I was like, I was thankful for her and then I would help her out with my, um, parameters and stuff.” The focus of this response began with how she felt cared for but she cheerfully concluded her response with how she was able to reciprocate that sentiment. Later in the interview, she was asked to reflect on something that increased her stress in class and her answer related to deadlines but not solely for the sake of her grade, also for the sake of her partners. Nemo shared that her partner “would usually get her work done. There were some moments where it's like, oh man, I gotta get this done. You know, like for the other partner too.” Despite associating this instance with an increase in deadline-induced stress, her response indicates the importance she places on her partner knowing that she can depend on her, the same way Nemo is able to depend on her.

Answering questions to bolster a partner’s understanding, as evidenced in Moscow’s testimony, or seeing a project through to completion because their partner would do the same, as evidenced in Nemo’s testimony, are key examples for this sub theme of reciprocity. However, many participants also sought opportunities to contribute equally because of the positive emotions they experienced as a result. Eduardo explained how some students who finish work early rotate around the room to provide help. When the researcher asked if he had ever participated in this, he said yes and shared that it was “good experience to be able to help someone who's like struggling and then you give them some words and they start working. Then you feel good about it.” While Eduardo’s response does address the increase in the other student’s understanding, he ends by citing his own positive emotions that occurred as a result of these interactions. Similarly, when asked how she feels about helping a partner who is confused, Bubbles shared “I really like to help each, um, to help, uh, other people to success. So it makes,

it makes me happy to help students". Similar to Eduardo's experience, Bubbles' response emphasizes the positive, personal side effect that occurs after being given an opportunity to help a struggling student.

Having the opportunity and content confidence to help a partner when they needed it was a significant concern for several participants. During the focus group, Danisha explained that if she understood the material in a given lesson or assignment, she felt more "excited and relieved" to be working with her partner because she was able to be more helpful. Jaky echoed this sentiment and claimed "you can help other people without being like, oh I think. Or like, oh I'm not sure. Like you're like, oh I know this is right" which Danisha claimed made her "more comfortable". Zoe followed this up by explaining that students are "more willing to voice your thoughts on things if you were like, or that you were right. Or if you were sure you thought you knew you were right. Rather than if you weren't sure. And you might be more hesitant to like speak up about something." These responses suggest that content confidence is perceived as a barrier to helping other students but when that barrier is not in place, they are willing and even "excited" to contribute equally to their collaborative activities.

An additional benefit to these ideal, reciprocal relationships is shared responsibilities and consequently faster completion of assignments. Danisha, while sharing about a positive, collaborative experience, claimed that her and her partner can divide the work equally so "she can be doing the questions while I'm doing like the, the program or in vice versa. Like she could be doing that or both. We could be like working on the same thing, but it's faster. We'd like divide the work. So it's easier to do it." This theme appeared across multiple participant perceptions. When asked to compare and contrast independent work versus collaborative work, Zoe responded that "sometimes you can't find the answers, so you're like struggling a little cause

it takes more effort to find it." This response views collaboration as advantageous because debugging or arriving at a solution can take more time or effort when working independently. Similarly, Alex, whose survey responses had indicated generally negative views towards collaboration, shared in his final interview that "my teacher always says that two brains are better than one brain and I find that true cause there's a lot of stuff that I have to do at once and it can't, so I have to slow down my pace and I'm usually late on a lot of my projects because of that." This response suggests a strong desire to share the workload and an appreciation of being able to work at a more appropriate pace when partners are doing just that.

When asked the same question, Moscow shared an appreciation for independent work in certain scenarios by stating "I can like work at my own pace and time. Like of course it's gonna be like a deadline, but like I can, like, I can work some of it in class. Some at home. I can know how much I, how much I did, how much I need to do mostly." Moscow expresses some advantages to independent work in the sense that they are aware of how much work they did and thus know exactly how much work is left to do. Interestingly, their response provides additional support for Danisha and Zoe's claim that collaboration is beneficial in terms of saving time and energy because Moscow's response assumes that additional time is needed outside of class or at home in order to complete the work that has been done independently. When asked explicitly about their experiences with Cooperative Learning elements in CS, Moscow reflected positively on interactions that had both specific roles and equal participation. When describing the specific roles they've experienced in CS, they attributed these to "equal like workloads kind of, and that you have your roles. Like you don't have to stress about like doing all of it, I guess by yourself or like both of them, it makes it organized, uh, I don't know, easier but more effective". This response provides greater insight into Moscow's views on collaboration versus independence.

There is a perceived relationship between the presence of specific roles, equal participation, reduced stress, better organization, and more effectiveness. The underlying theme of reciprocity emerges most evidently when considering the duality between Moscow's responses. When describing a scenario where partners are working equally, their overall impression is positive. Thus, whether it allowed them and their partner to divide and conquer (Danisha), identify bugs or solutions faster (Zoe), meet deadlines (Alex), or achieve better organization (Moscow) many participants view increased speed as an additional benefit to being part of a reciprocal team or partnership.

Pedagogical Needs

Perceptions of and preferences for various pedagogical practices emerged throughout the qualitative phases of this study. During the focus group, all students were asked about their experiences with the three tenets of Cooperative Learning: equal participation, specific roles, and positive interdependence. Equal participation and specific roles were each addressed by multiple students but positive interdependence was not. Thus, the first question for the first individual interview asked students to talk about a time where they felt positive interdependence was present in their CS class. Through this question, many students expressed a strong, perceived connection between interdependence and the grades they received on collaborative assignments.

Zoe shared that most of the assignments in her CS class are "a program where we both turn like a single one for both of us. So we usually work together to figure that out. So one of us figures it out then helps both of us cause we both get the grades for it. And then like if neither of us can figure it out, then we both probably fail the assignment." Her response indicates both positive and negative interdependence, both from the perspective of the grade they receive on the assignment. In response to the same question, Jaky perceived positive interdependence within all

of the group work they do in class. She shared the following: “the group work we've been doing, like I did the questions and then my partner, or did like the program. And I think we both like, had to have an understanding of what we were doing in order to, you know, like actually be able to do something. And I think that, like, that kind of helps us with like the actual AP exam, because like, oh, if we both know like what we're doing, we can do it individually, like without each other, which is what we have to do for the AP exam.” Her response once again relates positive interdependence back to an earned score on an assignment, here it was the projected score the students would earn on the AP exam at the end of the school year. She does hint at the relationship between positive interdependence and the actual content confidence that both her and her partner have when she addresses the need to be able to “do it individually” but this is again ultimately tied back to the scores she anticipates receiving.

Similarly, Moscow found this element of Cooperative Learning to be present in most of their daily activities. They shared the following:

> We were working on like normal lessons, but they were kind of connected. Like our lessons were connected and we were both working at the same time on the same lesson project. And the other points were like, weren't worth a lot, but like, we both had to get a good score. So like we're both working together on the same, um, uh, what's it called presentation lesson Kind of, um, to both get a good grade, like get, like to understand it and then to get a good grade. Um, And that, wasn't just like, wasn't just that one time, it was like the whole time that we were working together.

Once again, the response addresses the actual skills that each partner is acquiring, but these skills are framed by the grade that both students are receiving on these assignments.

For Bubbles, the presence of interdependence was seen as both a positive and a negative. She shared about an experience where she “had a partner and if she didn't do her part of the project, then it was going to affect me too, because we have to create an app. So we need both parts, you know, the design, the interface and the code to make it work. So if she, um, didn't do

her work, then I wouldn't be able to do my part." Here, she expresses concern over the effect that this interdependence is having on her individual ability to succeed. When asked to elaborate a little more on this, she shared that these situations are "stressful because you don't know if your partner is taking it serious as you are taking it, but so other times it could be great because you have a partner which the same as you like come from... I dunno how to say it. Like yeah. He's, that person is dedicated as you to the work." While the idea of equal participation is alluded to, she perceives the contrast between both positive and negative interdependence as either a "great" or "stressful" experience, respectively.

Alex responded to this question in a way that addresses both issues associated with negative interdependence and issues associated with receiving the same grade as your partner. When asked the same question, Alex was the only student who claimed that positive interdependence was never present in his collaborative experiences. He claimed "no, I've never been, we had that where if they succeed, I succeed, I haven't really had that feeling or I didn't feel like that was going on." Referring back to the other two elements that had been addressed in the focus group, he said "it was mainly, uh, these two specific roles and equal participation that really helped get the group work done." The researcher then asked how he knew that positive interdependence was missing from these interactions, to which he replied "I just didn't think that cause if I succeeded, I felt like cause if they didn't do the work, but I did all the work, they succeeded in a way and I succeeded in a way." This testimony provides an additional perspective for the relationship that these students have made between interdependence and their grades/scores in their CS class. For Alex, his negative view towards interdependence stems from their partner succeeding on an assignment without actually contributing. Assigning scores for projects that are completed collaboratively is a pedagogical practice that must be designed with

student perceptions in mind. For many of these students, their perceptions of this decision seem to be directly connected to whether or not the interdependence is positive or negative.

For Eduardo and Nemo, their perception of positive interdependence was not directly related to the scores they received. Nemo responded to this question by sharing that when working with partners "we both wanna be successful, but like in different branches in a way". Her interpretation of positive interdependence was through opportunities that allow her and her partner to succeed differently, using their individual strengths. For Nemo, these interactions are not directly related to the scores of grades associated with these projects. Similarly, Eduardo reflected on positive interdependence as a form of motivation. When asked to share a time where this tenet was present, he said that "A lot of group projects, especially when there's like a time limit. We, when we push each other to believe we can do it. Like if one of our teammates are feeling down, like, no, I can't do, it's too hard, but by pushing each other, like positivity, it gives like a boost and you seem to work better when your partners believe in you. Give you confidence, even if you're not really sure, but maybe that confidence is all you need to really push yourself over the edge and being able to work really good." Eduardo's response makes no mention of the grade he or his partner receives. Instead he reflects on the confidence gained, the increase in motivation, and ability to overcome something that was previously seen as too challenging.

The differences between student experiences continued to reveal themselves as this line of questioning continued. Students were subsequently asked to share a time they felt that a partner did and did *not* care about their success. When Jaky expressed feeling cared about, she shared that after an extended period of absence "my partner, like she was worried because I hadn't been there and we didn't know what we were gonna do for like the test and she had to help

me out". To clarify, Jaky was then asked if she felt her partner was worried because their grade would suffer or because she wanted to ensure Jaky understood the material. To this, Jaky claimed "she was like genuinely worried because she wanted me to have like an actual understanding of what we were doing." This reflection shows a different perspective to the pedagogical decision to give the same score to both partners. Here, Jaky expresses feeling cared about for both her partner's decision to worry about their score but also the associated concern that her partner shared towards her actual understanding of the material.

In a very similar experience, Danisha shared about a partner who "was like always trying to make things better and like and finish in time so we can get like both credit and she will, even if I was absent, she will always put my name on it." When asked to clarify if she just received credit or if her partner also explained the material, Danisha shared that "she like explained. I was like, what did you do? Like during while I left, she would explain it to me." Once again, this experience cites an instance where one partner received credit despite not contributing being present for as much of the assignment as the other partner. However, these experiences reflect gratitude for this decision because it was perceived as their partner caring about their success. These experiences contrast with some of the negative reactions that students had towards the pedagogical practice of receiving the same grade as their partner. However, in both testimonies, the participants emphasized that they were not just receiving a grade, but were also given an explanation of the concepts. This element of both experiences is where students claim to have felt that their peers cared about their success.

Similarly, Nemo, Bubbles, and Zoe felt that being provided with content support, being able to ask questions, and also being asked questions were all signs that someone cared about their success. Nemo stated that she felt cared about "all the time" because all of her partners have

“always been supportive and have always helped me out even when I need help”. Additionally, for one particularly important project she recalled that “she helped me out and I was like, I was thankful for her and then I would help her out with my, um, parameters and stuff”. For Nemo, being able to receive and provide help, again in a reciprocal fashion, were indicators that their partner cared about their success. Bubbles also felt that asking questions was an integral part of feeling cared for. She claimed that “when we were doing our hackathon project, I had a partner that was constantly asking me if I need help, if everything was okay. Also, when he was doing his part of the project, he asked me like, do you like this part, or do you want to change it?” This reflection echoes Nemo’s perception of the importance of being able to ask questions about the content, but Bubbles also adds the importance of being asked questions about the shared product that is being created. Zoe elaborates on this idea when she shared that “my partner this semester, like very like serious about like the creative aspect of the like programs and stuff. And that's also like a big part of our grades. I can tell, like they really cared cause she spent a lot of time working on the pro... working on like the creative part during class.” Through this experience, Zoe shares the association she has formed between the quality of the shared product and the amount she feels her partner cares about her success.

Jaky, Danisha, Nemo, Bubbles, and Zoe all express some connection between credit earned or quality of the shared product and how they felt their partner expressed concern for their individual success. The pedagogical decision to collect one product from a team or set of partners and the decision to award one score for said product appears to provide varying experiences for students in CS classrooms. For some students, this decision provides students with an opportunity to feel that their partner cares. For others, the experience varies based on the perceived amount of positive interdependence.

Making and Maintaining Connections

For all eight of the interview participants, forming connections with classmates was a deeply integral and intricate part of their collaborative experiences in their CS class. At various points throughout the focus group and individual interviews, seven of the eight participants cited feeling anxious or awkward about working with a partner. Fear of not knowing what to say or how to get a conversation started was a commonly cited concern. When the focus group discussion turned toward working with a student you don't know very well, Jaky shared that "I feel like if was, if you're with like some random person, like you're just awkward and you're like, 'oh uh what are we supposed to do? Like what do you wanna do? Do you like this?' Oh no." When asked about some of the negative aspects of collaboration, Nemo shared that her least favorite part was "being awkward. I don't like not, well I like talking, but like when the other person doesn't talk, I feel like you're talking too much. And then it's like, oh, what do I say now?" When asked about a time where students felt their voice had been excluded, Eduardo reflected that "when like your partners are kind of intimidating to speak up and you're just, your voice is like low and they can't hear you. And when that happens, you kind of just feel low, social anxiety, and stay quiet".

When asked specifically about something that increases stress or anxiety in their CS class, Moscow cited this uncertainty as their biggest source of stress. They shared "what if I say something and like they get offended or they say something and like, I'm like, oh, okay. I don't know. Like, uh, for me that's, that's really like not knowing who they are and that kind of gets me nervous." Here this reflection echoes each of the previously shared testimonies that fear of not knowing is perceived as directly related to not knowing who your partner is on a personal level. This uncertainty of how a partner might react was cited as a source of stress when Bubbles

shared that during a disagreement with a partner she felt “a bit nervous. Because you don't know how your partner is going to take it when you say, like, I don't agree with this.” Not knowing a partner and consequently not knowing how they might react to certain situations was also a source of stress for Alex who shared that “I still feel really nervous cause I don't know the person. I don't know what they're like. Uh, they could be mean they could be nice. They could be whatever.”

These experiences reflect a mixture of anxiety, nervousness, and stress that are attributed to either not knowing what to say or not knowing their partner well-enough to predict their reactions to certain situations. This reflection led to a dominant subtheme: working with friends versus working with strangers. Within the first few minutes of the focus group at Valley High, Danisha mentioned a strong preference for working with a friend instead of working with a partner that she didn’t know. Zoe elaborated on how this affected her feelings of stress when she chimed in and said “like you said about working with friends cause you get along with them better. And so when you have a disagreement, it's easier to like talk about like why like what you think guess like what you should do instead of something. Or like if you think you should do something different or you don't agree with what they're, they're saying it's easier to just like tell them what the issue is.”

Each of the girls participating in the focus group agreed with this sentiment. Danisha said “I agree”, Nemo elaborated by sharing that “it's just awkward sometimes too cause like if you're socially awkward, it's like uncomfortable, but like once you get to know them, then it's like fine”, and Jaky shared that “it's like less tense when there's like people you know”. Danisha explained how much she valued being given the chance to pick her partner in some classes multiple times throughout the conversation and several of these comments suggested that prior relationships

with partners was a prerequisite for some of these students. However, as the conversation continued, Danisha how much she valued being partnered with Zoe. Thus prompting the researcher to ask her to think of a time where she valued working with a student she didn't know. Danisha then explained that her and Zoe "didn't pick each other. Oh yeah. We met, you know." Zoe explained "you just have to get to know how to work with people if you know, if you're not close to them" to which Danisha replied "then be friends later on with them, like Zoe and I".

The insight gathered from this conversation suggested that although students value working with friends, these students do not view 'friend' as a predefined or fixed idea. Instead, friendships emerge as a result of certain collaborative opportunities. The idea of creating new friendships was paralleled at Park High as well. Eduardo shared about a time he was struggling during a project and "thanks to him trying to help me with the code. We started talking and we realized we both had similar ideas and we started talking about it and how we got came up with it. And after that we just started talking more and more in class and you know, we're pretty good friends." Eduardo's reflection stood out because he expressed establishing a friendship that not only lasted the given duration of the unit or project but also extended outside of class. However, this was not an isolated experience, Moscow also shared about a partner who they had never met before but after their teacher gave them some ice breakers they shared that "you kind of like, okay, they're not, they might, they're not fully rude or they're not as who I thought they might have been or feared they could have been. It's actually funny cuz I'm actually good friends with one of the partners that I met during collaboration." This testimony also demonstrates that through collaboration, students feel capable and eager to form bonds that last beyond the scope of the classroom.

Although not all reflections on working with strangers led to forming friendships that lasted outside of class, the idea that a bond could be formed between two students who were previously strangers is one that resonated across nearly all participants. Alex only felt like he had one partner that he collaborated with successfully. He was asked if there was anything he did to make that partnership successful. He replied “No. Mainly just start up a conversation or just talk about things mainly that's really about it.” To clarify, the researcher asked whether or not these conversations were related to CS and Alex shared that they were “not related to Computer Science. Like, uh, our experiences of first year in high school or how sucky middle school was. So, you know, it's just, it's mainly relatability mainly. That's how you really get along with people.” This reflection provides valuable insight into how some students form meaningful relationships with partners. Here, the ability to form relationships was traced back to simply having off-topic conversations. This was not an isolated experience. In one particularly memorable moment of the many different interviews. Jaky was commenting on the general benefits of working with other students and cited one benefit as the ability to “make jokes and stuff” to which Danisha chimed in and seemingly clarified “to waste time”. All four of the girls laughed in agreement and thus sparked the subtheme “not so wasted time”.

All of the participants placed value in these off-topic moments or non-content related conversations. However, the manner in which these conversations began and were facilitated differed for some students. Several students explained that these conversations were structured by their teachers to encourage the development of a bond. Zoe shared that at the beginning of the year, her teacher set up an activity where all students rotated through classmates and the teacher “had us all like find out stuff that's like similar between all of us. So we could like find a common ground with each other”. Zoe reflected positively on this experience even though she

shared that “it was a little frustrating when you couldn't really find anything that you had in common. But other than that, I thought it was like nice to get to know people more.” Alex, Moscow, and Eduardo all expressed similar appreciation for instances where their teacher had facilitated opportunities to create a bond. Alex claimed that “I can get really talkative, but if I don't know a person, I just really quiet and nervous, but if I get to know someone I'm out there, I, I can just go off and talk for hours and hours and hours.” In order to achieve that level of comfort, Alex’s primary piece of advice to teachers is to “mainly pair them up with someone they don't know. Maybe they'll get along, maybe not just do that regularly and you'll be good”. Alex, who demonstrated a generally negative view towards collaboration, reflects a genuine interest in establishing a meaningful relationship with his peers; however his comments also reflect a strong preference for interactions that have been structured by the teacher. This preference was also shared by Moscow. When asked what changes they would make to collaborative experiences more positive, they shared that “if the instructor is pairing the students, to give them like activities to do between them to help us, like not, not really bond, but like to get used to each other cause I feel like after a while, little bit that you know, that person a little bit, you're a little bit more comfortable and it's easier to work with them.” When asked to elaborate on what type of “activities” they would like, Moscow mentioned “ice breakers” multiple times and gave the example “tell your partner about your day or something like that.” They provided additional insight into these activities by clarifying “like little small things, like you may not remember, it's like kind of to get close to the person and to me it helped to get comfortable with my partners”. These seemingly “small things” hold great insight into how this student perceives the teacher as a facilitator and how they perceive non-content conversations as a means of building relationships that are comfortable enough to collaborate effectively. Eduardo provided

additional support for the use of ice breakers; “like what's your favorite food, favorite color, basic questions that normally you can, like, if you find interest in something they say you can become friends from there.” This reflection contributes to this sub theme of “not so wasted time” since these reflections suggest students perceive time away from completing an assignment or a project as an investment in their relationship with their partner.

In addition to guided forms of “not so wasted time”, several students shared similar experiences that were not explicitly facilitated by the teacher. Nemo explained that conversations would naturally arise, she shared that “we would talk a lot and we would have like inside jokes or like just every single day we would just keep on talking to each other and like find out oh, like, wow, you like that too?” Her experience demonstrates a positive reflection on these daily conversations and jokes that would arise but her reflection also demonstrates surprise that she was finding these commonalities with her partner. The inside jokes and humor that stem from these instances of “not so wasted time” was a shared experience with other participants. During the first individual interview, Moscow was sharing about a positive impact a partner made on the overall quality of the project so the researcher asked if any emotions, not grade-related, were impacted by this experience. They replied that their enjoyment was positively affected because “you have to do the work, but um, you can kind of also like goof around sometimes”. This testimony provides support for the relationship between wasting time, incorporating humor, and how positive a student perceives a collaborative experience. Nemo shared that when she and a partner are having an off-topic conversation, “[her teacher] just he sometimes laughs at them too”. She mentioned her teachers ability to laugh along with students multiple times and each time she smiled as she recalled the positive impact that had on the overall experience. This experience shows how Nemo perceived not only the humor between her and a peer, but also

between her and her CS teacher. The role that a teacher plays in establishing student-to-student connections is multifaceted, thus each participant was given a chance to share their perceptions of this role.

Making and maintaining connections with their peers was an evident priority for nearly all of the participants however there was a slight variance in how these students perceived responsibility for these bonding experiences. Participants were all asked a variety of questions in an attempt to unpack these perceptions. When asked to share about strategies that teachers can use to make students more comfortable during collaboration, she replied "it depends more on just the students than the teachers". Danisha, despite having a highly positive opinion towards their CS teacher, felt that they had no responsibility for building connections between students. This statement placed responsibility on the two students that are partnered together, rather than on the teacher who has assigned them to be partners. When asked to elaborate she explained that it's "because even when they have activities, it's more on us, the students, because it's more like, um, if I wanna talk to that person or not, because like the bond has to be like in any relationship, it has to be like both parties, not only one party". This comment suggests that in Danisha's experience, when a relationship only has one student contributing, she does not believe a bond can be formed. This reflection suggests that reciprocity, once again, plays a role on how positively a student perceives a collaborative activity. However, in this instance, reciprocity is expressed as necessary for the social emotional aspect of the partnership, not just the workload.

Most other students expressed pedagogical preferences for how these relationships and connections can be developed. Moscow, Eduardo, Nemo, and Jaky each cited "ice breakers" as being a key strategy but partner design also appeared across multiple student responses. Alex, who expressed that he did not know anyone in his CS class at the beginning of the year,

appreciates when his teacher assigns him a partner, when asked to give advice to a CS teacher, he says they should “mainly pair them up with someone they don't know. Maybe they'll get along, maybe not just do that regularly and you'll be good”. Nemo described a similar preference and even referred to it as “experiments”. When asked about strategies to support comfort between partners, she said “he like switches up the seats. I think that's pretty good, but I think it's best to like, be more interactive with each other and like, do like, um, experiments, like too, like see if things work out or not”. When asked to elaborate on how these “experiments” typically go, she cheerfully explained “of course there is like some kids who aren't like very good at like speaking to others, but it'll just take time”. Nemo expresses a preference for partner design to be fluid but she also expressed a need for her teacher to be patient with this process of forming relationships. This sentiment was shared by several other students.

Zoe, when asked to explain why she felt more comfortable in CS versus another class, explained that “it happened over time as students got like more comfortable with each other.” Alex was asked to explain how his stress and anxiety decrease within a partnership and he claimed “we slowly, slowly start to talk with… we slowly get there”. When asked to share about a time where she felt her voice was included, Jaky shared that about a partner she had first semester and “I felt like I could really talk to her and she would understand what I was trying to say to her and I'd understand what she's trying to say to me. I think that was an experience where I felt that cause just how I said that we both understood each other, even though we started off like kind of shy, we slowly progressed into getting each other better”. When asked to elaborate on a testimony related to conflict resolution, Eduardo shared about a partnership where “in the beginning we didn't agree in ideas or what we wanted to do, but once we had an idea and we started working on it, we started really working together a lot more and it was very good for both

of us and we became like good friends". Each of these experiences, while different in prompt, share a common thread: time. These students explicitly and implicitly reflect on time as a key factor in their ability to develop to make and maintain connections during collaboration.

Distribution of Voice

Many participants cited wanting to feel heard *and* wanting to hear their partner's voice as a primary concern for collaborative activities. Voice was implicitly and explicitly connected to how much student's felt their partner or teammates were contributing to the task. For Zoe, the absence of voice during collaboration in her math class created a shift in how she perceived the entire experience. She cited CS as the class she collaborates most frequently in and the researcher asked her to elaborate on why that is. She shared that "my math teacher does put us in groups, but no one actually like talks to each other unless you like know each other. And a lot of time, a lot of the time you don't, so everyone's just silent. So it isn't really group work. It's just people sitting at a table together." For Zoe, the fact that everyone was silent framed her perception of the experience; despite being placed into a physical group setting, she did consider the experience to be group work. Similarly, when asked to reflect on a time where they felt their voice was excluded in CS, Moscow opened up about a time where "the partners that I got weren't, um, like not including my work, but like, they either, they were doing all the work themselves without talking or anything, or they just didn't do the work. They were just sitting there. So it was, I like felt isolated, left out kind of." This response shows Moscow felt excluded not only in cases where effort was disproportionate, but also during cases where voice was disproportionate. When asked if there was anything that the teacher could do to reduce those feelings of isolation, Moscow replied, "maybe assigning roles to the project or whatever it is, but like, sometimes the students themselves just don't wanna cooperate for whatever. So, um, but I

think definitely like adding roles to like, okay, this person, the designer or the programmer, like, um, adding, not steps, but instructions of a sort that aren't like too constricting, but like, they, they give you like a sense of a path to follow."

Through the use of specific roles and accompanying instructions, Moscow believes that students who are predisposed to not contribute would be more willing to do so. This reinforces the perceived relationship between voice and effort. Since these specific roles were suggested as a possible solution to feelings of isolation, it also sheds light on the perceptions that students have formed related to their sense of belonging and equal participation. Eduardo provided more insight into this relationship when asked about factors that increase his stress or anxiety during collaboration. He shared the following: "Something that increased my anxiety is when all of my efforts to break the ice don't work. Some partners are really like shelled in and when you try to talk to them, they give you very blunt and just like, yeah. Okay. And then like you're trying to keep a conversation started or something and they're just not working with you and you can't really do much at that point since they're like they don't want to talk. So you just kinda, it's kinda awkward silence." Despite many attempts to elicit voice, their partner was not communicating even during casual, ice breaker conversations and, as a result, Eduardo felt an increase in anxiety.

In addition to increased feelings of isolation, anxiety, or awkwardness, a disproportionate distribution of voice between partners was also cited as a source of conflict. During the focus group at Park High, students were asked to share some aspects of collaboration that they didn't like and Eduardo shared that "it can be very hard to like, get your voice out and especially if you don't agree with something they're doing, it can lead to arguing and get no work done." This perception reflects a connection between being able to speak freely, conflict, and lower

productivity. When asked if there's anything a teacher could do to support students with this issue, Eduardo's response mirrored Moscow's: he felt the addition of explicit roles for students would support better balance of both voice and effort. He claimed "if he's given a specific role, so he's like, okay, you work in this and you work in this and in those specific roles have to work together. That helps a lot since we have to communicate to work on it and once you're assigned those roles, it can help a lot since we have to communicate to finish the work." Similar to Moscow, he felt that through the use of specific roles, a teacher can increase the need for students to communicate. When asked about a time where she felt her voice was being included, Zoe began by telling a story about a partner who wasn't listening. She shared that they were working on a project and "at first it was more like, like, a little stressful, cause I didn't think my thoughts were being like heard, but like the second day we came back, like everyone was more like open at about stuff. So whenever I suggested something, they actually like considered it or like tried to implement it." The researcher asked her to elaborate on how she felt during this experience and she explained that she "was getting frustrated with them before, so when they started like listening to my ideas, it like made me more, more like warm up to them more than before." This increase in Zoe's perceived ability to share her voice was connected not just to her stress and frustration but also to her overall relationship with her partner.

For several students, the ability for partners or a team to communicate successfully was directly related to their ability to resolve conflict. When sharing about a disagreement with a partner, Bubbles was asked to elaborate on what elements have to be in place in order for her to feel comfortable openly disagreeing with a partner. She claimed "when there is a, when there is communication between both and there is respect from each other, that is when it is, it is more

easy to share my disagreement." Her experience highlights the perceived importance of equal voice when partners are faced with conflict.

It is important to note that many of these responses indicate, once again, a desire for reciprocity. Previously, reciprocity had been explored in terms of effort and direct contributions to the completion of a program or project; however through these testimonies it becomes clear that students also want voice to be exchanged equally. This is in part because of the perceived relationship between voice and effort but also because of the perceived relationship between voice and feeling valued. When asked to share about a time where she felt her voice was included in CS, Nemo cheerfully replied, "all the time. I love, that's why I say I love being with partners cause I always get to like tell my thoughts about the program or just like in general, like anything and they'll be like, oh yeah. And then they tell me theirs. So it's like, I'm always a part of it." Here, Nemo reflects very positively on all of her collaborative experiences and cites being able to share her thoughts and being able to learn about her partner's thoughts as the source of this positivity. Several students expressed similar connections between feeling valued and an equal exchange of voice. In the survey administered in phase one, Eduardo responded 'strongly agree' to the following statement: "I found that working with a team enhanced my sense of who I am". During an interview he was asked to elaborate on this response specifically within his CS class and his response further highlighted the connections he had made between equal voice and self-worth. He explained that "When you work with a team, everyone has to use their personal own strengths to help the team. As for me, I'm a very creative person. So when working with a team and they're asking suggestions, I get a sense of who I am, I'm creative. I know I can give suggestions out. And every time we work as a team, uh, I feel like I know what tools I have to

help my teammates. So I get more of a sense of who I am, what my skills are and what I can do for them."

This response provides insight into the impact that is made when a teammate asks another for their input. This inclusion of voice not only provided an increase in his sense of self-worth but also in his long-term perceptions of who he is as a person and what strengths he brings into collaborative settings. Although he makes no explicit claims about the coding contributions he is making, by being able to contribute his voice to the task at hand he believes that he is able to uncover his personal strengths and also cites a belief that everyone else must use their individual strengths as well. Nemo also responded to this survey prompt with 'strongly agree' and when asked to elaborate on, she explained "I think because like, so many people have different thoughts in like their own types of ways. I think you eventually like adapt to it and you kind of like create yourself little by little into like who you are." Similar to Eduardo's experiences, Nemo perceives the many different thoughts and voices present in a collaborative setting as a key factor in how she views and creates her sense of self.

Emotional Well-Being

During both of the focus groups, students began citing anxiety, stress, social awkwardness, and fear of rejection as some of the primary concerns related to collaboration. Emotional safety was perceived as a highly important element of successful team and partner activities. The initial introduction that students had was cited by many students as a critical point in the relationship that would develop between them and their peers. All students were asked to share about some things that increase their stress or anxiety when working with a new student. Students were then asked if they felt their teacher could have done anything to support them or reduce that stress or anxiety. Although these two questions were asked during individual

interviews, five of the participants had very similar responses to both questions. Their responses have been summarized in Table 6.

Table 6: Summary of Sources and Interventions Related to Student Stress and Anxiety

Participant	Response to question: Think of a time you worked with a partner that you didn't know. What are some things that increased your stress or anxiety?	Response to follow-up question: Is there anything you think your teacher could have done to help with that issue?
Jaky	Just the fact that I didn't know them at the beginning, um, it would be hard to communicate because we didn't know each other and she was kind of shy and I was kind of shy with her too. And that kinda just made me stress a little because I was like, oh, what if it never gets better? Like what if we don't get to know each other? And then we both get lazy and we just don't wanna talk to each other and we don't do our work and that kind of stressed me out, but turned out fine in the end.	Allowing us to do our work together and not just like talk about school, but talk about other things while we do our work. I think that helps because we get to know each other better and we also get to know how we like to do our work together
Nemo	I get kind of nervous when I meet new people. So I was like kind of like enclosed in my own little world until I started talking to her.	Usually for like when you start the school year, you know how teachers start with icebreakers, I think that'd be like really helpful or like when you ask them questions about certain serious topics, not serious, but like just making sure that, you know, the person beforehand, it would be a much more helpful
Eduardo	Something that increased my anxiety is when all of my efforts to break the ice don't work. Some partners are really like shelled in and when you try to talk to them, they give you like very blunt and just like, yeah. Okay. And then like you're trying to keep a conversation started or something and they're just not working with you and you can't really do much at that point since they're like they don't want to talk. So you just kinda, it's kinda awkward silence.	The teacher can, if, if he's given a specific role, so he's like, okay, you work in this and you work in this and in those specific roles have to work together. That helps a lot since we have to communicate to work on it. And once you're assigned those roles, it can help a lot since we have to communicate to finish the work.
Moscow	When like you, I don't know them at all and it's just like, okay, time to work. Like without icebreakers or without like, Like I don't know them at all. Like for me, like they just like sit next to me and they're gonna say, okay, my partner now I'm like, oh, okay. Now, like, I don't know, do what to do. Like I don't know who they are. Like what if I say something and like they get offended or they say something and like, I'm like, oh, okay. I don't know. Like, uh, for me that's, that's really like not knowing who they are and that kind of gets me nervous.	Definitely like little warmups at the beginning of class that you'd have to share with your partner

Table 6: Summary of Sources and Interventions Related to Student Stress and Anxiety, Continued

Participant	Response to question: Think of a time you worked with a partner that you didn't know. What are some things that increased your stress or anxiety?	Response to follow-up question: Is there anything you think your teacher could have done to help with that issue?
Alex	Uh, basically me not knowing 'em, I don't know who they are. I don't even know what their name is. Like. I just, I don't know how to start up a conversation. So it's just, if I can get the work done and just get out of there, like if I'm nervous and I don't wanna start a conversation	*Conversation shifted to unpack his comment "get out of there" and the follow up question was not revisited.*

These five testimonies shed light into the anxiety and stress experienced by students when working with someone they previously did not know. As was previously addressed, a few students in the Valley High focus group expressed a strong preference for working with "friends", however as the study progressed and these conversations deepened, it was revealed that these same students did not know any students in their CS class on the first day of school but rather formed friendships over time. This insight sparked a need to ask these questions and better understand what part of working with unfamiliar students is the source of this stress or anxiety. These five experiences cite uncertainty as the primary source: not knowing how a person will react to different ideas, not knowing how to form a bond, or not knowing if a friendship is even possible. This uncertainty creates a stressful environment but many of the participants cite this feeling as temporary. Finding common ground with their partner was something these participants viewed as highly important and, once again, ice breakers and simple bonding exercises facilitated by their teachers are perceived as instrumental to the reduction of negative feelings.

In addition to forming relationships, students also cited having specific roles as an effective means of reducing stress. When asked to share some things that decreased his stress or anxiety, Alex explained that "relatability plays a big part in that or just joking around, you know,

and then getting the job done working. She has her role. I have my role, you know, we're both, we're both doing our part, you know, and we're talking, we're joking, you know, that's, that's really the main factor that gets my nervousness down." His response suggests that the structure provided by roles allows him and his partner to focus and maintain conversation which, in turn, reduces his nervousness. In Table 6, Eduardo provides additional support for this strategy. When asked what teachers can do to help alleviate his stress or anxiety towards working with a new partner, he explains that the teacher can provide students with specific roles which "helps a lot since we have to communicate to work on it. And once you're assigned those roles, it can help a lot since we have to communicate." This response also suggests that the focus and guidance provided by roles supports communication between partners and consequently reduces the stress experienced by this student. When asked how specific roles shaped their team's product or their outlook towards their team, Moscow claimed that the presence of specific roles "definitely put less stress on all of us and made it kind of fun, I guess. Cause we didn't, we weren't like all like chaotic, like, oh we have to do this, we have to do that. It was organized, um, efficient." Through this testimony, specific roles are perceived as capable of reducing stress by means of reducing chaos, increasing organization, and increasing overall enjoyment.

Physical Obstacles of CS

Students were asked to reflect on collaboration in non-CS classes in order to better understand the specific perceptions they have about their experiences within CS classes. During the focus group, students were explicitly asked how collaboration in CS is different from collaboration in their other classes. Danisha explained that "the program has to be only one computer. So you cannot take it home and you have to do it here. So it's a little bit more difficult to collaborate if you like, because we have like a computer then that program stays on that

computer. So in order for your like, um, partner to work in it, you have to give that computer to them." This experience provides insight into a unique challenge that stems from collaborating in certain coding environments. In this particular class, students use an integrated development environment (IDE) that is stored locally. Thus, the product that Danisha and her partner are developing collaboratively is physically stored on one device. Although this file can be uploaded to a shared cloud, there are several extra steps that must be taken every time progress on the program is made and the file can only be reopened on a device that has the IDE installed. Danisha's response shares frustration from not being able to take these projects home. Her frustration continued when she explained that in order for her partner to contribute, the physical device must be shared. Nemo expressed a separate form of frustration stemming from the same issue when she shared that "when someone's like absent, you have to give them your password. Cause like there's no other way to like log in and do it. You know, it's kinda hard." This issue not only echoes the frustration expressed by Danisha but also suggests a possible security issue created by this physical obstacle.

An additional obstacle that appears to be more prevalent during CS collaboration, is the negative perception of screen-reliance. When asked the same question as the Park High focus group, Alex shared that "in math we always look at each other, then we look back at the board, then we look at each other. That pattern. In computer science we always just look at the screen. We hardly look at each other and we just talk to each other." This experience shows that although Alex perceives communication as a key element of collaboration in CS, eye contact and actually looking at your partner during this communication occurs less in CS classes as a result of the screen being the focus. Interestingly, when asked how he feels about that difference in experience, Alex replied that "I feel computer science is better, cause I'm not that social, so I

don't have to look at a person when I'm talking to them when in math. Sure. It's fun, but I get a little nervous." However, for some of the other participants, this abundance of screen time did not appear to have a positive influence on student perceptions. When asked what activities from non-CS classes students wished they did more of in CS, three students answered by saying they wish they unplugged more often. Danisha said "maybe sometimes go outside because we're always in the computers. Like we don't have like stop because we, we start a module and everything we did the, the first and everything, the questions, another module. So like little bit more, I think like do different things…not only like being on the laptops." This request again reflects a challenge presented by the perceived overuse of laptops. When asked the same question, Jaky responded with a similar request: "probably just, just have like some time to just go outside, like just relax for a bit and not be spending like the entire class time in the actual classroom". While this response does not explicitly address screentime, Jaky does express an interest in spending more time outside and presumably unplugging from the routine of programming. When asked what strategies their teacher has used to increase comfort between partners, Nemo shared about an activity where "we'd have like, oh, outside, we did this thing when we had no internet at the time we had to do this, chalk thing and we had to, ask each other when's your birthday month. And then like if their birthday is in January and the others was October, they'd have to go into one circle where it's like above that one, if that makes sense". All three students who expressed an interest in spending time outside are in the same class and thus this response provides some additional context for this request. Nemo cites internet issues as the reason class had to take place outside but reflects positively on the experience and attributes this to increased comfort between her and a partner. Through this experience, Nemo provides

additional support for the concern that CS creates an environment that uses more screen time than some students might prefer.

Built-In Benefits of CS

Prompts that allowed students to compare and contrast their collaborative experiences within CS and non-CS classes were interwoven throughout each of the interview phases of the study. One of the biggest themes that emerged from these conversations was their perception of several inherent advantages within CS courses. Many participants perceived CS as naturally more creative than non-CS classes and associated this with more positive collaborative experiences. For example, during the focus group at Park High students were asked to compare and contrast collaboration in their various classes and Bubbles claimed that "you can be more creative in computer science than in a math class or English class. Like…" Eduardo chimed in to seemingly finish this thought and shared the following: "There in computer science, most of the time your partner, you might have different goals and most of the time you have to like mix them together to get them together. Well, in other classes you normally all have the same problem." Well, in computer class, you have a lot more creativity on what you need to do. So a lot of the time you end up mixing your work and get a brand new solutions. When asked to elaborate on this he said:

> It's a free project with like no set topic. Maybe your friend wants to do this and you want to do like something about cooking, do something about skating. So maybe you two mix it. And now you have like a guy in a skateboard riding around cooking. Well, in math, it's like two plus two. It's that? And you both work there to solve that problem, it's, you're both towards the same goal. In Computer science you know really have two different things you want sometimes. So you gotta compromise and do things together sometimes.

His response reflects a perceived novelty in CS whereas in other classes he perceives a more routine or expectable set of problems. He echoes Bubbles' sentiment that CS is more creative

and adds that this increases the need to mix ideas and find compromise. During this response, Eduardo expressed enthusiasm for this process that reinforced the generally positive association he places between this increased creativity and his overall experience with his partner.

During the first individual interview, students were given a list of skills and asked to predict how successful they would be in each area if they took a future CS class. The list of skills included: writing and reading code, learning more advanced CS topics, thinking creatively, explaining my ideas to others, and listening to other people's ideas. This handout can be found in Appendix E. Once participants were done with their predictions, they were asked if collaboration impacted any of the ratings. Zoe claimed that collaboration positively impacted her ability to think creatively but also gave an explanation of how the project-heavy nature of her class impacted this as well. She explained that her teacher provided a list of "requirements for projects but it's just like what like requirements for what you, he wanted to see in the code but it wasn't like, um, what's it called? Like an assignment, like they give us in like the textbook where it like already tells you what the end goal is supposed to look like. So it had to think more creative for that." Her response contrasts the open-endedness of her CS projects to those of a traditional textbook assignment. She reflects on this difference positively and cites it as one of the reasons her ability to think creatively has improved.

Students at both school sites perceived their CS class as being very project centric and this was largely seen as a positive difference. For Alex, the opportunity to complete projects was a key factor in his ability to perceive a collaborative experience as positive. Despite demonstrating largely negative views towards collaboration during the survey in phase one, when he asked to share a positive experience with collaboration in CS, he shared that "the things that we can create when multiple of us are working towards a specific goal, like that's really the

main positive." These "things that we can create" were the emphasis of many of his responses which demonstrated the value he places on producible outcomes. For example, when asked how collaboration impacted various emotions in CS, his sense of accomplishment was the only one he cited as being impacted. He explained that when he looks at an app he and a partner have developed "we're like oh my God, we made something, you know, has anybody else made this kind of stuff before?" Although these responses do not directly contrast between projects in CS and non-CS classes, the overwhelmingly positive reflections that Alex makes towards these opportunities demonstrates an appreciation for the project-centric nature of his CS class.

Chapter 5: Discussion and Recommendations

As technology's impact on society continues to expand, representation and diversity within the field of Computer Science becomes increasingly important. Despite the long held belief that computers are inherently objective, creativity and subjectivity are key components of technological progress. Thus, the homogeneity that currently plagues CS departments poses varying degrees of problems for private and public industries including creative stalemates, reduced problem solving capabilities, and racially biased software. The implications of allowing racial and gender underrepresentation to persist has made it increasingly clear to educational leaders at all levels that we must work to close these racial and gender gaps.

Research has shown that early access to CS courses is one of the most effective interventions for underrepresented student retention and, as a result, over the last decade there has been an unprecedented expansion of CS course offerings at high schools across the country. Enrollment data, exam pass rates, and other quantitative measures have been obtained through various studies in an effort to better understand how to support underrepresented students. However, very few research efforts have focused on student perceptions and lived experiences within these high school CS classes. This study is important in that it places a strong emphasis on student voice through a predominantly qualitative approach. In doing so, this study provides a deeper look at both the collaborative experiences that underrepresented students have in high school CS classes as well as how students perceive these experiences as related to their social emotional and academic development. Evidence from this study suggests a rich and diverse set of both positive and negative collaborative experiences that hold many implications for CS educators. This study provides insight into the following research questions:

1. What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?
    a. To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?
    b. To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?
2. What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?
    a. Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?

Review of the Methodology

Data collection for this study took place across four phases: student survey, focus group, individual interview, and a final, individual interview. Two schools were invited to participate and all students enrolled in AP CSP at these sites were invited to complete the survey. These results informed the selection of eight participants to form a subgroup that was diverse in terms of gender, culture, age, and general views towards collaboration. This participant diversity consequently allowed for a more diverse set of experiences to be unpacked through the remaining phases of the study. These eight students participated in the focus group, individual interview, and final, individual interview. Between these phases, the principal and secondary researcher engaged in two Preliminary Analysis Cycles shown in Figure 3. These cycles provided increased validity for the identified codes as well as increased clarity and refinement of the instruments that were used in the phase that followed each cycle. Once all phases had concluded, data analysis began. The qualitative data was analyzed through an iterative process of

identifying novel codes, categorizing experiences based upon these codes, categorizing these codes into broader themes, and constructing an understanding of the collective and individual experiences.

Summary of Findings

While the subgroup of eight participants each held unique views towards collaboration, their unique as well as their collective experiences provided support for several common themes. Each theme provided a great deal of insight into the experiences that these students have within their CS classrooms. The testimonies shared throughout this study showed a deep appreciation for the alternative solutions and diverse perspectives that were shared or generated when participants had the opportunity to work with peers. They expressed concern and frustration over interactions where effort *and* voice was not distributed equally. Students made many explicit connections between their teacher's pedagogical decisions and the varying levels of success they experienced with their partners. However, the pedagogical strategy that was shared most positively and predominantly was simply ice breakers. Participant reflections on this seemingly simple strategy highlighted the need for students to feel safe and connected to their partners or teammates. Establishing and maintaining connections with their peers was perceived as closely related to confidence, self-worth, willingness to compromise, and the overall degree of positivity for a given peer interaction. Many students claimed to experience equal or increased success in CS collaboration when compared to collaboration in other content areas. The negative aspects these students highlighted that were exclusive to their CS classes were largely surface level such as excessive screen time or software obstacles. The positive aspects that students claimed to be exclusive to CS were largely related to their collective perception that there are more opportunities to be creative or build something where everyone could incorporate their strengths.

Discussion of the Research Questions, Findings, and Theoretical Connections

Many studies have explored how collaboration relates to academic and social emotional experiences. To some extent, this study provides additional support for the findings established by these studies: what elements are in place when collaboration is successful, what elements are in place or absent when collaboration goes poorly, how do students benefit academically during collaboration, and how are social emotional factors influenced by collaboration. This study extends and deepens our understanding of how students perceive these experiences, their growth, and the challenges that accompany working with peers. In order to unpack the findings in a meaningful way, this section has been organized by the research questions this study sought to answer.

Research Question #1: What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?

a. **To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?**

The eight participants each shared and reflected on several different instances of Cooperative Learning but it is important to note that, to the participants, Cooperative Learning and Collaborative Learning were perceived as interchangeable terms. For the purpose of this study, the accountability structures that transform Collaborative Learning *into* Cooperative Learning were identified as specific roles, positive interdependence, and equal participation. In effort to preserve student voice, these tenets, as opposed to the explicit term Cooperative Learning, were the focus of many interview questions and follow-up conversations. The Narrative Inquiry framework used to structure this study supported this flexibility since, at its core, this framework seeks to prioritize the participant experiences and perceptions.

When first provided with a chance to share about the three tenets, most participants opted to reflect on equal participation. Participants expressed throughout every phase of the study that they appreciated when partners and teammates shared the workload. However, the distribution of effort was valued for many different reasons. Experiences where participation was not equal were perceived as strongly negative and vice versa. Most predictably, students wanted equal participation for the sake of being fair. However, equal participation was also seen as strongly connected to their sense of self-efficacy. During one reflection, Zoe shared that her experience with a partner was going very poorly until one day her partner asked for her help and sought her input on the project. She expressed feeling calmer and more confident in her ability to help. Several other students shared a similar experience; when a partner sought help or feedback, they were excited to be involved and experienced an increase in confidence. This relationship may largely be connected to the belief that when work is shared, partners get to "work on our strong suits" and even discover new strengths. Thus, peer interactions where equal participation is present appears strongly related to students feeling confident and capable.

Several of the participants attributed equal participation to an increase in comfort with the topic at hand but the perceived benefits of this Cooperative Learning tenet extended even further. By contributing equally to the completion of the task at hand or feeling valued when their partner requests help, participants also perceived an increase in their ability to solve problems independently as well as their long-term ability to think creatively. When individual creativity and problem solving skills are strengthened, these students are likely to experience even greater increases in their sense of efficacy. Computer Science is often "characterized as engendering a defensive climate" as a result of inherent competition and informal hierarchies within advanced courses (Barker et al., 2002, p. 43). Competition is often considered a harmful strategy for

underrepresented students but these experiences expand upon this idea. Transitioning from competition into teamwork is valuable, but when participation is equal, students perceive an even greater increase in the skills needed to experience success.

Equal participation was also largely connected to equal exchange of ideas. Students felt increased confidence in their overall product when both partners were contributing equally because they believed the differences between their perspectives and their partner's perspectives meant that they were less likely to overlook a key step. This idea was captured by one focus group discussion about a reduction in bias. Students explained that they often feel determined to do things one way, until they realize their partner has a better way. This exchange of ideas, rather than being viewed as conflict, was described as "fun" and they expressed gratitude for the experience. Students felt more confident in the final program because everyone had contributed in a meaningful way. This relationship was further solidified by multiple students who expressed decreased confidence and a decreased sense of pride when their work or ideas had not been included. One student even shared that although they anticipated the project would receive full credit, they didn't feel good about the grade "since it wasn't as much as my work, as it could have been, I was like, well it's not really like me getting a good grade in this. It was like the partner". A student's perceived ability to learn CS is a proven indicator of underrepresented student persistence (Anderson & Ward, 2014; Ericson et al., 2014; Milesi et al., 2017). Through these student testimonies, it is clear that the presence of equal participation plays a crucial role in strengthening a student's confidence, sense of accomplishment, and overall sense of efficacy.

Participants perceived similar relationships between efficacy and the addition of specific roles. Most students felt that by adding specific roles to an activity led to a stronger overall product. Students explained that this allowed them to incorporate everyone's individual strengths

and in doing so they felt more confident in their individual skills and in their team's final product. Underrepresented students are disproportionately affected by fear of failure and decreased confidence and specific roles as an instructional strategy is clearly perceived as effective at combating both. Additionally, participants felt that specific roles increased accountability and reduced the ability for teammates to hide or be excluded. This ties directly back into the perceived importance that all members of the team are participating equally. Participants felt that specific roles kept everyone on track and provided a neutral way for one or more members to check in with members who weren't participating. While it can be tempting for educators to assume that disengaged students are unmotivated or distracted, the insight provided by these participants paints a different picture. These students felt that when their peers were disengaged or when they themselves were disengaged it was often due to feeling nervous, lacking confidence, or general disconnect between partners. Specific roles and equal participation provided structures that these students perceived as effective at reducing the effects of these obstacles.

Research Question #1: What experiences and perceptions do students have with Cooperative Learning in Computer Science classes?

b. To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?

An irreplaceable component of any student-centered classroom is that all individuals must feel safe before they can be expected to make academic gains (Combs, 1976; Bransford et al., 2000; Turner, 2011). While this holds true for students of all ethnic and gender identities, it is well documented that underrepresented students are significantly more likely to report feeling unsafe (Voight, A., Hanson, T., O'Malley, M., & Adekanye, L. 2015; Williams, Schneider,

Wornell, & Langhinrichsen-Rohling 2018). A decrease in feeling safe is correlated with decreased connectedness, quality of relationships, and perceived opportunities for participation (Williams et al., 2018). The experiences of these eight participants confirms and builds upon this correlation. Virtually all of the negative collaborative experiences that were shared throughout this study were rooted in anxiety, feeling uncared for by a partner, or a general fear of meeting someone new. All eight of these students expressed the same basic need: to feel connected to their partner or team. This desire to build a relationship stems from their need to feel safe. For some students, they entered a new partnership filled with anxiety and an unsupported fear that their partner was going to be mean or dislike them. While collaboration is often touted as a cure for social disconnect, when implemented without fidelity these partner or team activities can have adverse effects and this was the case for a couple of participants.

Fortunately most of the collaborative experiences shared by the participants included structures and strategies that eased their anxiety and dissipated any fear of conflict. The most common strategy that students reflected on was ice breakers. While this is not one of the tenets that had been explicitly outlined prior to the beginning of the study, the Narrative Inquiry framework allowed this strategy to be explored in depth during the multiple rounds of semi-structured interviews. In doing so, it was clear that all eight participants valued when their teacher paused and provided students with a question to discuss that was *not* designed to assess their understanding. Some students even gave examples of these questions such as “what's your favorite food, favorite color, basic questions”. These moments to pause and build relationships appeared to only last a minute or so but had an immeasurable impact on how these participants perceived their place within that collaborative setting. Once that connection had been established, students claimed to feel calmer, less anxious, more included, more valued, more

excited to work with their partner, and several claimed to have made a friendship that extended beyond the classroom.

Establishing that basic connection with their partner was perceived as important for students who had positive views of collaboration and appeared to be even more important for the students who had negative or neutral views of collaboration. Some participants view themselves as so shy that they feel incapable of having a conversation that hasn't been started by either the teacher or their partner. However, some participants who consider themselves to be very extroverted still struggled with partners who were shy and consequently became anxious that they were talking too much. These perceptions and concerns illuminated the desire that these students have for this social aspect of collaboration to be equal as well. Students who felt they were talking too much or felt unsuccessful in making their partner warm up to them became susceptible to anxiety and stress when they previously cited none of these negative feelings. Both the experiences of the shy and the experiences of the extroverted students bring us back to the reminder that these students must feel safe before they can be expected to make academic growth. Thus, these social emotional experiences (research question 1b) and the aforementioned sense of efficacy (research question 1a) appear deeply intertwined.

Although positive interdependence did not appear to have a significant impact on student perceptions of their sense of efficacy, it was perceived as an important ingredient to maintaining this social connection with their partner. Participants perceived positive interdependence as knowing that their partner is counting on them and that they can count on their partner. These reflections illuminated once again the need for trust and safety to be present when students work in collaborative settings. The testimonies from the Latinx, female, and non-binary participants provide additional support for the importance of prioritizing relationships and community as

opposed to competition within CS classrooms. Students also attributed the presence of positive interdependence to a reduction in stress and increased confidence in voicing their opinions. Comfort level and willingness to speak up has been shown to be one of the strongest predictors for underrepresented student success within CS classrooms (Wilson, 2002). Thus, it stands to reason that when students experience these social connections where positive interdependence is present, there is an increase in comfort level, motivation to speak up, and overall chances of success.

The third tenet of Cooperative Learning, specific roles, was also perceived as having a very strong relationship to the participants' social emotional experiences. Similar to both equal participation and positive interdependence, having an explicit role when collaborating provided students with a reduction in stress, anxiety, and an increase in overall comfort. Specific roles were seen as a method of providing more clarity. Students valued knowing what both their teacher and their partner expected of them and this in turn created a more comfortable and conducive environment. Traditional socialization has often led female and minority students to be significantly less likely to share their opinions in white, male dominated classrooms. However, students in this study perceived specific roles as supporting an equal distribution of voice. Moscow, when reflecting on an instance where they felt their voice was being excluded was asked if there was anything that could have been changed to improve that situation and they replied that they wish they and their partner had been given specific roles. They continued by sharing that they felt there was more of a guarantee that they would be heard. This testimony, along with several others, provides valuable insight into how specific roles could be used to significantly increase underrepresented students' willingness to voice their ideas and consequently feel represented or heard within these CS classes.

Through the addition of specific roles, participants felt more supported and clear on *how* to interact with their partner. This was perceived as effective at combating their fear or reluctance related to sharing but some were presented with another anxiety obstacle: unequal voice. Whether speaking too much or not speaking enough, participants wanted their conversations to be *reciprocal*. Feeling comfortable sharing because they knew their partner would share also contributed to a growing sense of trust, increase in safety, and a level of positive interdependence where partners can count on one another. Through this research question, all three of the Cooperative Learning tenets revealed themselves to be deeply intertwined. However, at the core of this was a clear and simple need: social connection. Reducing anxiety, increasing willingness to share, and promoting feelings of safety are affirmed to be important not just for the sake of a shared project but also for the benefit of peer relationships and overall comfort throughout a team or partner activity.

Research Question #2: What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class?

a. **Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?**

Participants perceived the tenets of Cooperative Learning to have a roughly equal or greater presence within their CS classes compared to their non-CS classes. Many cited having stronger relationships with their partners during collaboration or that tasks were done more effectively in their CS class. These stronger relationships may be connected to the higher reported uses of either specific roles, equal participation, and/or positive interdependence. However, as noted earlier, students viewed Cooperative Learning and Collaborative Learning as

interchangeable. Thus, despite asking questions aimed at comparing these tenets across content areas, students focused more on any perceived differences between their CS and non-CS courses. The Narrative Inquiry framework facilitated the decision to allow students to interpret these questions openly and provided broader takeaways regarding student perceptions of teamwork across their classes.

A key takeaway revolves around some of the physical challenges of collaborating via a computer. Although adults are often guilty of criticizing adolescent screen time, students perceived the reliance on screens as a hindrance to successful relationship building and in some cases a hindrance to successful completion of an assignment. This idea provides a great deal of insight, once again, into the extent to which students crave a meaningful connection to their peers. Yet another CS specific issue occurs when a partner forgets their device which highlights the importance of trust and being able to depend on a partner. Interestingly, when collaboration occurred without a computer, students felt more engaged not in the content, but in their relationship with their classmates. Whether it was a pre-planned unplugged activity or an impromptu outdoor activity due to tech challenges, students perceived stronger social connections but made few comments regarding academic gains. This highlights some unique challenges presented by CS classes but reiterates once more the importance of incorporating opportunities for building relationships. The tendency of advanced CS courses to promote competition or "every man for himself" culture coupled with an abundance of screen time can lead to feelings of isolation (Kirk & Zander, 2002, p. 121). For Latinx, female, and non-binary students, these culture building activities could alleviate this issue.

While an overabundance of screen time was cited by several students as an obstacle to social connectivity, it was also cited as one of the reasons their CS class is more conducive to

collaboration versus their non-CS classes. At both participating schools, students are required to share their screens and when completing projects, they work together on a common product. This dependence on one another is not without challenges (e.g. a partner forgetting their device) but it was more predominantly seen as a beneficial aspect of the class. Although this study chose to focus on only three tenets that can elevate Collaborative Learning into Cooperative Learning, some research considers additional strategies; one of which is a shared product (Gillies, 2019). These student reflections suggest that not only working together on a task but working together to achieve one outcome is preferred. Students made reference to group work that is completed at a table or near a partner but described everyone focused on their own individual assignment. Zoe summarized this idea when she shared "since all the work [in CS] is partner work too, you're like naturally talking to each other all the time. And in math, even though you're in a group, you're still working on solo work. So there's not as much reason to talk to each other." For these participants, simply placing students in proximity to each other or giving them permission to work with a peer, without any additional structure, can still lead to feelings of isolation or reluctance to share their ideas. This finding underscores the issue with classes that engage solely in Collaborative Learning activities. While more beneficial than purely independent work, additional structures such as the tenets explored in this study, can encourage discussion and more meaningful connections between students.

Understanding how underrepresented students perceive the effects of certain instructional strategies may provide CS educators with more tools to support and retain these students. The expressed desire for meaningful, reciprocal relationships supports the reduction of competition-based strategies and the need to cultivate a community with CS courses. This is especially important when considering the cultural and social backgrounds that Latinx, female, and non-

binary students bring into a classroom. This study shows that the perceived benefits of equal participation, specific roles, and positive interdependence contribute to community building and beyond. A summary of the perceived positive relationships between Cooperative Learning tenets and student experiences is shown below in Table 7.

Table 7: Summary of Research Questions and Findings

Research Questions	Theme Connections	Cooperative Learning Connections
To what extent are student experiences with Cooperative Learning related to their sense of efficacy in Computer Science?	New perspectives Distribution of effort Pedagogical needs	*Equal Participation* Very strong relationship. Perceived as connected to content growth, development and identification of individual strengths, sense of accomplishment *Positive Interdependence* Little to no relationship *Specific Roles* Strong relationship. Perceived as connected to confidence, sense of pride, sense of efficacy, an increase in product quality and overall enjoyment, and a decrease in bias, stress, and anxiety
To what extent are student experiences with Cooperative Learning related to their Social Emotional Experiences in Computer Science?	Making and maintaining connections Distribution of voice Emotional well-being	*Equal Participation* Strong relationship. Perceived as connected to safety, reduced anxiety, reduced stress *Positive Interdependence* Strong relationship. Perceived as connected to trust, safety, sense of community, increased willingness to speak up *Specific Roles* Very strong relationship. Perceived as connected to feeling heard and valued, reduction in stress, anxiety, and an increase in overall comfort and willingness to participate

Table 7: Summary of Research Questions and Findings, Continued

Research Questions	Theme Connections	Cooperative Learning Connections
What differences do students perceive between the role that Cooperative Learning plays in a Computer Science class versus a non-Computer Science class? Are there any valuable aspects of collaboration that students have experience with that are absent from their Computer Science class?	Physical obstacles of CS Built in benefits of CS	*Shared products* Strong relationship Perceived as connected to logistical obstacles as well as certain social obstacles, however it was also perceived as conducive to communication *Positive Interdependence* Little to no relationship *Specific Roles* Moderate relationship Perceived as more prevalent within their CS classes and consequently attributed to increased communication and accountability

Suggestions for Practice

Embed Cooperative Learning Tenets into CS Teacher Training

Evident throughout the data are many perceived benefits, both social and academic, of incorporating various tenets of Cooperative Learning. All of the students believed that at least one tenet contributed to an increase in content confidence, creative problem solving, sense of accomplishment, willingness to speak up, trust, safety, and sense of belonging. As well as a decrease in stress, anxiety, and isolation. The differences between Collaborative Learning from Cooperative Learning can seem negligible but below the surface, the strategies that separate the two hold real power for supporting underrepresented students. Most teachers have basic comfort in implementing ‘group work’ where desks are arranged together or students are given permission to work with a neighbor. The nuances between Cooperative Learning and

Collaborative Learning mean that elevating this scenario can be done by incorporating a few accountability structures. It also means that teachers are not being asked to reinvent the wheel, as many professional development efforts are often viewed as. This an especially important consideration since the rapid expansion of CS course offerings has created an insufficient pool of CS teachers. Thus, as teachers with non-CS backgrounds receive the training needed to open CS courses, it is imperative that these trainings incorporate fundamental structures such as specific roles, equal participation, positive interdependence, and shared products.

Provide Explicit Opportunities for Students to Bond

At the high school level, educators too often assume that teenagers have acquired the social skills needed to introduce themselves, start a conversation, or form a friendship. In reality, these are skills that can take a lifetime to develop. While ice breakers are often incorporated at the beginning of the year, they aren't always revisited. Simple opportunities for students to have a discussion that is not related to CS can yield powerful results when it comes time for those same students to start discussing their coding project. These opportunities might include explicitly asking students to introduce themselves and share a hobby when first meeting a new partner or perhaps a warm up question on the board that asks students to talk about their weekend before the bell rings. The inherently creative nature of many introductory CS projects allow these opportunities to be related to content goals as well. As one student shared, prior to building an app to simulate ordering at a restaurant his teacher asked him and his partner to each share their favorite food. He expressed that he not only felt more comfortable but the conversation gave them extra ideas that they eventually incorporated into the code.

Minimize the Role of Competition

This study provides additional support for the long standing belief that students who identify within gender or cultural minorities face additional challenges in environments characterized by competitive or defensive climates (Barker et al., 2002; Wang et al., 2016). When coupled with the fact that most CS courses are also labeled as advanced, Latinx, female, and non-binary individuals become even more vulnerable. While competition can serve many purposes within other areas of education, confidence and comfort play an important role in the persistence of underrepresented students in CS and should thus be prioritized (Milesi et al., 2017; Wilson, 2002). Removing incentives to be the first team finished, praising students for individual growth instead of repeatedly praising top performers, or allowing student opinions to shape activities can help engender a stronger sense of community. In turn, this can create an environment where these underrepresented students feel more confident and comfortable.

Incorporate and Rethink Unplugged Activities

Computer Science classes will inevitably rely on screens more heavily than other content areas but there are still ample opportunities to disconnect. The data from this study supports the use of screen breaks as another meaningful way to promote connection across students. Unplugged activities within CS curricula are a broad term used to describe activities that do not require a device. These activities are often touted for taking a playful, kinesthetic approach to an abstract or advanced computing concept. However, teachers usually associate these activities with a moderate amount of prep work and class management which can lead to identifying only a few key ideas that are best served by unplugged activities and embedding them accordingly. This study poses the idea that any opportunity to give students a screen break, even those with minimal planning, can hold value. Thus, unplugged activities can also be something as simple as

“turn to your partner and discuss ____" or “stand, find a partner, and share about an obstacle you’ve faced in your code”. By staring primarily at their screens and not their partners, students perceived a social disconnect thus creating these intentional and regular opportunities could allow for improved connectivity.

Monitor and Modify Student Comfort Zones

The tendency to stick with *what* we know or flock to *who* we know can be observed in any classroom or workplace setting. Within high school CS classrooms, many students are pushed outside their comfort zone by the content, the AP course title, the social dynamic, or all the above. While it is imperative that students feel a sense of safety and connection within their classroom, it is also important that students try new things, work with new people, and develop new skills. When exploring student experiences related to specific roles, a couple of the participants expressed a tendency to take the passive, creative role (e.g. navigator or designer) while their partner took the hands-on role (e.g. driver or coder). Teachers must remain aware of these tendencies and work to provide students with opportunities to step outside their comfort zone. Perhaps labeling certain projects as skill building and instructing each partner or teammate to pick the role they are *least* comfortable with would provide all students with more opportunities to develop competence and confidence.

Allow Bonds to Form and Support Socially Disengaged Students

It is important that teachers remember: even with all the proper supports and structures, forming relationships takes time. There is no golden rule for how long and the data from this study supports that. Some participants wanted to rotate teams and partners as often as possible and others preferred to keep one partner for several units or even an entire semester. There were no clear patterns between these preferences, extrovertedness, or general views towards

collaboration. The only consistent request was that teachers show patience as students work to navigate these new relationships. In addition to this request came a wish that teachers would give students who are struggling socially some kind of resource to express their issues. This might be a class survey to check in with partner dynamics or simply asking a disengaged student how things are going. A student who is not enthusiastically participating does not necessarily equate to a student who wants to work independently; a little outreach can go a long way.

Recommendations for Future Research

Include Black Student Voices

The most glaring limitation of this study was the inability to include any participants who identify as Black. Thus, it would be extremely helpful to replicate this study at a school with a higher proportion of Black students who are enrolled in CS. As one of the most vulnerable and underrepresented groups in CS, it is imperative their voices be included in the conversation.

Longitudinal Study

This study suggests that the tenets of Cooperative Learning are effective at supporting underrepresented students in their current learning environment but it may be important to understand how the presence of these strategies shape their long term success in CS. This could be done by working with students in an introductory high school course and revisiting these ideas once students have participated in a college CS course.

Comparatively Analyze Different Classrooms

Helpful to understanding the true relationships that are proposed by this study may be comparatively analyzing the experiences of students in a class where minimal Collaborative Learning occurs and highly structured Cooperative Learning occurs. This type of study would

provide a stronger understanding of the role that these instructional strategies play in supporting underrepresented students.

Explore Relationships in Additional Intro Courses

Comparing experiences across course level could prove to be insightful. Many schools offer a course other than AP CSP as their introductory course. Thus if educators hope to support and retain underrepresented students from their initial interactions with CS, understanding perceptions of Cooperative Learning tenets at various levels could support this goal.

Include Measures Related to Instructional Patterns

This study relied solely on the perceived frequency of various strategies. Future research efforts may wish to include classroom observations to document instructional patterns more objectively.

Provide Explicit Interventions

This study did not impose any external treatments and relied on the participating teachers' self-assessed comfort with these strategies. Additional support for the findings generated by this study could be found if teachers were provided with more guidance on when, how, and how often to incorporate these strategies. This would allow for pre- and post-measures to take place and would also control for more factors that contribute to student experiences in the classroom.

Study Limitations

Although this study sought to strengthen educator understanding of CS student experiences, it was limited in terms of participants, scope, and generalizability. First and foremost, this study did not include the voices of any Black students despite the deeply present need in CS education to unpack their experiences. Between all CS classes at both participating schools, there was only one student who identified as Black and they declined to participate in

the study. While this speaks volumes to the ongoing obstacles these students face related to recruitment, it also inhibits these findings to include the unique experiences of Black students in high school CS courses.

In addition, the scope was also limited to student voices. This study examined the perceptions of students and chose to not include teacher perspectives. In doing so, this could be seen as a limitation. While teacher perspectives would have provided additional insight, the primary focus was student experiences and including any other perspectives may have taken away from this goal. Lastly, the data collected represents the experiences of only eight students at only two different schools. While generalizability was not a primary goal of the study, the small sample size places limitations on how these findings can be applied to students enrolled in different schools, in different communities. Thus, while the insight gleaned from this study is unique to these students and classrooms it still provides valuable takeaways that all educators and future research efforts may benefit from.

Summary

The underrepresentation of Black, Latinx, female, and non-binary individuals within Computer Science is present at the high school, university, and industry level. No single level can remedy this problem but is becoming increasingly clear that interventions must happen early. Presented by this study is an understanding that student experiences lie at the heart of these interventions. Thus, the strength of this study stems from its reliance on student voice. Quantitative information provides crucial insight into the causes and effects of underrepresentation and informs the systemic changes that need to take place. However, as educators we must not rely on numbers alone to make decisions on behalf of these students. The qualitative results of this study provide new perspectives to the bigger picture being created by

CS education research. While the experiences of all participants are unique, each serves as a reminder that the pedagogical views and decisions we make as teachers have powerful impacts on how students feel, behave, and succeed within our classrooms. The more we work to understand these experiences through the lens of the student, the more positive these impacts may be.

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Appendix A: Student Survey Protocol

Phase 1 of the study is designed to address research question 1, 1a, and 1b. The subsequent phases of the study will address these and the remaining research questions. Participating teachers will read the following script prior to administering the survey to students that consented to participate:

"Thank you for participating in this survey. The questions relate to your experiences in this Computer Science class but your responses will not be shared with me. These responses are not being used to evaluate the teacher or the course. Instead your responses will help educators better understand the types of experiences students have in Computer Science classes. By understanding your experiences, educators hope to work towards building more positive experiences for students in CS classes.

The survey will ask you about collaboration, participation, as well as some personal information. There are no right or wrong answers and you can skip any questions that you do not feel comfortable answering.

At the end of the survey, you will be asked if you are willing to participate in some follow-up interviews. The interviews are completely optional but students that participate will be eligible for a $50 gift card. More information regarding the interviews is provided at the end of the survey so please read and respond carefully.

Again, your responses will help educators better understand how students learn in CS courses and your responses will not be shared with your teacher. You can begin the survey."

Student Survey					
Question	**1**	**1a**	**1b**	**2**	**2a**
Collaborative Learning, Self-Efficacy, and Student Performance in CS1 POGIL (Yadav, et al.)					
I found working as part of a team in this class to be a valuable experience.	x				
In the teams in this class, the team worked well together.	x				
I found teamwork to be a productive use of course time.	x				
I found that teams helped me learn course material more than if I just studied alone.	x		x		

I learned more in courses where I have been a member of a team.			x		x		
I found being part of a team improved my course grades.			x		x		
I found that teams make good decisions.			x				
I found that working with a team helped me develop skills in working with others.			x	x			
I found that working with a team helped me develop more respect for the opinions of others.			x	x			
I found that working with a team enhanced my sense of who I am.			x	x			
I found that being on a team helped me become better at problem solving.			x		x		
Being part of a team discussion improved my ability to think through a problem.			x		x		
I feel that working in teams has improved my critical thinking skills.			x		x		
BASICS - ECS Resource							
Student Grouping Strategies							
How often did you do the following in your Computer Science class in the past month?	I worked with a partner (2 people)	1 - Never 2 - A few class sessions 3 - About half the class sessions 4 - Many class sessions 5 - Once or more per class session	x				
	I worked with a small group (3 or more people)		x				
	I worked with the whole class		x				
	I worked independently/alone		x				
Student Contribution to Small Group Work							
	Contributed to group work (verbally or nonverbally)		x				

	Worked collaboratively with other students		x				
	Shared responsibility for activity and project work with group members		x				
Student Engagement in Discussion							
	Talked to other students about my computer science work		x				
	Responded to questions other students had about their computer science work.		xx				
	Discussed what I was learning with other students in the class.		x				
	Please answer “2” to this question.						
Demographics (BASICS - ECS Resource)							
Before this school year, how much experience did you have with Computer Science? (Select all that apply)		- I took a CS class in middle school - I took a class other than AP CSP in high school - I’ve participated in a club or after school group that did some Computer Science - I’ve participated in a summer camp or workshop that involved Computer Science					
What grade are you in?		9th 10th 11th 12th					
How old are you?		15					

	16 17 18					
I identify my gender as:	Female Male Non-binary/3rd gender Prefer not to say					
Which of the following best represents your cultural and/or ethnic identity? Select all that apply.	Asian or Pacific Islander Black or African American Hispanic or Latino Native American or Alaskan Native White or Caucasian Other					

Self-Added

Section Information

Computer Science educators could benefit greatly from hearing more details about the unique experiences that students have within these classes. To better understand how students learn in CS, the researcher will conduct 3 different interviews to hear directly from students. Please look at the following table to learn more about these interviews.

<u>Round 1: Focus Group</u>

- When: March
- What: small group of 3-4 students gather to answer some questions about collaboration in CS
- How long: ~60 minutes
- Where: your CS classroom

<u>Round 2: Individual Interview</u>

- When: April
- What: one-on-one conversation where participants will get a chance to share their CS experiences with the researcher
- How long: ~45 minutes
- Where: your CS classroom

<u>Round 3: Individual Interview</u>

- When: May
- What: one-on-one conversation where participants will get a chance to share their

CS experiences with the researcher

- How long: ~45 minutes
- Where: your CS classroom

Any student who is invited to participate in these conversations will receive a $50 gift card.

Are you interested in participating in 3 after-school interviews to further discuss your experiences in Computer Science	Yes No					
[If "Yes" to above] Please provide your name so you can be contacted about the interviews.	[Open Response]					
[If "Yes" to above] Please provide your phone number or email so you can be contacted to schedule the interviews.	[Open Response]					
[If "Yes" to above] Please provide the days and times you would most likely be available to be interviewed. (Note: the exact dates and times will be determined later).	[Matrix question with days across the side and times across the top]					

Appendix B: Focus Group Protocol

Phase 2 of the study is designed to address research question 1, 1a, 2, and 2b. The subsequent phases of the study will address these and the remaining research questions. The principal researcher will read the following script to students that consented to participate prior to beginning the focus group:

"Thank you for participating in this focus group. The questions relate to your experiences in this Computer Science class but your responses will not be shared with your teacher. These responses are not being used to evaluate teachers or courses. Instead your responses will help educators better understand the types of experiences students have in Computer Science classes. By understanding your experiences, educators hope to work towards building more positive experiences for students in CS classes.

This conversation will be audio recorded however all of your responses will remain confidential. Only myself and one other researcher will listen to these responses.

These questions will ask you about collaboration and participation in your Computer Science and non-Computer Science classes. There are no right or wrong answers and you can skip any questions that you do not feel comfortable answering by just saying 'skip' or 'pass'. The conversation should last approximately 45 minutes but if at any time you need to stop, please let me know and you can stop. Are you ready to get started?"

Focus Group					
Question	**1**	**1a**	**1b**	**2**	**2a**
1. Tell me about a positive experience you've had while collaborating in a non-Computer Science class.				x	
2. Tell me about a positive experience you've had while collaborating in your Computer Science class.				x	
3. How is collaboration in your Computer Science class the same from collaboration in your other classes? How is it different?				x	
4. When you work with a partner/team, in any class, what are some things that you enjoy?	x			x	x
5. When you work with a partner/team, in any class, what are some of the things that you don't enjoy?	x			x	x
6. Cooperative Learning is a specific type of team activity where some or all of the following elements are in place:	x			x	

• Positive Interdependence: where the team believes that they can only succeed if everyone in the group succeeds • Specific Roles: each member of the team has clear expectations of what they should be doing to help the group • Equal Participation: each member of the team contributes in some way to the task/project/discussion Tell me about your experience with these 3 elements in any class.					
Note: The three elements will be printed onto a piece of cardstock for students to hold and reference as needed throughout the interview.					
7. Tell me about your experience with these 3 elements in your Computer Science class.	x			x	

Appendix C: Focus Group Handout

- **Positive Interdependence**
  Where the team believes that they can only succeed if everyone in the group succeeds

- **Equal Participation**
  Each member of the team contributes in some way to the task/project/discussion

- **Specific Roles**
  Each member of the team has clear expectations of what they should be doing to help the group

Appendix D: Individual Interview #1 Protocol

Phase 3 of the study is designed to address research question 1, 1a, and 2a. The principal researcher will review the consent form and remind students that they may stop at any time during the interview/study. Then the principal researcher will read the following script to students that consented to participate prior to beginning the interview:

"Thank you for returning to participate in this interview. This will be similar to the focus group but will give me a chance to hear more details about your unique experiences in your Computer Science class. I want to remind you that responses will not be shared with your teacher and these responses are not being used to evaluate the teacher or the course. Instead your responses will help educators better understand the types of experiences students have in Computer Science classes. By understanding your experiences, educators hope to work towards building more positive experiences for students in CS classes.

This conversation will be audio recorded however all of your responses will remain confidential. Only myself and one other researcher will listen to these responses.

These questions will ask you about collaboration and participation in your Computer Science and non-Computer Science classes. There are no right or wrong answers and you can skip any questions that you do not feel comfortable answering by just saying 'skip' or 'pass'. The interview should last approximately 45 minutes but if at any time you need to stop, please let me know and we will stop. Are you ready to get started?"

Individual Interview #1					
Question	**1**	**1a**	**1b**	**2**	**2a**
1. During our focus group, we discussed Cooperative Learning. This is any activity where some or all of the following elements are in place: ● Positive Interdependence: where the team believes that they can only succeed if everyone in the group succeeds ● Specific Roles: each member of the team has clear expectations of what they should be doing to help the group ● Equal Participation: each member of the team contributes in some way to the task/project/discussion Can you think of a time where _____ was present? Where _____ wasn't present? E.g. Tell me about a time where you felt like a partner or	x				

teammate cared about your success in your Computer Science class? Tell me about a time where you felt like a partner or teammate did not care about your success in your Computer Science class?					
Note: The three elements will be printed onto a piece of cardstock for students to hold and reference as needed throughout the interview.					
2. Are there any specific changes you would make to your team/partner activities to make your experience in your Computer Science class more positive?	x				
3. Can you tell me about a specific activity your teacher used that made you feel more comfortable with your partner?					
4. Consider the following items: sense of accomplishment, enthusiasm, excitement, enjoyment. Does collaboration in CS affect any of these items?		x	x		
5. [Give participant a paper with items and scale] Take a few minutes and consider each of the following skills. What things do you think you would do well in a future Computer Science class? a. Writing and reading code b. Learning more advanced Computer Science topics c. Thinking creatively d. Explaining my ideas to others e. Listening to other people's ideas		x	x		
6. Do you think your collaboration in this class has impacted how you rated item _____? Notes: Based on student responses, choose 1-2 items from the previous question and ask students to elaborate on the connections (if any) between CS success in these areas and collaboration.		x	x		

7. Think of a time you worked with a partner that you didn't know. What are some things that decreased your stress or anxiety? What are some things that increased your stress or anxiety?	x		x		
8. Tell me a time where you felt like your voice was being included or excluded in your CS class.			x		
9. If you were going to give advice to a CS teacher to help support their students during collaboration, what advice would you give?	x				

Appendix E: Individual Interview #1 Handout

	1 (not successful)	2	3	4	5 (very successful)
Writing and reading code					
Learning more advanced CS topics					
Thinking creatively					
Explaining my ideas to others					
Listening to other people's ideas					

Appendix F: Individual Interview #2 Protocol

Phase 4 of the study is designed to address research question 1, 1b, and 2. The principal researcher will review the consent form and remind students that they may stop at any time during the interview/study. Then the principal researcher will read the following script to the group of students that consented to participate prior to beginning the interview:

"Thank you for returning to participate in this final interview. This will be similar to the previous conversations we've had but will give me a chance to hear more details about your unique experiences in your Computer Science class. I want to remind you that responses will not be shared with your teacher and these responses are not being used to evaluate the teacher or the course. Instead your responses will help educators better understand the types of experiences students have in Computer Science classes. By understanding your experiences, educators hope to work towards building more positive experiences for students in CS classes.

This conversation will be audio recorded however all of your responses will remain confidential. Only myself and one other researcher will listen to these responses.

These questions will ask you about collaboration and participation in your Computer Science and non-Computer Science classes. There are no right or wrong answers and you can skip any questions that you do not feel comfortable answering by just saying 'skip' or 'pass'. The interview should last approximately 45 minutes but if at any time you need to stop, please let me know and we will stop. Are you ready to get started?"

Individual Interview #2					
Question	**1**	**1a**	**1b**	**2**	**2a**
1. In our last conversation you mentioned how important it is to feel comfortable with your partner, I want you to think of a non-CS class. What activities do your teachers use to make you feel more comfortable with partners or teammates? Are there things from your other classes that you wish you also did in CS?	x			x	x
2. From survey: "I found that working with a team enhanced my sense of who I am". You responded with ___. Can you elaborate a little more on your response to that question?	x		x		

3. Think of a time where you disagreed with a partner. How did you feel? How did you express those feelings to your partner?	x		x		
4. How did the problem get resolved? How do you think the teacher could have supported that disagreement?	x		x		
6. You've mentioned that you appreciate when your partner contributes equally. In addition to helping with the work, what are some other qualities you want your partners to have? What are some personality traits you want your partner to have?	x		x		
7. How often do you feel like you help students with their work in CS? When your partner comes to you with a question, how does that make you feel?	x	x			
8. When you have to work independently in Computer Science, what are some of the challenges? What are some of the things that you value?	x	x			
9. What's one final thing you wish CS teachers knew about student collaboration?	x				

Appendix G: Parental Consent Form

Cooperative Coding: How Underrepresented Students Perceive Collaboration in Computer Science

Parental Consent

Dear Parent or Legal Guardian,

My name is Devon Senneseth and I am a student in the Department of Education at California State University San Marcos. I am conducting a research study to gain a better understanding of the ways that collaborative activities in a Computer Science classroom affect students. The purpose of this form is to provide you with information that will help you decide if you will give consent for your child to participate in this research.

KEY INFORMATION ABOUT THIS RESEARCH STUDY:
The following is a short summary of this study to help you decide whether you want your child to be a part of this study. Information that is more detailed is listed later on in this form.

The purpose of this study is to better understand the effects that collaboration has on student experiences in their Computer Science classrooms. Your child will be asked to complete a survey at the beginning of the study and they may or may not be selected to participate in one focus group and two individual interviews. Most students will only participate in this study for approximately 20 minutes, however if your child volunteers and is selected to participate in additional phases of the study, they would be participating for approximately 3 additional hours over the course of approximately 3 months. The primary risk of participation is fatigue, boredom, or anxiety. The main benefit is contributing to the knowledge that Computer Science teachers rely on to make decisions that support all students.

STUDY PURPOSE:
The purpose of the study is to gain a better understanding of the ways that students perceive collaborative activities in a Computer Science classroom. The study hopes to learn how collaboration affects the ways students feel valued in class, the ways a student builds relationships, and the ways academic growth is made. Your child is being asked to take part in the study because they are currently enrolled in a Computer Science course at their high school.

NUMBER OF PARTICIPANTS:
If you agree to participate, your child will be one of approximately 250 participants participating in this research. There will be two school sites participating in the study. All students enrolled in a Computer Science course at these schools will be invited to participate in the study, however no more than 4 students from each site will be selected to participate in the focus group and interviews.

PROCEDURES FOR THE STUDY:
If you agree for your child to participate in the study, she or he will

- **Complete an online survey.** During the 1st week of the study, students will complete a survey that will ask questions about their collaborative experiences in their Computer Science course. The survey will last approximately 20 minutes and will ask questions about how they view collaboration in your Computer Science course, how they view collaboration in other courses, some additional demographic questions, and whether or not they are interested in participating in the interview portion of the study.
- **Focus Groups & Interviews.** If on the survey they indicated that they were interested in participating in the interview portion of the study, the researcher will consider their overall responses to the survey as well as their demographic information. Using the pool of students who volunteer to participate in the focus groups and interviews, the researcher will select students in a way that creates a diverse group of participants. The focus group and the individual interviews will include questions related to their experiences with collaborative activities, relationships with peers, and academic experiences both in their Computer Science course and in another course of their choosing. For example, they may choose to talk about their experiences in their Computer Science course and their current English course. Or they may choose to talk about their experiences in their Computer Science course and their current math course, etc. Students will have the opportunity to skip any questions and will be able to stop participation at any point during a focus group or interview.
    - **Focus Group:** Selected students will be asked to meet in their Computer Science classroom after-school. At each of the school sites, a group of 4 students will be invited to this focus group. The focus group will last approximately 60 minutes and students will respond to interview questions as well as respond to the other ideas shared by participants.
    - **Individual Interview #1:** The students who participate in the focus group will be invited to participate in an individual interview approximately 3 weeks after the focus group. This individual interview will be scheduled after-school and will take place in the student's Computer Science classroom. The individual interviews will last approximately 45 minutes.
    - **Individual Interview #2:** The students who participate in the focus group will be invited to participate in an individual interview approximately 3 weeks after the first individual interview. This individual interview will be scheduled after-school and will take place in the student's Computer Science classroom. The individual interviews will last approximately 45 minutes.

All of the above activities will take place in the student's Computer Science classroom and all identifiable, private information (e.g. names) will be removed or replaced with a pseudonym. No data from this study will be used for additional, future research.

RISKS AND INCONVENIENCES:
There are minimal risks and inconveniences to participating in this study. These include boredom, fatigue, or anxiety while participating in one or all of the portions of the study. Some students may experience some discomfort talking about their classroom experiences either on the survey or during the focus group or interview portion. Some students may find the after-school time to be an inconvenience.

SAFEGUARDS:
To minimize these risks and inconveniences, the following measures will be taken:

- **Boredom**: If a student becomes bored, they simply need to let me know and they will, at any point in the study, be given the opportunity to stop participating.
- **Fatigue**: If they become fatigued, the student simply needs to inform the researcher and we can take as many short breaks as the student deems necessary or the current activity can be stopped completely.
- **Anxiety**: If they feel anxiety, they simply need to let me know and they can step outside at any time, take a short break or walk, or they can decide they no longer wish to participate in the study.
- **Discomfort**: If at any point a student experiences discomfort with a question, they can choose to skip the question or decide that they no longer wish to participate in the study. A student may exit a focus group or interview at any time and can cease participation in the study whenever they choose.
- **Inconvenience**: The survey provided to students in the first phase of the study allowed students to volunteer for the after-school portions of this study and also asked students to provide days and times that were most convenient for these activities to take place. However, if a student feels inconvenienced by the time required to participate, the student can suggest a reschedule or cancel an interview at any time. If none of these are suitable solutions to minimizing the risks and inconveniences, the student may choose to no longer participate in the interview portion or in any portion of the study.

CONFIDENTIALITY:
If your child does not indicate that they are willing to participate in the focus group and interviews, then your child's responses and information will be anonymous when they complete the survey. They will not be required to provide an ID number, name, or any other unique identifiers as part of their survey responses.
If they are interested in participating in the interview portion of the study, they will be asked to provide a name and contact information to allow the researcher to coordinate the focus group and interview days and times. However, their responses to the survey, responses to the focus group, their responses to the individual interviews, and all personal data will be kept confidential and a pseudonym will be used when the data from this study is reported, and discussed. Due to the nature of focus groups, complete confidentiality cannot be guaranteed for this portion of the data collection process. The results of this study may be used in reports, presentations, or publications but the student's name will never be used. All data collected from this study will be stored on a password protected computer and on a password protected cloud folder. The principal researcher and a secondary researcher are the only ones who will have access to the data. The data will be stored for up to 3 years following the conclusion of the study, after which time all digital files will be permanently deleted from storage.

VOLUNTARY PARTICIPATION:
Your child's participation in this study is voluntary. Your child may decline participation at any time. You may also withdraw your child from the study at any time; there will be no penalty. It will not affect your child's grade or treatment in class. Likewise, if your child chooses not to participate or to withdraw from the study at any time, there will be no penalty.

BENEFITS OF TAKING PART IN THE STUDY:
The benefits of your child participating in this study are that they might gain a better understanding of what they value about collaboration and how it does, or does not, support their learning. This reflection may benefit their views on collaboration or how they perceive their role within a classroom.

ALTERNATIVES TO TAKING PART IN THE STUDY:
If you decide not to participate in this study, your child will have the option to resume working on their regular classroom assignments during the 20 minutes of class time where the survey is being administered to participants. The survey will not be used by your child's classroom teacher as a measure of participation or performance. They will be able to sit in class and engage in other coursework while participants complete the survey for approximately 20 minutes. Your child's teacher will not be participating in the study and thus will still be available for instruction and support during this 20 minute period.

PAYMENT OR INCENTIVE:
Students will receive a $50 gift card if they are selected and choose to participate in the focus group and interview portions of the study. As a way to thank students for their after-school time spent engaging in the focus group and two individual interviews. Students who express interest in participating in this portion of the study on the survey and are then selected to participate in the interview portion will receive their gift card at the end of the study regardless of their responses and regardless of whether or not they complete all phases.

CONTACT INFORMATION:
If you have questions about the study, you can ask me now or anytime during the study. You can also call me at 619-871-4447 or e-mail me at senne01@cougars.csusm.edu. You may also contact the faculty advisor for this study, Dr. Rong-Ji Chen at rchen@csusm.edu. If you have any questions about your rights as a participant in this research or if you feel you have been placed at risk, you can contact the IRB Office at irb@csusm.edu or (760) 750-4029. You will receive a copy of this form for your records.

PARENT'S CONSENT:

By signing below, you are giving consent for your child to participate in the above study.

Please check the option that applies to you before signing with the following options:

☐ I give permission for my child's interview responses to be to be audio recorded.
☐ I do not give permission for my child's interview responses to be audio recorded.

Your child's name: _____
Parent's name: _____
Parent's Signature: _____
Date:_____

Appendix H: Student Assent Form

Cooperative Coding: How Underrepresented Students Perceive Collaboration in Computer Science

Assent Form

My name is Devon Senneseth and I am a student in the Department of Education at California State University San Marcos. I am inviting you to participate in a research study about collaboration in high school Computer Science classes. Your parent(s) know we are talking with you about the study. This form will tell you about the study to help you decide whether or not you want to take part in it.

What is the key information about this research study?
The following is a short summary of this study to help you decide whether you want to be a part of this study. Information that is more detailed is listed later on in this form.

The purpose of this study is to better understand the effects that collaboration has on student success, emotional and academic, in their Computer Science classrooms. You will be asked to complete a survey at the beginning of the study and you may or may not be selected to participate in one focus group and two individual interviews. Most students will only participate in this study for approximately 20 minutes, however if you volunteer and are selected to participate in additional phases of the study, then you would be participating for approximately 3 additional hours over the course of approximately 3 months. The primary risk of participation is fatigue, boredom, or anxiety. The main benefit is contributing to the knowledge that Computer Science teachers rely on to make decisions that support all students.

Why is this study being done?
The purpose of the study is to gain a better understanding of the ways that collaborative activities in a Computer Science classroom affect students. The study hopes to learn how collaboration affects the ways students feel valued in class, the ways a student builds relationships, and the ways academic growth is made. You are being asked to take part in the study because you are currently enrolled in a Computer Science course at your high school. You cannot take part in this study if you are planning on transferring out of your Computer Science course before the end of the semester.

What do I need to do?
If you decide to be in the study, I will ask you to

- **Complete an online survey.** During the 1st week of the study, students will complete a survey that will ask questions about their collaborative experiences in their Computer Science course. The survey will last approximately 20 minutes and will ask questions about how you view collaboration in your Computer Science course, how you view collaboration in other courses, some additional demographic questions, and whether or not they are interested in participating in the interview portion of the study.
- **Focus Groups & Interviews.** If on the survey you indicate that you are interested in participating in the interview portion of the study, the researcher will consider their

overall responses to the survey as well as their demographic information. Using the pool of students who volunteer to participate in the focus groups and interviews, the researcher will select students in a way that creates a diverse group of participants. The focus group and the individual interviews will include questions related to their experiences with collaborative activities, relationships with peers, and academic experiences both in their Computer Science course and in another course of their choosing. For example, they may choose to talk about their experiences in their Computer Science course and their current English course. Or they may choose to talk about their experiences in their Computer Science course and their current math course, etc. Students will have the opportunity to skip any questions and will be able to stop participation at any point during a focus group or interview.

- **Focus Group:** Selected students will be asked to meet in their Computer Science classroom after-school. At each of the school sites, a group of 4 students will be invited to this focus group. The focus group will last approximately 60 minutes and students will respond to interview questions as well as respond to the other ideas shared by participants.
- **Individual Interview #1:** The students who participate in the focus group will be invited to participate in an individual interview approximately 3 weeks after the focus group. This individual interview will be scheduled after-school and will take place in the student's Computer Science classroom. The individual interviews will last approximately 45 minutes.
- **Individual Interview #2:** The students who participate in the focus group will be invited to participate in an individual interview approximately 3 weeks after the first individual interview. This individual interview will be scheduled after-school and will take place in the student's Computer Science classroom. The individual interviews will last approximately 45 minutes.

What are the benefits to me?

If you take part in this study, you might gain a better understanding of what you value about collaboration and how it does, or does not, support your learning. This reflection may benefit your views on collaboration or how you perceive your role within a classroom.

Are there any risks to me if I decide to be involved in this study?

There are no foreseeable risks however some kids may face boredom, fatigue, or anxiety while participating in one or all of the portions of the study. If you become bored, simply let me know and you will, at any point in the study, be given the opportunity to stop participating. If you become fatigued, let me know and we can take as many short breaks as you deem necessary. If you feel anxiety, let me know and you can step outside at any time, take a short break or walk, or you can decide you no longer wish to participate in the study. Some students may experience some discomfort talking about your classroom experiences either on the survey or during the interview portion. If at any point you experience discomfort with a question, you can choose to skip the question or decide that you no longer wish to participate in the study. Some students may find the after-school time to be an inconvenience. If this is the case, the researcher will do their best to pick a day of the week that is most convenient or the student may choose to no longer participate in the interview portion or in any portion of the study.

How will my information be protected?

Your responses will be confidential throughout the entirety of the study. You will not be required to provide an ID number, name, or any other unique identifiers as part of your survey responses unless you are interested in participating in the focus group/interviews. If you are interested and selected to participate in the interview portion of the study, your responses from the individual interviews will be kept confidential and a pseudonym will be used when data is reported and discussed. However, due to the nature of focus groups, complete confidentiality cannot be guaranteed for this portion of the data collection process. The results of this study may be used in reports, presentations, or publications but your name will not be used. All data collected from this study will be stored on a password protected computer or on a password protected cloud folder. The principal researcher and a secondary researcher are the only two people who will have access to the data. The data will be stored for up to 3 years following the conclusion of the study, after which time all digital files will be permanently deleted from storage.

Do I have to be in the study?
No, you don't. The choice is yours. Your participation in this study is completely voluntary. No one will get angry or upset if you don't want to do this. And you can change your mind anytime if you decide you don't want to be in the study anymore. It will not affect your grade.

Do I get anything in return for participating in this study?
You will receive a $50 gift card if you participate in the interview portion of the study. As a way to thank you for your after-school time spent engaging in the focus group and two individual interviews. Students who express interest in participating in the focus group/interviews and are then selected to participate in the interview portion will receive their gift card regardless of how you respond to questions and regardless of how long you choose to remain and participate in the study.

What if I have questions?
If you have questions about the study, you can ask me now or anytime during the study. You can also call me at 619-871-4447 or e-mail me at senne01@cougars.csusm.edu. You may also contact the faculty advisor for this study, Dr. Rong-Ji Chen at rchen@csusm.edu. If you have any questions about your rights as a participant in this research or if you feel you have been placed at risk, you can contact the IRB Office at irb@csusm.edu or (760) 750-4029. You will receive a copy of this form for your records.

PARTICIPANT'S CONSENT:

By signing below, you are giving consent to participate in the above study.

Please check the option that applies to you before signing with the following options:

☐ I give permission for my interview responses to be to be audio recorded.
☐ I do not give permission for my interview responses to be audio recorded.

Name of the Participant (Write your name on the line): _____
Signature of the Participant (Put your signature on the line): _____
Date:_____