Title

Empowering Teachers to Change: A Mixed Methods Examination of Equity-Oriented STEM Instruction

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Publication Date

2016

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By

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A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Education

in the

Graduate Division

of the

University of California, Berkeley

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Fall 2016

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Abstract

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In this dissertation study, I employed mixed methods to examine the varied perspectives teachers have about equity-oriented STEM instruction and how their equitable teaching practices make certain academic and STEM identities available to their students. Both qualitative and quantitative data sources were collected from eight case study teachers and 24 focal high school students who participated in a summer residential college preparatory program for students from nondominant communities. Based on the eight case study teachers' pre- and post-survey data, teaching philosophy statements, and other teacher materials (lesson plans, reflection responses, etc.), I highlight the two main perspectives on equity-oriented STEM instructions that teachers exhibited across the summer session: *equity is equality* and *empowering students for success*. The findings revealed how five teachers' perspectives shifted over the summer from equity is equality to empowering students for success. Teacher learning was supported by the use of cultural artifacts and by the development of both collegial and teacher-student relationships.

This study also analyzed the equitable teaching practices of two focal teachers. Specifically, the equity-minded focal teachers: 1) utilized culturally relevant teaching practices; 2) developed relationships with students; and 3) emphasized diverse perspectives and participation in the STEM fields. Drawing upon the *practice-linked identity framework* (Nasir, 2012; Nasir & Cooks, 2009; Nasir & Hand, 2008) I examined qualitative and quantitative data sources to show how material, ideational, and relational resources available in the focal teachers' classrooms supported students' identity development. These teachers' teaching and classroom environments made three identities available to focal students, including *capable learners*, *potential change agents*, and *future STEM professionals*. Statistical analyses ($p < 0.05$) of students' pre- and post-surveys indicated that students made significant gains in their identity development.

Findings from this research can inform the design of professional development experiences to develop equity-minded teachers. These include supports for teacher learning, developing equitable teaching practices, and fostering equitable learning environments.

Dedication

This dissertation is dedicated to my incredibly beautiful family (both by birth and through love), especially my mommy—my first teacher. Without your love, support, and laughter, I would not have become the person I am today or have accomplished this task. This dissertation is also dedicated to all of the teachers and students who have I worked with over the years; you continue to inspire and shape my career in education.

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Acknowledgements

First, I give thanks to God; with Him, all things are possible, we have joy, and the freedom to be and to become.

It has been a privilege to be a part of the Graduate School of Education, where I was able to develop and refine my skills and understandings as an educational researcher. Thank you to my incredible dissertation committee members! Professor Na'ilah Nasir, thank you for believing in me when it felt like no one else did. You have opened numerous academic and personal doors on my behalf, and I am grateful for all you've done. Professor Aki Murata, thank you for providing me with a space within the GSE to hone my understandings of teacher education and being a constant source of support. To Professor Marcia Linn, thank you for becoming a part of my academic journey—your academic, professional, and personal guidance have meant the world to me. To Professor Malo Hutson, thank you for being a voice of reason, support, and reminder of the ways in which equity matters in our world and lived experiences. To all of my Berkeley family and colleagues, I am full of gratitude for your mentoring, support, and friendship. To my SRATUS, CPLD, Murata RG, JWL RG on Teachers and Teacher Education, and CUE 2/3 families, your feedback and support pushed my thinking and research, and I am grateful to have grown in these communities. Caron Williams—you have been a constant source of support, guidance, and laughter. When I needed strength, answers to questions, or a hug, I always found it in you. Thank you for being my daily dose of Blackness and keeping me sane! Finally, my experiences at Berkeley have been enriched in more ways than I can count because of those I am blessed to call my friends: Alea Holman, David Philoxene, Eric Berson and Family, Jarvis Givens, Jennifer Collett, Jennifer Wade, Jody Siker, kihana ross-Vakil, Kimberly Seashore, Krystal Strong, Maxine McKinney de Royston, Sepehr Vakil, Tammie Visintainer, and Tierra Bills.

To my extended family and friends, life would not be the same without you! To my sister through love, Telona, you are my rock; I am grateful for your unconditional love, laughter, and our sisterhood. Thank you to Asha, Aziza, Candy, Carla, Cindy Lowery, Kelli, Michele, Pia, Safini, Tamanika, Tolifer, and Winter for always encouraging me and simply being there, no matter what. To my godchildren, Jalyn, Mahogany, and Malcolm, you are a constant source of joy, smiles, hope, and love. To my church family at The Way Christian Center—thank you for increasing my hope, love, and faith!

To Joseph Prevost, I am incredibly grateful for the myriad ways in which you have supported me. Your continuous support, confidence, and warmth gave me strength to survive the infamous last stretch!

Finally, to my immediate family—Daddy, Mommy, Derrick, Shari, and Cindy—thank you for your love, faith, and encouragement. I am eternally grateful to my parents; you have each shown me in multiple ways that you believe in me, support my educational, professional, and personal endeavors, and that our faith is most important. Shari and Cindy—all those years of doing homework on the back row of the church have finally paid off exponentially!

An Introduction to Empowering Teachers to Change: A Mixed Methods Examination of Equity-Oriented STEM Instruction

The 21st century has been filled with numerous technological advances, shifts in global competition, and an increased focus on STEM (science, technology, engineering, and mathematics) education. Many of the fastest-growing industries within the global economy are STEM-related (Bureau of Labor Statistics, 2009; National Science Board, 2007), and despite the economic downturn of the late 2000s, the number of jobs in science and engineering continued to grow (NSF, 2014). These trends indicate the growing importance of the STEM fields both internationally and domestically. Within the United States, much of the funding for STEM education is aimed at preparing K – 12 students to enter the STEM pipeline as undergraduates and ultimately enter the STEM fields (National Academy of Sciences (NAS), 2007; National Science and Technology Council (NSTC), 2013).

Many of the initiatives to strengthen STEM education in the U.S. have been specifically designed to increase the number of students from nondominant communities[1] in the STEM fields (NAS, 2007, 2011; NSTC, 2013; President's Council of Advisors on Science and Technology (PCAST), 2012). These initiatives specifically target racial and ethnic groups that are underrepresented in the STEM fields (i.e., Alaskan Natives, Black/African American, Hispanic and/or Latin@, and Native Americans). For example, a 2011 report published by the National Academies Press, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, highlights the need for broader participation in the STEM fields from students from nondominant communities. The report outlines potential strategies to enhance K – 16 STEM learning experiences and increase student interest in and access to STEM careers and education. Although there is much agreement that fostering diversity within the STEM fields is critical, some researchers argue that focusing on access issues is not enough. Rather, educational researchers need to attend to the sociocultural and sociopolitical realities of students from nondominant communities. In so doing, research has highlighted the ways in which these realities influence student learning in STEM across formal and informal settings. These critical perspectives illuminate why bringing the equity agenda—the types of rigorous learning opportunities provided for students from nondominant communities—to the forefront of STEM education is crucial for the success of *all* students.

In this mixed methods dissertation study, I examine teachers' perspectives on equity-oriented STEM instruction, how those perspectives shift over time and influence their instructional practices with a focus on the features of professional development that were useful for their growth. Ultimately, I explore how their perspectives on equity-oriented STEM instruction and related teaching practices influenced student outcomes. I argue that teachers' perspectives range from narrow to broad conceptions of equity, and that their orientations can shift based on their professional development, collegial, and teaching experiences. Teachers' perspectives about equity-oriented instruction and related teaching practices are consequential for classroom interactions and student

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[1] This term, *students from nondominant communities*, is chosen because it implies the power dynamic inherent in race and ethnicity within the US. Terms, such as minorities or students of color, ignore these important and influential power relationships (K. Gutiérrez & Rogoff, 2003).

learning outcomes, such as identity development and achievement. Using open coding and thematic analysis of 1) classroom observation data of focal teachers (N = 2); 2) observation data of professional development sessions (N = 6); 3) teacher (n = 8) and focal students (N = 22) pre- and post-survey data, and 3) interviews with students (N = 7) and a focal teacher (N = 1), the findings reveal that teachers' equity orientations range from narrow views of equity to those that evidence empowering students to become change agents and shift over the summer session.

This study was conducted from Spring to Summer 2015 at the Summer Academy for Underrepresented Students Entering STEM (SAUSES)[2] in the East Bay region of San Francisco Bay Area in Northern California. SAUSES was selected because of its reputation for serving students from nondominant communities who intend to enter their undergraduate careers as STEM majors *and* for having teachers and staff members committed to advancing the equity agenda. At the time of data collection, SAUSES program sites were making significant changes to their professional development series for teachers to specifically target equity-oriented STEM teaching and learning. In an effort to better understand and document how teachers' perspectives on equity and STEM instruction, I chose to examine the SAUSES East Bay site.

In chapter one, I examine the theoretical perspectives on and empirical examples of equity-oriented STEM instruction. This literature review is organized around three broad strands of STEM education literature: 1) contemporary trends in STEM education; 2) critical perspectives on STEM education; and 3) empirical research on equity-oriented teaching and learning. In this chapter, I provide an overview of the relevant STEM education literature, including reform efforts in response to calls for broader participation in the STEM fields, critical perspectives on STEM education, advancing the STEM equity agenda, and equity-oriented STEM instruction. The review of the literature draws upon sociocultural perspectives on learning and research advances in preservice and inservice teacher education in addition to the STEM education literature to situate the dissertation study within the broader STEM education research literature.

After setting the stage for the empirical investigation, I detail the research methodology utilized for the dissertation study in chapter two. I describe the criteria used to select the research site, the Summer Academy for Underrepresented Students Entering STEM (SAUSES) in the East Bay region of the San Francisco Bay Area. Additionally, this chapter outlines the methods utilized to collect data, data sources, and descriptions of the analytical frameworks employed for data analysis in the findings chapters.

In chapter three, I argue that teachers' perspectives on equity-oriented STEM instruction range from less to more sophisticated conceptualizations of equity. I present findings from the data analysis of teachers pre- and post-surveys, along with other data sources, which demonstrate the varied equity orientations SAUSES teachers have. Based on this analysis, case study teachers (N = 8) exhibited two main orientations to equity-oriented STEM instruction: *equity is equality*—the idea that equity is the same as equality or equal resources—and *empowering students for success*. Across this second category, *empowering students for success*, teachers have increasingly sophisticated conceptualizations of equity. In this chapter, I discuss the ways teachers' perspectives shifted by highlighting the types of shifts teachers made, and the types of supports that supported or constrained their growth.

[2] All names are pseudonyms.

In chapter four, I analyze the work of two focal teachers—one computer science teacher and a chemistry teacher—and discuss the varied roles that teachers take on as they endeavor to implement equitable teaching practices. Based on classroom observations, a focus group interview with students, and other data sources, I discuss the three dimensions of the focal teachers' equitable instructional practices: culturally relevant instructional practices, develop and maintain relationships with students, and emphasize diverse perspectives and participation in the STEM fields. Based on their instructional practices, there were several student learning outcomes, and I focus on how teachers' instruction made multiple identities available to students in chapter five. Drawing upon Nasir and colleagues' *practice-linked identity framework* (Nasir, 2012; Nasir & Hand, 2008; Nasir & Cooks, 2009), I discuss the three identities made available to students, including *capable learners*, *potential change agents*, and *future STEM professionals*, and the types of material, ideational, and relational resources that were available to students in the learning environments to take up these identities.

Finally, chapter six provides an opportunity for reflection on the empirical findings of the dissertation study. In this chapter, I discuss the implications of the study and how the study findings contribute to our theoretical and pedagogical understandings of equity-oriented STEM instruction. I then explore the possibilities of future research in equity-oriented STEM instruction, both for educational researchers and practitioners, in order to better support STEM teaching and learning for students from nondominant communities. I end the chapter with a discussion of why SAUSES teachers' mindsets matter and the contributions these findings make to the field's understanding of equity-oriented teaching broadly and to STEM education specifically.

Chapter 1: How Did We Get Here? A Theoretical and Empirical Examination of the STEM Education Literature

STEM Education in the U.S.

Within the United States, there is a focus on increasing the number of students entering the STEM pipeline to create a diverse workforce for solving 21st century challenges and strengthen national security (Koehler, Binns, & Bloom, 2016; NAS, NAE, & IM, 2007, 2011; President's Council of Advisors on Science and Technology (PCAST), 2012). Since the early 2000s, there has been a proliferation of STEM-related partnerships between governmental agencies, universities, corporations, and school districts. For example, the Chevron Corporation, Ford Motor Company, and other businesses (e.g., Ford Next Generation Learning (NGL) website; Hoachlander & Yanoksky, 2011) have partnered with educational organizations to implement initiatives to foster interest and better prepare K – 12 students entering the STEM pipeline. Other partnerships, like those between university-based research laboratories and federal agencies, have focused on advancing STEM-related industrial knowledge and innovations to strengthen national security. Although collaborations between universities and federal laboratories—particularly the Department of Defense—have been commonplace historically (Gupta, Sergi, Tran, Nek, & Howieson, 2014), these partnerships tend to increase during periods of war or other global conflicts (see Vissoughi & Vakil, in press, for a full review) and have increased since the 1990s as measured by cross-institution collaborations (NSF, 2014). A recent NSF report (2014) suggests that some of these partnerships are characterized by research projects with shared funding sources (e.g., each institution receives money from a federal or other type of grant), co-principal investigators, and co-authored publications (NSF, 2014) in an effort to strengthen STEM research efforts. Gupta and colleagues (2014) posit that such collaborations not only bolster national security efforts and advancements, but also increase and improve the workforce entering the STEM pipeline; the researchers suggest how to increase the number of these partnerships and form long-lasting relationships between university research laboratories and the Department of Defense.

These efforts highlight a few of the myriad ways approaches to increasing preparation for and participation in the STEM pipeline in the U.S. over the last nearly 20 years. In the following sections, I provide an overview of the relevant STEM education literature, including reform efforts in response to calls for broader participation in the STEM fields, critical perspectives on STEM education that incorporate sociocultural perspectives on learning, advancing the STEM equity agenda, and equity-oriented STEM instruction. By doing so, I situate my dissertation study in the context of educational research focused on STEM education and highlight its significance both for STEM education broadly and equity-focused STEM education research specifically.

STEM education efforts. There were many reasons for the focal shift from science and mathematics education reforms in the 1990s to STEM education in the early 2000s. One major concern was about how science and technology would become an integral part of our daily lives and society (Koehler et al., 2016; Sanders, 2009). Others were concerned about the U.S.' global competitiveness (Charette, 2014; Koehler et al., 2016; NAS, 2007; STEM Education Coalition Website). This shift in U.S. reform movements also signaled a desire to strengthen the nation's military positioning and technological advances, overall global presence, and economic prosperity (Atkinson & Mayo, 2010; Galama & Hosek, 2008; NAS, NAE, & IM, 2011; NGSS Website; STEM Education Coalition Website). Increased federal spending on STEM education was one instantiation of this focal shift. This was evidenced by the establishment of the *America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science* (America COMPETES) Act by President Bush's administration and Congress in the late 2000s. America COMPETES provided federal funding to

1) increase the number of certified science and mathematics teachers in public schools;
2) provide scholarships for STEM teacher education programs;
3) establish teacher professional development workshops to strengthen content and pedagogical knowledge;
4) create and implement plans to broaden access to Advanced Placement (AP) Math and International Baccalaureate (IB) coursework for students attending schools in low-income neighborhoods; and
5) conduct research in the physical sciences sponsored by the National Science Foundation (NSF) and Department of Energy (Bush/White House News, 2007; Public Law 110–69, 2007).

These STEM education efforts continued when America COMPETES was renewed under President Obama's administration in 2010 and 2015. Additional changes to the act included a focus on renewable energy research and innovations (Burwen, 2015; Mervis, 2015).

Nationwide calls for broader participation in the STEM fields have also spurred K-12 educational reforms, emphasizing an increased focus on STEM education in schools (e.g., Project 2061; NAS, NAE, & IM, 2007; NRC, 2012). For example, in 1985, the American Association for the Advancement of Science (AAAS) introduced Project 2061. This reform effort focused on developing a science-literate population who would be around for the next viewing of Haley's Comet in 2061—hence the name, Project 2061 (AAAS, 1989; AAAS Website). One of Project 2061's publications, *Benchmarks for Scientific Literacy* (AAAS, 1993), outlined the types of knowledge and habits of mind students across grade levels needed in technology, engineering, mathematics, and science upon high school graduation (AAAS website, 2009). Although *Benchmarks for Scientific Literacy* was not intended to specify and develop science curricula to meet these goals (AAAS, 1993; AAAS website), it has been widely used as a tool to guide the design of state standards, which led to curriculum development (McComas, 2014). Critiques of the *Benchmarks* include that it limits students' learning opportunities, identity development, and agency (Bang & Marin, 2015; Bang, Warren, Rosebery, & Medin, 2013), does not value students' lived experiences and privileges Western science (Bang et al., 2013; Bang & Marin, 2015; Seiler, 2001), and does not does not promote students' use of scientific knowledge to engage with socioscientific issues (Sadler & Zeidler, 2009).

One of the most recent reform efforts in the U.S. has been the adoption of National Content Standards (NCS) in mathematics, science, and engineering. These efforts were informed by research on teaching and learning in mathematics, science, and engineering education. NCS focuses on students gaining conceptual understanding, solving problems, and engaging in the best practices of each domain rather than rote memorization or lecture-based learning (CCSSI-M, 2010; NRC, 2012). For example, the Common Core State Standards in mathematics (CCSS-M) were introduced with the goal of developing and strengthening students' conceptual understanding and engagement in mathematical practices (CCSSI-M, 2010). This was a bold effort, and demonstrated a move from typically focusing on mathematics procedural fluency to higher order thinking skills (e.g., reasoning, generalizing, etc.). Thus, the CCSS-M garnered support from mathematics education organizations, such as the National Council of Teachers of Mathematics (NCTM).

Simultaneous efforts were being made to strengthen science and engineering education via the Next Generation Science Standards (NGSS). The NGSS were developed and based on the framework the National Research Council (NRC, 2012) provided for science and engineering education. This three-pronged approach to science and engineering education—often referred to as *3D learning*—focuses on:

1) *Crosscutting Concepts*, which are the themes that are found across and within the varied fields of science and engineering (e.g., patterns, systems, etc.);
2) *Disciplinary Core Ideas (DCI)*, which are core concepts in the life, physical, earth, and applied sciences and engineering and technology; and
3) *Science and Engineering Practices*, meaning students will engage in eight specific scientific and engineering practices that guide and inform the work of scientists and engineers in the field (NRC, 2012).

The CCSS-M and NGSS were reforms that can provide teachers with opportunities to facilitate deep student understanding rather than simply covering content standards (Slotta & Linn, 2009), signaling a move from breadth to depth of student understanding for science, engineering, and mathematics education.

Implementing reform-inspired STEM education initiatives—such as expanding STEM course offerings at schools in urban and suburban districts and increasing student interest in STEM majors and careers—put forth by the NRC, AAAS, or NCTM would ostensibly foster integrated course content within schools. In the 1990s, for example, pre-engineering and engineering courses became more widely available in suburban districts—and eventually urban districts—through the development and implementation of the Project Lead the Way (PLTW) curricula (Bottoms & Anthony, 2005; Bottoms & Uhn, 2007; Rogers, 2006; see Tai, 2012 for a full review of PLTW). PLTW was piloted in a few states in the U.S. as a high school curriculum to prepare students to major in engineering as undergraduates. It eventually expanded to all grades (e.g., K-12) and has been implemented in almost every state in the U.S. and across much of the United Kingdom (Bottoms & Anthony, 2005; Bottoms & Uhn, 2007; Rogers, 2006; Tai, 2012). PLTW has been shown to be a tool for improving student outcomes, including student learning of engineering concepts (Rogers, 2006) and mathematics and science NAEP scores (Stone, 2011). Other efforts included the development of Linked Learning Pathways, which are not unique to STEM education, but have provided high school students with STEM-focused learning and internship experiences (CCASN website; Hoachlander, 2014; Hoachlander & Yanokfsy, 2011; Stone, 2011). Ultimately these educational reform efforts were introduced to cultivate a more diverse, capable, and STEM-literate workforce within the United States.

Declining global performance amidst the STEM crisis. Taken together, the joint ventures and educational reforms created a sense of urgency for increasing the number of STEM-literate students in the U.S. Despite the persistence of this so-called STEM crisis and numerous efforts to broaden participation in the STEM fields, the U.S. continues to have a declining global STEM performance based on factors such as achievement scores, innovative technology creation, or ability to think critically to solve 21st century problems (Johnson, 2011; New York Academy of Sciences (NYAS) Website; OECD, 2014). Researchers posit that America's shift in global STEM performance is partially due to increased spending on STEM-related research and education in other countries. Some countries, like Brazil, Peru, or Sweden had not typically invested financially in STEM research at levels commensurate with the U.S. (Katsomitros, 2013; NAS et al., 2007, 2011), but are now doing so and making advances in STEM research and innovations. Additionally, countries such as India or China that have been investing in STEM education, as well as research and development (R&D), for many years significantly increased spending on these efforts (Katsomitros, 2013). For example, in 2011, China spent 871 billion yen (roughly 131 billion U.S. dollars) on STEM R&D, making China the country with the second highest expenditures on STEM R&D (Katsomitros, 2013)—and nearly equal to U.S. spending (NSF, 2014). Others argue that there is a shortage of available U.S.-born STEM workers, which has spurred increased federal spending for STEM education and research efforts to compete with other countries (see Charette, 2014; Salzman, 2013; Wadhwa, Gereffi, & Rissing, 2007) and anti-immigration attitudes by some in the STEM fields (see Matloff, 2012).

Breiner and colleagues (2012) partially attribute the United States' poor STEM performance and a dearth of students interested in STEM to the varied conceptualizations of STEM and how it affects individuals' lives. For example, there are multiple ways educational systems and agencies have defined and characterized the STEM acronym and related fields (Breiner et al., 2012). Educational researchers (Breiner et al., 2012; NAS, NAE, & IM, 2011; NRC, 2006, 2012; Stone, 2011) suggest this trend in STEM performance is the result of numerous, yet uncoordinated, educational reform efforts including:

1) increased emphasis in schools on traditional mathematics and science education than technology and engineering in secondary education (Bybee, 2010), especially in school contexts with strict mandates implemented as a result of No Child Left Behind legislation (Darling-Hammond, 2010; Parker, 2015);

2) the need to reconceptualize what young children are capable of learning and increase the cognitive demand in elementary school science (Metz, 1995, 1997); and

3) years of disagreement about how to implement reform-oriented instruction (Atkinson & Mayo, 2010; Boaler, 2008; Fairweather, 2008).

For example, researchers discuss the widespread lack of content integration across STEM subjects as taught in many schools, and highlight the need for a change in the status quo of disconnected STEM education experiences (Charette, 2014; Hoachlander, 2014; Hoachlander & Yanofsky, 2011; Linn, Davis, & Bell, 2013; Rockland, 2010; Sanders, 2009). Students oftentimes have piecemeal STEM learning experiences, rather than understanding STEM courses from an interdisciplinary approach. Having connected learning experiences would allow students to engage in meaningful instruction and envision how STEM education is relevant to their own lives (Breiner et al., 2012; Bryan, Moore, Johnson, & Roehrig, 2016; Sanders, 2009). Moreover, teachers often sacrifice students' development of deep understanding of content and focus on lecturing rather than inquiry-based approaches to STEM learning in order to cover content standards, which can ultimately lead to incoherent and disjointed learning experiences (NRC, 2012; Slotta & Linn, 2009; Yael, Linn, & Roseman, 2008).

Additionally, the STEM education literature focuses on the lack of interest in STEM and documents the disparities in student outcomes (e.g., undergraduate STEM majors, measures of achievement, etc.) by racial, ethnic, and gender groups. For example, despite numerous efforts to increase participation, the number of women and individuals from nondominant communities entering the STEM pipeline as undergraduates or professionals has been consistently low since the early 2000s (NSF, 2015). Additionally, minority-serving institutions[3] (MSIs) continue to produce the majority of STEM undergraduates from nondominant communities—especially historically Black colleges and universities (HBCUs) (Palmer, Maramba, Gasman, & Lloyd, 2013). Other research documents the ways in which students from nondominant communities are pushed out of the STEM pipeline or professions due to feeling like outsiders (Brown et al., 2015).

In terms of achievement data, students in the United States consistently struggle to perform as well, or better than, their peers from other countries in science (O. Lee & Luykx, 2006; M. Martin, Mullis, Foy, & Stanco, 2012; OECD, 2014; Valverde & Schmidt, 2000). When achievement data is disaggregated by race and ethnicity, disparities persist between students from nondominant communities and their Asian and white peers (Norman, Bentz, & Meskimen, 2001; OECD, 2014). As researchers and policymakers make sense of these disparities, discussions have centered upon increasing the number of students prepared to enter and access the STEM pipeline. For example, a 2011 report published by the National Academies Press, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, highlights the need for broader participation in the STEM fields for students from nondominant communities. The report outlines potential strategies to enhance K – 16 STEM learning experiences and increase student interest in and access to STEM careers and education. The authors point out that recruitment and retention efforts will take time to implement, and therefore persistency is necessary (NAS, 2011). These efforts intend to provide students with 1) outreach programs by targeting students' school and home communities, 2) academic and socioemotional support, and 3) access to rigorous STEM learning environments and high quality teachers.

Other narratives common to this literature include issues related to STEM teacher education. Teacher educators need to better prepare teachers to teach STEM subjects, particularly in urban areas (Atwater, Russell, & Butler, 2014; Buxton & O. Lee, 2014; NAS et al., 2007, 2011; OECD, 2014; PCAST, 2012). Teachers also need to better prepared to meet the specific needs of students classified as English Language Learners (ELLs) engaging in STEM learning (Moschkovich, 2013; Weinburgh, Silva, Smith, Groulx, & Nettles, 2014). Finally, teachers must examine and confront their beliefs

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[3] Minority-serving institutions (MSIs) include historically Black colleges and universities (HBCUs), Hispanic serving institutions (HSIs), and Tribal colleges and universities (TCUs). For more information on MSIs, see https://www.doi.gov/pmb/eeo/doi-minority-serving-institutions-program; a list of MSIs in the United States is available at https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst-list-tab.html

about students from nondominant communities (Atwater, Russell, & Butler, 2014; Bryan & Atwater, 2002; O. Lee & Luykx, 2006; O. Lee, Luykx, Buxton, & Shaver, 2007; Nasir, 2016; A. Rodriguez & Kitchen, 2005).

Explanations for disparities in outcomes. The body of scholarship in STEM education reviewed thus far focuses on two important and related issues—students from nondominant communities having access to high quality STEM learning experiences *and* a better prepared and more diverse STEM workforce. Although there is much agreement that fostering diversity within the STEM fields is critical, the framing of these issues is limited. The access to high-quality STEM education frame—a very narrow conceptualization of equity— is often cited as a way to mitigate pipeline diversity issues. This argument about equity in STEM implies having access to good teachers and rigorous instruction are enough for students from nondominant communities. In contrast, some researchers point out that simply having access to high quality inquiry-based instruction does not ensure that teachers, peers, and others will support students from nondominant communities to engage in rigorous learning (Ortiz & Capraro, 2016; Russell, 2014; Varelas, D. Martin, & Kane, 2012). Indeed, research has shown that many teachers rely upon deficit narratives to account for differential learning outcomes between students from nondominant communities and their white peers (Howard & Rodriguez-Scheel, 2016; Ladson-Billings, 2006a; Valoyes-Chavez & D. Martin, 2016). This research, which has roots in the culture of poverty narratives prominent in the 1960s (e.g., Lewis, 1966; Moynihan, 1965), narrowly views differences as a result of cultural or cognitive deficits that students must overcome in order to succeed (e.g., Howard & Scott, 1981).

Some educational researchers have explored how cultural deficit models have been used in education and educational research to explain achievement disparities (see McDermott & Varenne, 1995; Song & Pyon, 2008; or Valencia, 2012, 2015). Many researchers cast these disparities as an *achievement gap*, which places blame on students (and often their families and the communities in which they live). Framing disparities as an achievement gap limits students' potential, and renders students deficient rather than attempting to build upon their existing and developing academic, language, and socioemotional literacies. Within educational research, there is a hyperfocus on the achievement gap (R. Gutiérrez, 2008, 2013; Emdin, 2011), which can reinforce teachers' deficit thinking about student abilities (Sheppard, 2011). In stark contrast, framing these same disparities as *opportunity gaps* (Carter, 2013; Mahiri & Sims, 2016; Mosely, 2006) or our *educational debt* to students (Ladson-Billings, 2006a) shifts the narrative to focus on structures—which are often rooted in racist structures (Hilliard, 2003; Ladson-Billings, 2009; Noguera & Wing, 2006)—that limit and/or impede learning opportunities made available for students from nondominant communities.

Additionally, the access frame is limited in other ways. It does not explicitly acknowledge and address the historical and contemporary structural inequities students from nondominant communities must navigate and contend with daily. Take, for example, the discussion of access to science learning and careers in the *National Science Education Standards* (*NSES*). The NSES alludes to groups that have historically been excluded from participating in scientific endeavors (NRC, 1996). A. Rodriguez (1997) argues that reform documents, like the *NSES*, often use vague language rather than specifically identifying groups that have been historically excluded from scientific activities. This includes students from nondominant communities (based on race, class, and/or language), girls, and/or women. Furthermore, when research acknowledges those who have been marginalized in the STEM fields (e.g., *Science for All Americans*, etc.), the reform documents do not specifically address *how* to implement equitable STEM instruction both in terms of teachers' ideologies and pedagogy (A. Rodriguez, 1997, 2013, 2015).

Critical perspectives on STEM education. This lack of attention to equity is one of the reasons reform movements do not gain the traction necessary for making strides towards improving learning environments for nondominant youth. Therefore, the burgeoning scholarship on critical perspectives on STEM education emphasizes the sociocultural and sociopolitical realities of students from nondominant communities. In so doing, the ways in which these realities influence student learning in a variety of in and out-of-school settings are highlighted.

Rather than focus on deficit-model thinking or utilize the increasing access to STEM frame, critical scholars in STEM education examine the experiences of students from nondominant communities. Drawing from a sociocultural lens that views learning as constructing meaning through participation in social and cultural activities (Lave & Wenger, 1991; Nasir & Hand, 2006; Vygostky, 1978), research has revealed the myriad ways in which students from nondominant communities experience STEM education and professions. For example, Brown and colleagues (2016) report the ways in which students from nondominant communities are pushed out of the STEM pipeline or professions (i.e., rather than viewing this as dropping out) due to feeling like outsiders, experiencing microaggressions, or feeling more aligned to their racial/ethnic communities than their scientific communities. Others have examined how professors in the STEM fields from nondominant communities are marginalized in the academy (Atwater, 2016), in addition to identifying anti-deficit model thinking approaches to STEM pipeline issues (Harper, 2010), or students' sociocultural and sociopolitical realities that influence learning (Gutstein, 2006; D. Martin, 2013; Nasir, 2012; Rahm & Moore, 2016; A. Rodriguez, 2015; Rosebery, Warren, & Tucker-Raymond, 2015; Seiler, 2001; Tan & Calabrese Barton, 2012).

Other critiques include the ways STEM education reform measures and instruction are oftentimes motivated by the militarization of the U.S. (Vossoughi & Vakil, In Press) rather than how students and their communities can use their STEM knowledge for social change and empowering their own communities (Calabrese Barton, 2001, 2003; Garibay, 2015; Vossoughi & Vakil, In Press). For example, Garibay (2015) points out that students from nondominant communities majoring in the STEM fields are more committed to being agents of social change than their white counterparts, revealing notable differences in why some students from nondominant communities and their white peers pursue careers in the STEM fields. These critical perspectives illuminate why bringing the equity agenda—the types of rigorous learning opportunities provided for students from nondominant communities—to the fore of STEM education is crucial for the success of all students.

Moving the equity agenda forward. By advancing the equity agenda, educational researchers and educators can potentially design and provide learning opportunities that live up to the inclusionary potential of a STEM-literate society. The recent adoption and implementation of national standards [e.g., Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS)] offer a unique opportunity to design learning experiences that make both equity *and* rigorous, meaningful learning central to STEM education. The National Research Council (2012) recommends providing students with learning experiences that are meaningful, rigorous, and build students' STEM identities, and reform documents such as NGSS and CCSS offer teachers opportunities to reframe their notions of student success and ability.

It is important for teachers to confront and shift their fundamental notions about student ability, fundamental notions about how students learn, what counts as student success, who or what students can become (e.g., identities they can take up), and the variation within groups is especially important in large, urban areas. This is especially important in urban schools where students must negotiate the additional set of developmental demands with the realities of racism, poverty, violence, and other structural inequities that play out in classrooms (K. Gutiérrez & Calabrese Barton, 2015; Nasir, Snyder, Shah, & ross, 2012). There is an expansive body of literature documenting the ways structural inequities and racial narratives about students' abilities play out in classrooms and influence students' opportunities to learn (e.g., Nasir, Snyder, Shah, & ross, 2012). Shah (2013) discusses how *racial-mathematical discourse*—narratives about racial and ethnic groups who are or are not good at doing math—matter for student learning. For example, Shah (2013) points out ideas students may have about their peers, such as "I shouldn't ask Pamela for help because she's Black and Black people are not good at doing math." These narratives can inhibit or support students' positioning within mathematics classrooms, identity development, and opportunities to learn mathematics (D. Martin, 2013; Nasir et al., 2012; Nasir, Cabana, Shreve, Woodbury, & Louie, 2014; Shah, 2013). Thus, if teachers want their ideologies of desiring all students to be successful to be consistent with their classroom-level actions, they must be aware of, confront, and find ways to explicitly challenge these narratives in their classrooms.

Equity-focused teachers who are not only knowledgeable of sociocultural influences on student learning, such as race and socioeconomic status—but are *also* equipped to engage students in rigorous, inquiry-based learning—are critical for transforming STEM learning settings (K. Gutiérrez & Calabrese Barton, 2015; Johnson, 2011; Sheth & Braaten, 2013). These teachers utilize equity pedagogies that build upon students varied ways of knowing (C. Lee, 2001; Gonzalez, Moll, & Amanti, 2005; Nasir, 2012; Nasir & Hand, 2008). In equity-focused teaching, teachers demonstrate that they value their students' multiple forms of knowledge (Mavhunga, 2016; Ramos de Robles, 2016), which is imperative to support students' attitudes towards participating in the STEM fields and STEM learning (Mavhunga, 2016).

Additionally, these teachers employ pedagogies that are known to promote success for students from nondominant backgrounds, such as *critical pedagogy* (CP; Darder, Baltonado, & Torres, 2003; Duncan-Andrade & Morrell, 2008), *culturally relevant pedagogy* (CRP; Ladson-Billings, 1995, 2006b), or *culturally sustaining pedagogy* (CSP; Paris & Alim, 2014; Ladson-Billings, 2014). For example, culturally relevant pedagogy (CRP) is a widely utilized equity pedagogy centered upon three tenets: 1) set high expectations for all students' academic achievement; 2) identify students' culture as a vehicle to support learning while teaching them how to navigate the dominant culture; and 3) develop students' sociopolitical consciousness (Ladson-Billings, 1995, 2006b). A teacher's mindset about equity-oriented instruction is most important for implementing (CRP) and takes time to develop (Ladson-Billings, 2006b; Mensah, 2013). Much of the research on CP, CRP, and CSP has occurred in English Language Arts or humanities classrooms where these equity pedagogies are more frequently utilized than in STEM classrooms (see Aronson & Laughter, 2016 for a full review of culturally relevant education across disciplines). Although there is a dearth of literature on equity pedagogies in STEM learning environments, research in science learning suggests that strategies like CRP can benefit students by developing their self- confidence, affinity, and awareness of their contributions to and capacity to do science (Goldston & Nichols, 2009; Milner, 2011; Patchen & Cox-Petersen, 2008; Tsurusaki, Calabrese Barton, Tan, Koch, & Contento, 2013).

Equity-oriented STEM instruction. There is a growing body of scholarship on equity-oriented STEM learning in both in- and out-of-school settings that documents influences on student engagement, development of students' STEM identities, and students' sense-making and varied ways of knowing (Bang & Marin, 2015; Bang & Medin, 2010; Bricker & Bell, 2014; Nasir et al., 2014; Rahm & Moore, 2016; Rosebery et al., 2015; Tsurusaki et al., 2013; Vakil, 2014; Wright, 2011). When using equity pedagogies in STEM courses, such as culturally relevant or critical pedagogy, teachers link content to students' lived experiences and funds of knowledge (Bang & Marin, 2015; Bang & Medin, 2010; Seiler, 2001; Tsurusaki et al., 2013). In doing so these teachers also address issues of race and acknowledge students' multiple identities (Hargrave, 2015; Nasir et al., 2012; Nasir et al., 2014); and develop and maintain authentic and meaningful relationships with students (Johnson, 2011; Milner, 2011; Nasir et al., 2014; Vakil, 2014).

Fewer studies investigate the variations in *how* equity-oriented STEM instruction is implemented and the teaching practices utilized, *how* equitable STEM instruction can bolster and promote students' agency (e.g., ability to act on something), and *how* micro-level interactions can describe the social milieu of classrooms with equity-focused teachers (Carlone, Scott, & Lowder, 2014; K. Gutiérrez & Calabrese Barton, 2015; A. Rodriguez, 2015; Tan & Calabrese Barton, 2012).

Learning to teach with equity and STEM in mind. To understand how to facilitate teachers' development of equity-oriented instructional practices, there is a growing body of research in both preservice and inservice teacher learning. Research suggests that professional development opportunities should include the acknowledgement of the emotional work involved as teachers engage in learning to teach with equity in mind (K. Gutiérrez & Vossoughi, 2010; Rivera Maulucci, 2013), consider the constraints teachers face in learning contexts (Rivera Maulucci et al., 2015), and set parameters for teacher accountability (Rosebery et al., 2015). For example, Nasir and colleagues (2014) suggest that teachers working towards equitable mathematics instruction need time, collaborative work environments, and support at multiple levels (e.g., classroom, mentor teachers, departmental level, etc.) in order to make changes in their teaching practices.

There is an extensive body of knowledge documenting successful professional development experiences and K – 12 STEM teaching and learning (Arias, Bismack, Davis, & Palinscar, 2016; Linn, Davis, & Bell, 2013; Berson, Borko, Million, Khachatryan, & Glennon, 2015; Murata, 2011). One way to strengthen inquiry-based learning is to focus on developing teachers' pedagogical content knowledge (PCK, see Shulman, 1986) through teacher learning, reflection, and strategies that the teacher can use to acknowledge and utilize their students' multiple identities (Mavhunga, 2016).

There are few qualitative studies that research the relationship between professional development learning and the resulting successes and challenges of enacting equitable teaching practices in STEM-focused classrooms (e.g., Nasir et al., 2014; Rivera Maulucci, Brotman, & Sprague Fain, 2015; Rosebery et al., 2015). This growing body of literature suggests that some of the challenges to teachers' growth are a lack of science content knowledge or pedagogical content knowledge (Brown, Davis, & Kulm, 2011; O. Lee et al., 2007) and teachers' biased behavior toward students from nondominant communities (Brown, Davis, & Kulm, 2011). For example, Okhee Lee and colleagues (2007) found that teachers who engaged in two years of professional development about equity-oriented elementary science instruction still struggled to develop an understanding of how to use students' culture and home languages in their science instruction. Although teachers had explored how to build upon students' developing literacies, they found it difficult to integrate these skills into their science instruction due to a lack of content knowledge (O. Lee et al., 2007).

Few studies look to out-of-school settings as a context to investigate ways to create equity-oriented, STEM instruction. In this dissertation, I argue how this setting can be a critical space to carry out such investigations as out-of-school settings do not face the pressures of testing and systems of standardization that become a barrier in classrooms. Linn and Eylon (2011) point out that even with well-designed professional development, curriculum, and assessments, it will take time for teachers to change their teaching practices such that they align with their orientation towards robust learning in STEM. Thus, further research in this area will advance the field's understanding of the features of professional development that allow teachers to shift their equity-focused teaching practices *and* demonstrate if and how their teaching practices influence student learning outcomes (e.g., achievement, interest in STEM, etc.). I build upon this expanding line of research by focusing on the processes that allow for equity-oriented instruction in an out-of-school setting (e.g., professional development experiences, reflection, collegiality), the ways in which teachers' practices change, and the types of learning opportunities made possible for students.

Dissertation study. The dissertation study is a mixed methods study, which relies heavily upon an in-depth case study of teachers' perspectives on equity-oriented STEM instruction and how these teachers work to foster and maintain equitable and robust learning environments for their students. This research project focuses on the Summer Academy for Underrepresented Students Entering STEM (SAUSES), a five-week STEM-focused college preparatory residential program for high school students from nondominant communities in Northern and Southern California. My dissertation study focuses on the SAUSES East Bay site in Northern California. Generally, all SAUSES students participate in the program for three years (i.e., summers after grades 9 – 11) and take STEM courses each summer that are aligned to the Next Generation Science Standards (NGSS) and Common Core State Standards-Mathematics (CCSS-M); at the East Bay site specifically, students also take elective courses focused on scientific research and college readiness.

Research questions. In this dissertation study, I examine teachers' equity-oriented perspectives, instruction, and student outcomes (e.g., learning, STEM identity development), and answer the following research questions:

1. **Equity Orientations:** What are SAUSES teachers' perspectives on equity-oriented STEM instruction, and how do their perspectives change over the course of the program?
2. **Teaching Practices:** As SAUSES teachers aim for equity-oriented STEM instruction, in what ways are their perspectives on equity reflected in their teaching practices? What successes, tensions, and challenges do teachers experience?
3. **Student Outcomes:** How are learning opportunities and academic and STEM identities made available to SAUSES students through teachers' equity-oriented instruction?

Chapter 2: Research Methods

This study focused on the ways that teachers' perspectives about equity-oriented STEM instruction changed over time, and highlights the varied learning opportunities teachers provided for their students based on their orientations to equity-oriented STEM instruction. This study also explored how teacher learning was influenced by professional development experiences, collegial relationships, and other program-level supports. I employed a range of research methods, and in this chapter, I provide a detailed description of the research methods I employed for data collection at the Summer Academy for Underrepresented Students Entering STEM (SAUSES[4]) East Bay site.

This study utilized mixed methods, including case study methodology, surveys, and statistical analyses, which allowed for a fuller examination of the ways teachers' perspectives on equity-oriented STEM instruction and teaching practices shift over time and the ways in which student outcomes are influenced. By utilizing case study methods, I was able to provide a narrative description of teachers' perspectives and their enactment of equity pedagogies, and the ways in which students were influenced. The survey data and statistical analyses of data sources complemented the qualitative descriptions captured through video and fieldnotes observations. In so doing, this dissertation study provides an in-depth understanding of the variation in teachers' orientations to equity-oriented STEM instruction and their related instructional practices, and how their practices influenced student learning outcomes, such as achievement, STEM identity development, and attitudes toward STEM learning.

I begin this chapter by offering an overview of the research design, the motivations for conducting this study, and the rationale for selecting the SAUSES East Bay site, including a historical overview of the program. After reviewing the research questions guiding the study, I discuss the affordances and limitations of using a mixed methods research design that relies heavily upon case study methodology. Next, I provide a detailed description of the research site, SAUSES East Bay. In so doing, I provide the reader with an understanding of the social milieu in which the study of teacher learning *and* STEM teaching and learning occurred. Next, I provide descriptions of the research participants, data sources, and data collection procedures. The chapter ends with a discussion of the analytical frameworks I employed for data analyses and researcher positionality.

Research Design

Data collection for this study occurred across the three program sites of the Summer Academy for Underrepresented Students Entering STEM (SAUSES) in California during the full cycle of the 2015 SAUSES summer program. SAUSES was selected because of its reputation for serving students from nondominant communities who intend to enter the STEM pipeline as undergraduates *and* for having teachers and staff members committed to advancing the equity agenda. The program began in 2004, and was the first educational program offered by a Bay Area-based nonprofit, Institute Devoted to the Equity Agenda (IDEA). IDEA is the brainchild of a couple with philanthropic goals of supporting nondominant communities to engage with STEM

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[4] All names are pseudonyms.

education in multiple ways within the San Francisco Bay Area region, particularly Silicon Valley (e.g., supporting and preparing students to enter the STEM pipeline, investing in startup companies, etc.).

Prior to the study, the SAUSES program had primarily focused on providing students with access to advanced STEM courses that are often gatekeeper courses in public high schools (e.g., algebra II, calculus, computer science (CS), etc.) and preparing students well to enter the STEM pipeline at institutions of higher education. The content of professional development experiences in prior years had mainly addressed how teachers could create and maintain equitable learning environments (e.g., equity-oriented classroom management strategies and participation protocols[5]) for students from nondominant communities. These efforts supported the organization's goals to prepare students from nondominant communities to be competitive for admissions to undergraduate programs in the STEM fields, STEM pipeline recruitment and retention, and developing students' STEM identities. Since it started, the SAUSES program had generally been considered successful in a variety of ways (e.g., majority of SAUSES alumni major and persist in STEM, alumni attend top tier universities, etc.; IDEA Report 1, 2015). Unfortunately, IDEA staff had not made significant efforts in developing and implementing professional development experiences for teachers *specifically* around equity-oriented teaching practices. This included a lack of emphasis on theoretical perspectives and practical examples about how and why such practices are relevant and necessary for teaching STEM courses.

Thus at the start of the dissertation data collection, the pedagogical design team (PDT) had designed an initial phase of professional development experiences to focus on equity. One of the overarching goals of the professional development experiences was to support teachers in aligning their teaching practices with SAUSES' program vision for equity-oriented instruction. This marked SAUSES' first attempt to formally engage in professional development specifically addressing equity-oriented STEM instruction, and as a part of this dissertation study I documented the subsequent SAUSES professional development design, professional development implementation, and instructional component of the summer session. By utilizing mixed methods research methodology, my dissertation takes up the following research questions:

1. **Equity Orientations:** What are SAUSES teachers' perspectives on equity-oriented STEM instruction, and how do their perspectives change over the course of the program?
2. **Teaching Practices:** As SAUSES teachers aim for equity-oriented STEM instruction, in what ways are their perspectives on equity implemented in their teaching practices? What successes, tensions, and challenges do teachers experience?
3. **Student Outcomes:** How are learning opportunities and academic and STEM identities made available to SAUSES students through teachers' equity-oriented instruction?

[5] Participation protocols are teachers' explicit communication about how students are expected to respond during whole or small group portions of the lesson. For example, teachers may pull an equity stick or card from a cup (a popsicle stick or index card with a student's name written on it) as a form of involuntary participation rather than only calling on student volunteers. See LAUSD Protocols for more information.

Mixed Methods Rationale

In the dissertation study, I draw and build upon the extant research literature of equity-oriented STEM instruction, including teaching practices, professional development models, and influences on student learning outcomes. I employed a mixed methods approach (Creswell, 2009; Creswell & Tashakkori, 2007) to answer the research questions, which included the use of qualitative data by conducting an in-depth case study *and* collecting and analyzing quantitative data, such as surveys and student assessment scores.

One of the affordances of utilizing mixed methodology is that it allowed for a deeper understanding of teachers' perspectives on equity-oriented STEM instruction, how those shifts in thinking and teaching practices occurred, and the nature of the learning environments they worked to create and maintain for their students than if only using a qualitative or quantitative approach (Creswell, 2014). Ultimately, a mixed methods approach allowed me to unpack the ways in which student learning outcomes were influenced by their teachers' instructional practices and classroom learning environments and the program structures that supported or constrained teachers' shifts in perspectives and teaching practices. This dissertation research design was also useful for making sense of the complex relationships between students and their teachers and their varied viewpoints of equity-oriented STEM instruction (Creswell & Tashakkori, 2007).

Case study approach. I conducted a case study of the SAUSES East Bay site because it allowed me to provide a descriptive narrative of the varied perspectives teachers have on equity and how their perspectives and equity pedagogies are taken up in their classrooms (Bloomberg & Volpe, 2012; Creswell, 2007, 2014; Scholz & Tietje, 2002; Stake, 2006; Yin, 2003, 2014). A case study approach to qualitative data collection and analysis provided an in-depth examination of how teachers' mindsets about equitable STEM instruction shift and the ways teachers developed their expertise around implementing equity-oriented STEM instruction (Corbin & Strauss, 2015; Stake, 2006; Yin, 2014). Because of the varied data sources collected (focus group interview, semi-structured interview, fieldnotes or video recordings of classroom and professional development observations, etc.) with a small group of teachers (n = 10) during a specific time period (Spring to Summer 2015) in the present case study, I am able to provide a rich, detailed description of teacher shifts in perspectives and practices *and* the programmatic structures that supported their learning (Creswell, 2014; Yin, 2014). The small sample size of teachers allowed for sustained interactions with teachers to uncover the complexity and interconnected components of their efforts to engage in equity-oriented STEM instruction. By triangulating the case study data with the quantitative data sources for the study (e.g., teacher and student pre- and post-survey results, student assessment scores, etc.), I can strengthen my understandings and interpretations of how teachers work to create equitable classrooms (Creswell, 2009). In so doing, I can potentially provide a revelatory case for highlighting the varied roles teachers take on as equity-focused STEM instructors and a powerful approach to support teachers to shift their mindsets around equity-oriented instruction (Yin, 2014).

Limitations to methodological approach. Using a mixed methods approach for the dissertation study allowed for a comprehensive picture of how teachers work to create and maintain equitable STEM learning environments. The mixed methods research design provided me with complementary information that could be triangulated (i.e., qualitative data are further supported or explained by quantitative data sources), but there were limitations to this approach as well. For example, utilizing self-report surveys to capture teachers' perspectives on equity and their ideas about approaches to teaching STEM from an equity mindset; students' attitudes about STEM learning and fields; and students' views on and evaluations of their teachers allowed me to make inferences about the participants (Creswell, 2014). To obtain validity evidence (Wilson, 2005), the survey items were adapted from an established interview protocol (Johnson & Marx, 2009) and piloted using teachers and teacher educators (explained in more detail later in this chapter) prior to use with teacher study participants. The questions used for the teacher survey were not tested for reliability prior to use. Validity evidence provided support for the consistent use of the survey items over time (i.e., across cohorts of teachers), but reliability evidence would have strengthened the quality of the survey items (Wilson, 2005). If I had employed more reliability tests (e.g., Cronbach's alpha), I may have revised and/or avoided using survey items that were not reliable measures of teachers' perspectives and/or revised questions to increase the quality and interconnectedness of the survey items across the teacher participants (Wilson, 2005).

Another limitation to the methodological approach to the dissertation study was my positionality as a teacher leader within the SAUSES program. Although I had an insider perspective on the organizations (IDEA—the nonprofit operating SAUSES programs and SAUSES), and was easily able to establish rapport in order to build and maintain relationships with IDEA staff and the SAUSES instructional teams, there were limitations to this study due to my position as teacher leader. Utilizing ethnographic research methods, such as participant observation, to learn side-by-side rather than in a supervisory role to teacher participants, may have produced different results for the study. In so doing, I may have been more privy to information that teachers and/or students did not feel comfortable sharing with an individual in a supervision role and reduced the level of report bias (Yin, 2014).

Research Site Selection

Prior to the dissertation study, I was familiar with the SAUSES program based on its longtime success, popularity, and prestige within the various communities I belong to (e.g., university setting, church, neighborhood, STEM education colleagues, etc.), yet I did not know the program intimately. One afternoon, while working in our shared research office space, Steven—one of my equity in STEM colleagues—suggested I apply for an open position with the SAUSES East Bay site as a teacher leader. This position would allow me to work with an organization and teachers who were interested and invested in doing equity-oriented STEM work and see how their teaching influenced student learning. Additionally, conducting research at this site would allow me to pursue my research interests and questions around the nature of equity-oriented STEM teaching and learning in a well-resourced, out-of-school setting with high school students from nondominant communities. In turn, I could use this experience to inform future research endeavors on equity-focused K – 8 STEM teaching and learning *and* research with and preparation of teacher educators and teacher candidates.

During an initial conversation with Roberta, the Director of Educational Programs for IDEA, I learned that this was the first year that the organization was making a concerted effort to design professional development targeting equity-oriented teaching practices. Roberta stated that the majority of the teachers who had worked for SAUSES in the past made explicit statements about wanting to learn "how to put things [theories] into practice," and that they had a few teachers who were reluctant to engage in those practices (Personal Communication, March 4, 2015). Based on my prior teaching *and* research experiences as a science educator committed to advancing the equity agenda, the organization was interested in drawing upon my knowledge and experiences to design a set of professional development sessions for SAUSES teachers. The professional development sessions would be particularly important for developing and refining teachers' practices at the three existing sites in order to inform the expansion of the program at two other sites for Summer 2016.

As the teacher leader, I was responsible for co-constructing and co-facilitating these professional development sessions for collaborations across the two sites in the San Francisco Bay Area (Silver Hill and East Bay) and Southern California (Cali South). I would also lead the sessions at the East Bay site during the summer session. All of the professional development sessions were collaboratively designed by the IDEA pedagogical design team (PDT), curriculum team, teacher leaders at other SAUSES sites, and was led by the Director of Educational Programs for IDEA (see Table 1 for demographic information of team members). Other responsibilities as teacher leader included providing support to teachers throughout the summer session, substitute teaching in classrooms as needed, and assisting the IDEA research team with data collection for the organization's research project.

Table 1
SAUSES Instructional Leadership Team Demographic Information

Pedagogical Design Team (PDT)	*Jan** M, Black, East Bay University Doctoral Candidate in Education, Consultant for IDEA, and IDEA Educational Programs Writing Teacher *Roberta** F, East Asian, IDEA Director of Educational Programs *Steven** M, Iranian, East Bay University Doctoral Candidate in Education, Consultant for IDEA, and former IDEA Educational Programs Computer Science Teacher
SAUSES Teacher Leaders	*Dean* (Silver Hill)* M, Latino, Public High School Teacher *Vivien* (Cali South)* M, Black, Public High School Teacher *Tia (East Bay)* F, Black, East Bay University Doctoral Candidate in Education

Note. * indicates a returning SAUSES staff member

Taking up this role afforded me the opportunity to study side by side with IDEA and SAUSES staff and teachers (Erickson, 2006) *and* utilize my experiences as both a researcher and teacher educator to document and better understand the development and implementation of equity-focused teaching practices in this learning context (K. Gutiérrez & Vossoughi, 2010). I was hired for the position—beginning my pursuit of better understanding how teachers learn to build and maintain equity-oriented STEM learning environments. Because of my unique position within the organization, I was easily able to establish rapport with members of the SAUSES instructional team, staff members, and students.

Overview of research project. Data collected for the dissertation study draws from a larger study across the three SAUSES sites in California: two in the San Francisco Bay Area, East Bay and Silver Hill; and one site in Southern California, Cali South. At both San Francisco Bay Area sites, pre/post-survey data from teachers (N = 19) and students (N = 138) were collected[6]. I chose to conduct an in-depth case study at one of the San Francisco Bay Area sites, SAUSES East Bay for three reasons: 1) its reputation in the community for having teachers and staff committed to advancing the equity agenda; 2) it was in its 12th year of operation—longer than any of the other SAUSES sites—and was considered the flagship site of the SAUSES programs; and 3) I was the teacher leader of the SAUSES East Bay instructional team during the time of data collection.

History and overview of SAUSES program. The Summer Academy for Underrepresented Students Entering STEM (SAUSES) program—the first education program IDEA implemented—started in 2004 at East Bay University. In 2011, the program launched at other sites and eventually expanded to three sites at the time of data collection. At the time of data collection, there were nearly 400 SAUSES alumni from the various sites.

SAUSES is a free, five-week STEM-focused college preparatory residential program for high-achieving[7] high school students from nondominant communities. At the time of data collection, there were three SAUSES sites at highly selective, historically white institutions[8] (HWIs) in Northern and Southern California: East Bay University, Silver Hill University, and Cali South University. The program targets California residents from diverse racial/ethnic backgrounds [i.e., African American, Filipino, Latino/a, Native American, Pacific Islander, Southeast Asian (specifically Cambodian, Laotian, and Vietnamese), and biracial[9]]; students from families with low-income SES; and who will be first generation college students. On average, there are about 70 students at each of the three SAUSES sites—most of who identify as African American or Latino/a—with nearly even numbers of female and male participants in each cohort of incoming students (IDEA Website, ND). Table 2 provides information about each of the SAUSES sites.

SAUSES students typically participate in the program for three years (i.e., the summers before entering grades 10 – 12). Each summer during the residential program, students take four core STEM courses (computer science, engineering design challenge (EDC), mathematics, and science) that are aligned to the Next Generation Science Standards (NGSS) and Common Core State Standards - Mathematics (CCSS-M) and

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[6] Pre/post data for the Southern California teachers was incomplete, so were not included in the study.
[7] Average GPA for SAUSES students is 3.5 (IDEA Website, ND).
[8] The term, historically white institution (HWI), is used in place of predominantly white institution (PWI) to denote the sociohistorical factors contributing to the high percentage of white students at PWIs. This term also highlights how racial campus climates, institutional infrastructures, and the ways in which PWIs have typically benefited white students in ways other students do not (e.g., racial isolation Black or Latino students may feel at these institutions). See Smith, Allen, and Danley (2007) for a full review.
[9] At least one parent must identify with one of these racial/ethnic groups.

elective courses that are unique to each site. For example, SAUSES East Bay offers two elective courses each summer (i.e., Scientific Research Exploration and College Readiness), whereas Silver Hill offers three elective courses (i.e., SAT Prep, Entrepreneurship, and College Readiness). The academic year component of the program includes opportunities for students to engage in college admissions and financial aid workshops, networking events with local STEM professionals, and course offerings (AP Computer Science, SAT Prep, etc.).

During Summer 2015, IDEA was also developing and implementing strategic plans for new program sites. This included opening sites for Summer 2016 at a public, selective, HWI in Northern California that will become a Hispanic-serving institution[10] (HIS) by Fall 2018 *and* at one of the oldest, private historically Black colleges located in an urban area in the Southeastern region of the U.S. Therefore, the IDEA research team and SAUSES staff were deeply interested in documenting the successes and challenges at current sites to ensure successful program expansion.

Table 2
SAUSES Sites 2015

SAUSES Site	Year Started	Number of Teachers (2015)	Number of Students (2015)	Number of Alumni (2015)
Cali South University[11] (Los Angeles, California)	2012	6	80	53
East Bay University (San Francisco Bay Area, California)	2004	10	64	224
Silver Hill University (San Francisco Bay Area, California)	2011	10	75	100
Total		26 teachers	218 students	377 alumni

Research Site Description

SAUSES East Bay is located at East Bay University, which is a public, highly selective, HWI in the East Bay region of the San Francisco Bay Area. Since SAUSES East Bay is the oldest program site with a well-established history of course offerings, networking opportunities for students, *and* the highest number of alumni attending the university as undergraduates, it is considered the flagship site. In addition to the traditional SAUSES program offerings (e.g., core content courses, networking opportunities, etc.), the East Bay site also had unique elective course offerings, such as the Scientific Research Exploration course for first year students. In this course operated by the East Bay University Physics Department, a small group of four to five students worked alongside a graduate student mentor to engage in a science-related research project.

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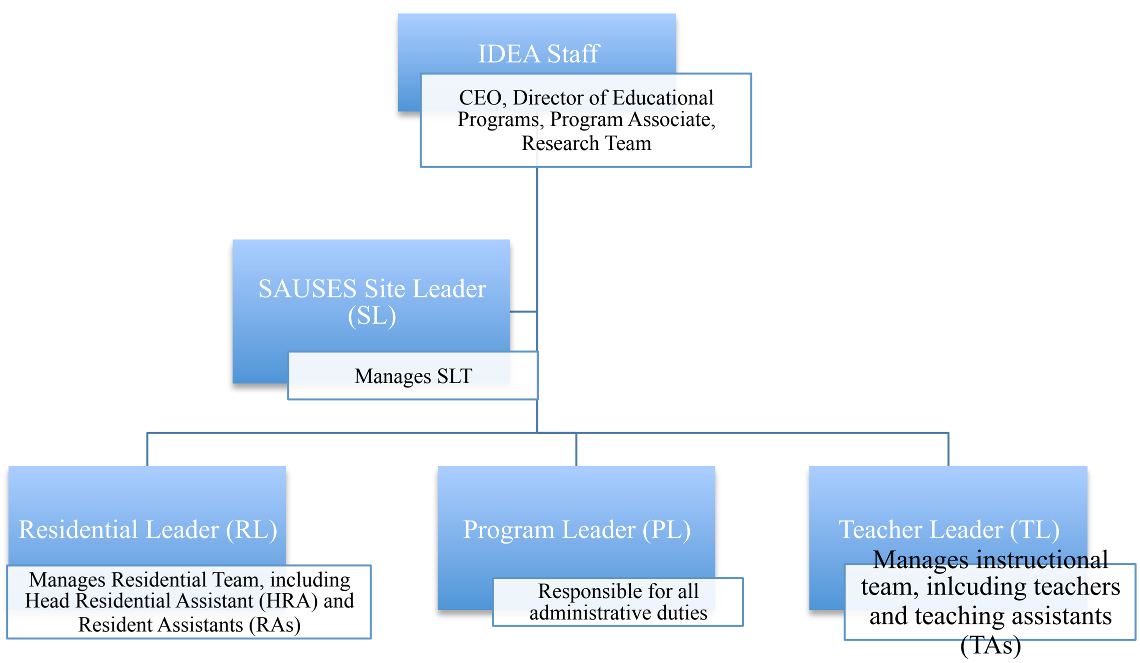
[10] HSIs have student populations that are at least 25% Hispanic, making them eligible to apply for federal funding through Title V and/or Title III, Part A programs (HACU Website, ND).
[11] Due to programmatic restructuring, Cali South was the result of downsizing two campus programs in 2014 to one program in 2015, resulting in a slightly larger number of students than other sites.

SAUSES East Bay site leadership team (SLT). The team responsible for operating each SAUSES site included a site leadership team (SLT), consisting of the site leader (SL), teacher leader (TL), residential leader (RL), and program leader (PL); Figure 1 details the IDEA/SAUSES organizational structure. The site leader was responsible for all employees and students at the site, and the collaborative model required each team member to manage her own staff (i.e., RL managed the residential staff, TL managed the instructional team, etc.). Additionally, each leadership team member worked together daily. The SLT met weekly during the summer session to share and address any staff or student concerns (e.g., tardiness, engagement, health issues), create or revise site plans (e.g., field trips, community meetings, course (re)scheduling, etc.), and discuss pertinent events for the week (e.g., high profile donors visiting classrooms, culmination ceremony). As needed, IDEA staff members joined the SMT weekly meetings to share any program-level organizational developments, learn more about the site-level interactions at the East Bay site, and introduce program donors to the SMT. Also, because the East Bay site was the flagship site for the program, members of the pedagogical design team (PDT) often stopped by the site to observe classroom instruction or check in with me (site TL) to determine the types of additional supports teachers and/or students needed.

Figure 1
IDEA/SAUSES Organizational Structure



Residence halls. SAUSES East Bay students lived in East Bay University's Focal Point Residential Hall for five weeks. Other college-preparatory residential programs affiliated with the University's outreach programs (e.g., TRIO programs, such as Upward Bound and Upward Bound Math and Science, etc.), along with unaffiliated sports camps, undergraduate internship programs, and a host of other summer programs utilized this residential hall for their students. Students shared a suite with 7 same gender students and an RA; within the suite, there were typically four to five bedrooms, one to two bathrooms with showers and toilet stalls, and a common living room area. Amenities at the residence hall included a dining hall, common areas/study spaces, community rooms, vending machines, and a fitness facility. SAUSES teachers, staff, volunteers (e.g., members of STEM professional communities participating in networking events), often ate breakfast, lunch, or dinner[12] with students. Therefore, the dormitory provided multiple spaces for SAUSES students to interact with each other, SAUSES teachers and staff, as well as other high school and college students throughout the summer session.

Residential staff. The residential staff, led by the residential manager (RM), consisted of the head residential assistant and 6 residential assistants (RAs; see Table 3 for demographic information). Because they spent more time with SAUSES East Bay students than other staff members, they are mentioned here, as they played a significant role in the lives of students. They are not included as participants for the larger study, but certainly added to the social milieu of the site in multiple ways. For example, RAs not only lived in the dormitory with students in their suites, but also served as tutors for students during study hall, partnered with teachers and attended class sessions once a week. This was to ensure they could share knowledge about course content or scope during study hall after classes or in the residence hall. The residential staff also participated in one all SAUSES staff (e.g., instructional, residential, and leadership teams) professional development meeting on June 18, 2015. Their participation will be highlighted in chapter six when I analyze and discuss program structures and supports, such as professional development sessions and teacher/RA partnerships. Their contributions to the whole and small group discussions during the professional development session were critical for pushing the thinking of the instructional team, and in turn, the instructional team influenced their perspectives on working with students.

[12] IDEA provided free individual meal cards for any adults wishing to eat in the dining hall with students.

Table 3
Residential Staff Demographic Information

Residential Manager (RM)	Alexa F, African American/Black, 2015 Graduate of East Bay University
Head Resident Assistant (HRA)	Norma F, African American/Black, 2015 Graduate of California University, Bay Area
Resident Assistants (RAs)	Canady F, Latina, 2015 Graduate of Cali South University
	Kristiana F, Puerto Rican, Graduate Student at East Bay University
	Yolanda F, African American/Black, 2015 Graduate of Silver Hill University
	Elmo M, Latino, Incoming Fall 2015 Graduate Student at East Bay University
	Olatunji M, African American/Black, Undergraduate at California University, Bay Area
	Reginaldo M, Latino, Undergraduate at Sunny Beach City University

Weekly schedule. The weekly schedule for SAUSES East Bay had an academic component from Monday to Friday, including coursework, opportunities for networking with STEM professionals, community service, and more. In the following sections, the academic and non-academic components of the program are discussed.

Academic weekly schedule. SAUSES students engaged in a rigorous academic weekly schedule that included core content and elective courses; study hall; and networking or other events each evening. During the week, students followed a typical undergraduate course schedule that included a MWF or T/Th sequence for coursework. For example, students had their science courses on Monday, Wednesday, and Friday, whereas mathematics courses were held Tuesday and Thursday. The only exception was for computer science (CS) courses, which met daily for the first time during Summer 2015 (e.g., increased from three to five days per week). All core content courses (e.g., mathematics, science, and engineering design challenge) were aligned to the Next Generation Science Standards (NGSS) and/or Common Core State Standards-Mathematics[13] (CCSS-M), and the curricula for courses were developed by the IDEA curriculum team prior to the summer session. SAUSES teachers were responsible for creating their own lesson plans based on the curricula provided. The full weekly schedule is outlined in Table 4, and Table 5 provides the specific course sequence for each cohort of students.

[13] The NGSS and CCSS-Mathematics are the national standards for science and engineering (NGSS) and mathematics learning (CCSS-Mathematics) that have been adopted by the majority of the states in the U.S. Spurred by the need to strengthen student achievement and prepare students to compete in a global economy, the Standards represent a shift from learning focused on rote memorization to increasing levels of instructional rigor and cognitive demand (Kisa & Stein, 2015; NGSS website).

Table 4

SAUSES East Bay Weekly Academic Schedule

<table>
<tr><th>Time</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>8:30 – 10:00</td><td>CS A,
Science B</td><td>CS A,
Math B</td><td>CS A,
Science B</td><td>CS A,
Math B</td><td>CS A,
Science B</td></tr>
<tr><td>10:20 – 11:50</td><td>CS B,
Science A</td><td>CS B
Math A</td><td>CS B,
Science A</td><td>CS B,
Math A</td><td>CS B,
Science A</td></tr>
<tr><td>12:00 – 1:00</td><td colspan="5">Lunch at Focal Point Dining Hall</td></tr>
<tr><td>1:15 – 3:15</td><td>Engineering Design Challenge (EDC)</td><td rowspan="3">Elective Courses
(1:30 – 4:00)</td><td>EDC</td><td rowspan="3">Elective Courses
(1:30 – 4:00)</td><td>EDC</td></tr>
<tr><td rowspan="2">3:30 – 5:30</td><td rowspan="2">Study Hall
(4:00 – 5:45)</td><td>Community Meeting – All SAUSES Staff
(3:30 – 4:00)</td><td rowspan="2">Study Hall
(4:00 – 5:45)</td></tr>
<tr><td>Instructional Staff Meeting and/or PD
(4:30 – 6:00)</td></tr>
<tr><td>6:00 – 7:00</td><td colspan="5">Dinner at Focal Point Dining Hall</td></tr>
<tr><td>7:00 – 9:00</td><td>Networking Night</td><td>Study Hall</td><td>Speaker Series</td><td>Study Hall</td><td>Fun Friday</td></tr>
<tr><td>9:00 – 11:00</td><td colspan="5">Free Time</td></tr>
<tr><td>11:00</td><td colspan="5">Lights Out</td></tr>
</table>

Table 5

SAUSES East Bay Course Sequence by Cohort

<table>
<tr><th>Cohort (Based on grade entered Fall 2015)</th><th>Computer Science (CS)</th><th>Science</th><th>Engineering Design Challenge (EDC)</th><th>Mathematics[14]</th><th>Elective</th></tr>
<tr><td>Year 1 students (Grade 10)</td><td>CS I</td><td>Biology</td><td>EDC I</td><td>Algebra II</td><td>Scientific Research Exploration</td></tr>
<tr><td>Year 2 students (Grade 11)</td><td>CS II</td><td>Organic Chemistry</td><td>EDC II</td><td>Pre-Calculus/ Trigonometry</td><td rowspan="2">College Readiness</td></tr>
<tr><td>Year 3 students (Grade 12)</td><td>CS III</td><td>Physics</td><td>EDC II[15]</td><td>Calculus</td></tr>
</table>

Classrooms and passing periods. Students' classes were held in classrooms across the East Bay University campus, often in buildings that were being utilized by the University for courses in each of its summer sessions and other programs (e.g., TRIO/Upward Bound, exchange programs, etc.). Because the campus is large and

[14] Students were assigned to math courses based on a placement test taken in May 2015 and academic year transcripts verifying prior courses taken.

[15] This was the second year SAUSES offered the EDC course. Due to the implementation schedule for this course, both the Year 2 and Year 3 cohorts engaged in EDC II, as it was the first year this course was offered. In Summer 2016, EDC III would be offered for the Year 3 cohort.

teachers often did not teach in the same classroom for Sections A and B of the courses, students and teachers had 20 minutes between classes for a passing period. For example, the science courses for Year 1 and Year 2 students were held in one of the campus' main science buildings near the western border of campus, and students would have to go to their computer science classes in central campus, which could easily take 15 minutes to walk at a brisk pace. Although students were initially resistant about walking this distance, by the end of the first week of classes, students saw it as an opportunity to get to know each other and their instructors better. It was commonplace to see small groups of instructors and students walking together from one classroom building to another and engaging in discussions about their personal lives. Students often helped teachers transport materials from one location to another or stopped at campus cafes for food or drinks during the passing period daily. These interactions added to the social environment of the program, and will become important for subsequent analyses of teacher-student and student-student interactions.

Weekend schedule. Each Friday night, students remained on campus and typically engaged in social activities determined by the residential staff. After completing a community service project or field trip, students left the East Bay University campus each Saturday afternoon. This allowed students to spend about 24 hours at home with their families, before they returned to campus each Sunday afternoon (see Table 6 for full weekend schedule). Upon returning to campus on Sunday afternoon, they engaged in a public and life-speaking course, which was taught by a team of instructors who were contracted by an outside consultant. This course was not observed by the IDEA research team or me, and was not included in the study.

Table 6
SAUSES East Bay Weekend Schedule

Saturday	Sunday
Field Trip OR Community Engagement Activity 8:30 a.m. – 1:00 p.m.	Scholars Return to Campus 2:00 p.m.
Scholars Picked up by Families 1:00 p.m.	Life/Public Speaking 3:00 – 6:00
	DINNER at Focal Point Dining Hall 6:00 – 7:00
	RA Workshop 7:00 – 8:30
	Study Hall or Free Time 8:30 – 11:00
	LIGHTS OUT 11:00

Data Collection

Having thoroughly described the research setting, I now turn to the data collection procedures in the next section of this chapter. To answer my research questions, I collected the following data from Spring to Summer 2015 at the SAUSES East Bay site: over 30 hours of observations of professional development sessions prior to and during the summer session; lesson plans and two formal classroom observations of each teacher (N = 10); pre/post-survey data from teachers (n = 8); teachers' pedagogical philosophy statements (n = 5) and reflections on their teaching experiences across the summer session (n = 9); a semi-structured follow-up interview with a focal teacher (n = 1); pre/post-survey data from students (N = 59); student evaluations of their teachers (n varies by teacher, ranging from n = 4 to n = 29 completed responses); and a semi-structured focus group interview with students (N = 7). In the sections below, I first outline each research question, data collected to answer each research question, and an overview of the proposed analysis methods (see Table 7). An overview, rather than a detailed description of all analytical procedures, is provided here because the specific analytical procedures utilized to obtain each set of findings are presented in the corresponding findings chapter. The remainder of this chapter includes a description of the study participants and the data collection methods (development of protocols, data sources, etc.) utilized for the dissertation study; it concludes with a discussion of researcher positionality.

Table 7
SAUSES East Bay Teacher Participants Demographic Information

Research Question	Unit of Analysis	Data Sources	Analytical Method(s) for Data Sources
What are SAUSES teachers' perspectives on equity-oriented STEM instruction, and how do their perspectives change over the course of the program?	Teacher (N = 8)	Teacher pre/post survey (n = 8); Fieldnotes from summer professional development (PD) sessions (n = 4); Initial and revised drafts of teachers' pedagogical philosophy statements (n = 5); and Teacher reflection statements (n = 8); a semi-structured interview with focal teacher (N = 1)	Open coding and thematic analysis of data sources (Creswell, 2007, 2014; Miles & Huberman, 1994; Ritchie, Lewis, Nicholls, & Ormston, 2014; Saldaña, 2013)
As SAUSES teachers aim for equity-oriented STEM instruction, in what ways are the perspectives on equity implemented in their teaching practices? What successes, tensions, and challenges do teachers experience?	Focal teachers (CS II and Chemistry, N = 2)	Teacher pre/post survey (n = 8); Pedagogical philosophy statements (initial and revised drafts; n = 8); PD session Google form survey responses (e.g., define X and give an example of how you did that in a class session this week, what questions you still have about X?; n = 2); semi-structured interview with focal teacher (N = 1) Video recordings and fieldnotes from PD observations (N = 3); Video recordings and/or fieldnotes of classroom observations (CS II, N =	Open coding and thematic analysis of data sources (Creswell, 2007, 2014; Miles & Huberman, 1994; Ritchie et al., 2014; Saldaña, 2013)

		8); (Chemistry, N = 3); Student focus group interview (N = 7 students); and Student evaluations of focal teachers (CS II, n = 22; Chemistry, n = 22)	
How are learning opportunities and academic and STEM identities made available to SAUSES students through teachers' equity-oriented instruction?	Student Focal teachers (CS II and Chemistry, N = 2)	Student pre/post surveys (n = 22); Student focus group interview (N = 7 students); Pre/Post assessments for students in CS II (n = 22) and chemistry (n = 22) courses; Final rubric score course grades for students in chemistry (n = 22) and CS II (n = 22); Video recordings and/or fieldnotes of classroom observations (CS II, N = 8); (Chemistry, n = 3)	Quantitative analysis of students' pre/post surveys Open coding and thematic analysis of data sources (Creswell, 2007, 2014; Miles & Huberman, 1994; Ritchie et al., 2014; Saldaña, 2013) Practice-linked identity framework (Nasir, 2012; Nasir & Hand, 2008; Nasir & Cooks, 200

Participants

The main study participants included the SAUSES East Bay instructional staff (teacher and teaching assistants, N = 13) and students (N = 64). As previously stated, there were several individuals who were a vital part of the life of the SAUSES program, such as the site leadership team (SLT), residential staff, IDEA staff members, and countless others who were involved with SAUSES in some capacity (volunteers, visiting alumni, etc.). Since these individuals were not the targeted unit of analyses for the dissertation research questions, they were not included in the dissertation study; however, their influence on the interactions between students, students and teachers, or other interactions are reported in the analyses of the data as appropriate.

Instructional staff. The instructional staff included 10 teachers and three teaching assistants (TAs). The teachers were the main unit of analysis for the dissertation study, and TAs were included as they were important members of the instructional team for the engineering courses (i.e., EDC I and II courses). There were three core content area teachers per cohort of students (i.e., one computer science (CS), mathematics, and science teacher for each cohort of students), for a total of nine teachers, and one teacher who taught the College Readiness elective course for multiple cohorts. Additionally, the science and CS instructors co-taught an engineering course for each cohort of students, Engineering Design Challenge (EDC), with assistance from a TA.

Table 8 includes the self-reported demographic information for each teaching staff participant in the study, including their gender, racial/ethnic background, and profession outside of SAUSES. IDEA staff members recruited members of the teaching staff to voluntarily participate in the study during professional development sessions. Roberta and I stated that study participation was not a requirement for employment with IDEA, and that participants could withdraw from the study at any time; this statement was reiterated at each professional development session.

Table 8
SAUSES East Bay Teacher Participants Demographic Information

Total SAUSES East Bay Teachers (N = 10)				
Science Teachers (n = 3)	Mathematics Teachers (n = 3)	Computer Science Teachers (n = 3)	EDC Teaching Assistants (TAs) (n = 3)	Elective Courses Instructors (n = 1)
Student Cohort: Year 1 (Entering Grade 10 Fall 2015)				
Biology Marva F Armenian Public High School Teacher	Algebra II *Martin* M Armenian Public High School Teacher	CS I *Adam* M white Public High School Teacher	EDC I *Regina* F African American/Black East Bay University Doctoral Student in Environmental Engineering	Scientific Research Non-SAUSES Staff East Bay University Graduate Students (Not Included in Study)
Student Cohort: Year 2 (Entering Grade 11 Fall 2015)				
Chemistry *Jazmyn* F Latina East Bay University Doctoral Candidate in Chemistry	Pre-Calculus/ Trigonometry[16] *Julian* M Latino East Bay University Doctoral Candidate in Physics	CS II *Anthony** M African American/Black East Bay University Doctoral Student in Education	EDC II *Fredericka* F African American/Black East Bay University Undergraduate in Computer Science	College Readiness *Fleeta* F Puerto Rican East Bay University Doctoral Student in Education
Student Cohort: Year 3 (Entering Grade 12 Fall 2015)				
Physics *Emmanuel** M white Private High School Teacher	Calculus *Walter** M African American/Black East Bay University Doctoral Candidate in Environmental Engineering	CS III *Drew** M white California University Instructor	EDC II[17] *Jonathan* M Latino University of Percyville Undergraduate in Engineering, SAUSES East Bay Alumnus	College Readiness *Fleeta* F Puerto Rican East Bay University Doctoral Student in Education

Note. * indicates a returning teacher to SAUSES East Bay

Students. SAUSES East Bay student participants included 64 high school students from nondominant communities entering grades 10 – 12 for Fall 2015, ranging in age from 14 – 17; only students who completed the entire summer program were included in the data collection[18] (see Table 9). Due to atypical student attrition rates for

[16] Five Year 1 students were enrolled in Trigonometry and two Year 2 students were enrolled in Calculus for Summer 2015 based on placement test results and academic year grades on student transcripts.
[17] As a reminder, students in Year 2 and Year 3 cohorts each engaged in the EDC II course, as the EDC III course had not yet been developed and implemented by the IDEA curriculum team.
[18] 64 out of 70 students completed the entire summer session, and 59 students completed pre/post surveys.

the program, the cohort of Year 3 students had fewer students than the Year 1 and Year 2 cohorts (i.e., typically, the number of students per cohort is almost equal). Students attended a range of public and private high schools (e.g., urban and suburban public school districts; elite, independent day schools, etc.) throughout the San Francisco Bay Area during the academic year.

Table 9
SAUSES East Bay Students

Cohort (Grade Entered Fall 2015)	F	M	African American/ Black	Latin@	Southeast Asian (Cambodian/ Laotian)	Biracial
Year 1 (10^{th}) n = 27	15	12	7	16	3	1
Year 2 (11^{th}) n = 24	13	11	12	11	0	1
Year 3 (12^{th}) n = 13	6	7	5	8	0	0
Total Students N = 64	34	30	24	35	3	2

Student participants signed assent forms and their parents signed consent forms to participate in the research component of the program. All participants were notified that participation was not required to be a part of the SAUSES program and that they could withdraw from the research component at any time. The IDEA research team chose the second year students as a focal group because this cohort would be able to discuss changes in the program and the instruction (e.g., increase in computer science course sessions, etc.) and could be included in a follow-up study during their third year in the program. Therefore, the IDEA research team and I (as the East Bay teacher leader) observed in the computer science and engineering courses regularly and more often than other courses.

Focal teachers. Two of the case study teachers, Jazmyn and Anthony, are highlighted in this chapter and were the focal teachers for the dissertation study since they were two of the teachers of the focal cohort and co-taught a course together. Jazmyn, a new teacher at SAUSES East Bay, was a Latina doctoral candidate in chemistry at East Bay University; she taught two sections of a chemistry course three mornings each week (e.g., MWF schedule). Anthony, an African American/Black doctoral student in education at East Bay University who was a returning SAUSES East Bay instructor, taught a computer science course five mornings each week. Each of their class sections included about half of the cohort, with an average class size of 12 students for each focal teacher's course section. They co-taught an engineering course with the entire focal cohort of 24 students for three afternoons each week (MWF). At the time of data collection, neither focal teacher had earned a teaching credential, but were content specialists in their respective fields. Their prior teaching experiences occurred across informal STEM learning settings (e.g., after-school programs, university outreach programs, etc.) *and* Anthony had obtained a master's degree and formal graduate training as a school counselor.

Focal students. SAUSES East Bay focal student cohort included 24 high school students from nondominant communities entering grade 11 in Fall 2015, ranging in age from 15 – 16 years old. The majority of the focal students identified as female and African American/Black (see Table 10). Students attended a range of public and private high schools (e.g., urban and suburban public high schools; elite, independent day schools, etc.) throughout the San Francisco Bay Area during the academic year. During Summer 2015, the SAUSES East Bay focal students engaged in core content courses, such as chemistry, computer science, and mathematics (trigonometry or calculus[19]); for these courses, students were divided into two sections with an average class size of 12 students. Students also engaged in two other courses as an entire cohort: college readiness and engineering design challenge (EDC).

Of the 24 focal students, one African American/Black male student and one Latino student did not complete the entire summer program due to participation in study abroad programs sponsored by their academic year school sites. These two focal students were included in data collection procedures, such as classroom observations and the student focus group interview, except for the student pre- and post-survey and course pre- and post-assessments.

Table 10
SAUSES East Bay Focal Students

	F	M	African American/ Black	Latin@	Southeast Asian (Cambodian/ Laotian)	Biracial
Year 2 Cohort (Entered 11th Grade Fall 2015)	n = 14		7	6	0	1
		n = 10	5	5	0	0
	N = 24		12	11	0	1

Qualitative Data Sources

Professional development observations. In late March 2015, all of the teacher leaders from each SAUSES site (e.g., East Bay, Silver Hill University, and Cali South) met with the pedagogical design team (PDT) to collaboratively design the initial professional development sessions (i.e., two sessions in April 2015). One of the goals of this professional development planning sessions was to envision how to best prepare teachers to implement a range of equity-oriented teaching practices[20] across all three sites. By drawing upon the PDT's doctoral candidates' expertise on research advances in equity-oriented STEM instruction *and* the teaching and administrative experiences of the returning teacher leaders (see Table 1 for demographic information of the SAUSES instructional leadership team), the team developed the agendas for the two April

[19] Two male students (one African American/Black; one Latino) were enrolled in calculus.
[20] Practices could range from those focused on classroom management, such as the use of equity sticks (an involuntary form of student participation where a teacher pulls a stick from a cup to call on students, rather than calling on student volunteers) to facilitating discussions, such as engaging students in sharing their personal experiences with racism.

professional development sessions. The director of educational programs for IDEA, Roberta, and the teacher leaders for each site (N = 3) collaborated weekly to create and/or revise the remaining professional development session agendas (i.e., four sessions throughout May and June prior to working with students). The agendas for *each* of the six professional development sessions (i.e., April to June 2015) were similar across each site[21] to foster both collaborative and consistent learning environments across all campuses. Each professional development meeting with teachers lasted for approximately 7 – 8 hours (e.g., occurred as an all day Saturday session from 9:00 a.m. to 5:00 p.m.)

During the five-week summer session (June to July 2015), I facilitated two professional development sessions (65 – 75 minutes each) for the SAUSES East Bay teaching staff. The two summer session professional development sessions were based on a template for the session contents designed by the PDT to encourage consistency across all SAUSES sites. The PDT and other SAUSES teacher leaders provided feedback on the content for each professional development session, and I subsequently revised the agendas to incorporate this feedback.

During each of the 10 professional development sessions (April to July 2015), segments of or the entire professional development meeting were video and/or audio recorded[22] and I recorded fieldnotes at each session. Prior to the SAUSES summer session, the professional development for teachers occurred monthly (e.g., April, May, and June). During the 2015 summer session, there were two professional development meetings (July 1st and 15th), followed by a final debrief session at the end of the summer session (July 27th). Table 11 outlines the details of each of the 10 SAUSES professional development session from April to July 2015.

Table 11

2015 SAUSES Professional Development (PD) Sessions

2015 PD Session Observation Dates	**Participating SAUSES Campus(es)**	**PD Session Facilitated by**
March 29th	Collaborative Planning Session with PDT and All Teacher Leaders	Jan, Roberta
April 11th and April 12th	East Bay, Silver Hill Teaching Staffs[23] Cali South Teaching Staff	Dean, Jan, Roberta, and Tia Steven, Vivien
May 9th	East Bay, Silver Hill	Tia and Dean
June 6th	East Bay (Morning Session) East Bay, Silver Hill (Afternoon Session)	Tia (Morning Session) EDC Curriculum Team (Afternoon Session)
June 18th	East Bay Teaching and Residential[24] Staffs	Tia, Roberta
June 19th	East Bay Teaching Staff	Tia
July 1st	East Bay Teaching Staff	Tia

[21] There were a few minor adjustments at each site based on individual site needs, such as logistical information and variations in class offerings, but the majority of the content was the same.
[22] I chose not to video record segments of the PD meetings because they were not pertinent to the dissertation or broader study (e.g., Mandated Reporter Training, Human Resources paperwork, etc.).
[23] Teacher pre-survey completed.
[24] This included the Residential Director (RD) and the Resident Assistants (RAs) living with the students in the dorms for Summer 2015.

July 15th	East Bay Teaching Staff	Tia
July 27th	East Bay Teaching Staff [25]	East Bay Site Leadership Team

Classroom observations. I formally observed each teacher (N = 10) two times between June 29, 2015 and July 23, 2015. These observations occurred as a part of the requirement that all teacher leaders observe each classroom teacher twice during the five-week summer session (June to July 2015). During each formal observation of SAUSES East Bay teachers (N = 10), I collected a lesson plan provided by the teacher, utilized a classroom observation protocol (described in detail below) for taking notes about the lesson implementation, and video and/or audio recorded the class session; each observation lasted approximately 60 minutes of the 90 minute class session (core content courses or EDC) *or* 60 minutes of the 150 minute class session (College Readiness only). Two undergraduate research assistants[26] transcribed the video data collected from the classroom observations; each undergraduate research assistant completed the required Collaborative Institutional Training Initiative (CITI) trainings for engaging in human subjects research in the social and behavioral sciences.

Prior to the summer session, the PDT and teacher leaders iteratively developed a classroom observation protocol based on an existing protocol created by Professor Kris Gutiérrez and colleagues. This was done to not only ensure consistency in what teacher leaders across all three SAUSES sites focused on during classroom observations, but also to assist with data collection around how SAUSES teachers were implementing equity-oriented teaching practices in their classrooms. As the teacher leader for the East Bay site, I also observed in classrooms informally daily throughout the summer session, and took fieldnotes for each of the informal observations. During both formal and informal observations, I interacted with students and their teacher. This included a variety of interactions, such as asking clarifying questions to students about their assignments and/or verbal or written responses, assisting the instructor as needed (e.g., covering the class if the teacher needed to use the restroom or set up technology, etc.), or posing questions or providing hints to students to facilitate their thinking when they approached me for instructional support. The dates for each of the formal classroom observations of each teacher are listed in Table 12.

Each formal observation was debriefed with the teacher typically within 48 hours of the lesson observation, either in person or via a Google hangout, and lasted approximately 30 – 45 minutes. There was not an established protocol to debrief the lesson implementation, and was therefore typically informal between the teacher and me (the teacher leader). All of the debrief conversations were guided by the overarching SAUSES guiding pedagogy, the ABCs (applicable, befriend, and critical thinking). In each debrief, I asked each teacher to identify what she felt were the strengths and areas of concern of the lesson plan and implementation. By doing so, the teacher was prompted to reflect on her lesson plan and implementation—rather than me solely identifying these for the teacher—and was co-constructing knowledge about her performance and strategies to strengthen her performance in the classroom.

[25] Teacher post-survey completed.
[26] Undergraduate research assistants attend East Bay University and the University of North Carolina, Chapel Hill. See the CITI website (https://www.citiprogram.org) for information about training modules.

Additionally, the IDEA research team was especially interested in collecting data around their computer science (CS) instructional team. Therefore, I collaborated with the team to revise a classroom observation protocol specifically for the CS courses. Based on their research agenda for the larger study, the IDEA research team primarily focused on the CS II classrooms at each SAUSES site[27], and utilized this CS-classroom observation protocol during weekly observations. At SAUSES East Bay, a member of the Research Team and/or I observed the CS II classroom approximately twice each week, depending on staff availability.

Table 12
Classroom Observations

Summer Session Week Number	Monday	Tuesday	Wednesday	Thursday
1 Week of June 22nd	Informal Observations in Each Classroom Weekly			
2 Week of June 29th	CS II	N/A	Physics, EDC II	Algebra II, CS II, College Readiness
3 Week of July 6th	Chemistry, CS II	Calculus	CS I, CS II, EDC	N/A
4 Week of July 13th	Chemistry, CS II	Trigonometry, CS II	CS III, CS II, EDC II	Algebra II, Calculus, College Readiness
5 Week of July 20th	Chemistry, Biology, CS II	Trigonometry, CS I	Biology, Physics	CS III

Teacher reflection statements. Once the summer session with students ended, I led a debriefing session with teachers and other SAUSES and IDEA staff members on July 27, 2015. Teachers were asked to reflect upon their experiences in the summer and answered prompts about their teaching philosophy statements, implementing their lesson plans, and the types of supports they found useful for lesson implementation. All teachers were required to complete the reflection electronically, and were allotted 45 minutes to complete the reflection statement. The contents of the final reflection can be found in Appendix A.

SAUSES guiding pedagogy. In an effort to strengthen equitable teaching practices across all of the SAUSES sites, the Institute Devoted to the Equity Agenda (IDEA) contracted the pedagogical design team (PDT) for SAUSES to develop the guiding pedagogy document. This would allow all SAUSES teachers to better

[27] At the time of data collection, the IDEA research team was particularly focused on the CS courses due to the increase in class meetings (i.e., the frequency of CS course class meetings shifted from two to five days a week). This was due to SAUSES' increasing focus on students developing and utilizing CS programming knowledge/skills due to few schools with high numbers of students from nondominant communities offering CS courses *and* funding received from a NSF grant in collaboration with a professor in the East Bay University's Computer Science Department. The CS II classroom was a focal classroom for the larger SAUSES study since it contained the focal student cohort.

understand which instructional strategies they could draw upon for equity-oriented STEM instruction. This document, which was referred to as the ABCs, was intended to serve as a guide for teachers to utilize for pedagogical approaches to SAUSES curriculum implementation. The PDT introduced this document at the initial professional development session for teachers and teachers received both electronic and paper copies for their records. If teachers relied upon the ABCs to guide their instruction, they would foster a learning environment "for students to grow more competent in the STEM subjects covered in SAUSES while, concomitantly, encouraging and empowering them to be agentive, social-justice oriented STEM practitioners" (SAUSES ABCs, 2015, p. 1).

The ABCs included the overarching SAUSES core principles: 1) applicable; 2) befriend; and 3) critical thinking. To be *applicable*, course content should be relevant to students' lives and the communities they belonged to, in addition to providing them with opportunities to develop their understandings of how to use their STEM knowledge and skills to fight forms of oppression in their communities. By *befriending* students, teachers were to develop and maintain authentic relationships with their students. Engaging students in rigorous learning opportunities with both high cognitive demand and that were situated in sociopolitical contexts (i.e., within relevant social justice issues) would support students' *critical thinking* development.

Teaching philosophy statements. The teaching philosophy statement had two pages of prompts for teachers to respond to, which required teachers to share their ideas about their educational philosophies and how they envisioned implementing that in their SAUSES classrooms (see Appendix B for teaching philosophy statement contents). Teachers responded to the first page of prompts during the initial professional development session on April 11, 2015, immediately after completing the pre-survey. In so doing, their thinking was not influenced by any of the presentations during the session about equity, equitable teaching practices, and/or the expectations for SAUSES teachers' pedagogy.

The second page of prompts was distributed to and completed by teachers after they had reviewed the SAUSES guidelines for pedagogy. The next two prompts of the teaching philosophy statement asked teachers, *In what ways does your pedagogical approach and educational philosophy mirror the 3 core guidelines for pedagogy of the SAUSES program? In what ways does your pedagogical approach and educational philosophy differ from the 3 core guidelines for pedagogy of the SAUSES Program?*

Scholarly publications. As part of the professional development series, each teacher was assigned homework at the end of each session. After the initial professional development sessions in April 2015, each teacher read and responded to two scholarly publications related to equity-oriented instruction (see Table 13 for citations). The selected readings that were content-specific were chosen because of their accessibility to a practitioner-based audience; examples of and suggestions for equitable instructional practices; and length of reading (i.e., journal articles or book chapters longer than 20 pages were excluded or condensed due to time constraints for completing the assignment). Part of this particular assignment required teachers to write a letter to the author(s) of each scholarly publication to share their general reactions and ideas, in addition to any implications for instructional practices and constructive feedback (see Appendix C for assignment details). Teachers completed this assignment prior to the professional development session on May 9, 2015, and shared their reflections with each other during a discussion at the professional development session and an electronic version with me (their teacher leader at the East Bay site).

Table 13
Scholarly Publications Assigned to SAUSES Teachers

General Reading on Critical Pedagogy	Duncan-Andrade, J. (2009). Note to educators: Hope required when growing roses in concrete. *Harvard Educational Review*, *79*, 181 – 194. doi: 10.17763/haer.79.2.nu3436017730384w
Content-Specific Readings: Mathematics	Jilk, L. M. (2014). "Everybody can be somebody": Expanding and valorizing secondary school mathematics practices to support engagement and success. In (N. S. Nasir, C. Cabana, B. Shreve, & N. Louie, Eds.), *Mathematics for equity: A framework for successful practice* (pp. 107 – 125). New York, NY: Teachers College Press. Gutstein, E. (2003). Teaching and learning mathematics for social justice in an urban, Latino school. *Journal for Research in Mathematics Education, 34*, 37 – 73. doi: 10.2307/30034699
Content-Specific Reading: Science	McKinney de Royston, M. R., Madkins, T. C., & Nasir, N. S. (In Press). "Mama! Do we have cotton balls?": Understanding politically relevant science instruction. *Pedagogies*.
Content-Specific Reading: Computer Science	Wart, S. V., Vakil, S., & Parikh, T. S. (2014). Apps for social justice: Motivating computer science learning with design and real-world problem-solving. In the Association of Computing Machinery *Proceedings of the 2014 Conference on Innovation & Technology in Computer Science Education* (pp. 123 – 128). doi: 10.1145/2591708.2591751

Student focus group interview. A small group of students (n = 10) were nominated by SAUSES East Bay staff to participate in a focus group interview. Students were nominated based on non-teaching staff members' recommendations from among those who responded to email announcements about participating in the focus group interview, per the request of the IDEA Research Team. Of the nominated students, seven students volunteered to participate in the interview (n = 7, including one Year 1 student, five Year 2 students, and one Year 3 student), while three declined. Two female members of the IDEA research team facilitated the focus group interview during lunch on July 20, 2015 for approximately 50 minutes; students were given a $20 Amazon gift card for participating in the interview. The focus group interview protocol (see Appendix D) contained 13 questions, and the majority of the questions focused on students' experiences in their CS courses, with one question focused on student-student relationships during the academic year of the program. Students' requests to have their names be removed from the audio recording of the interview were honored by the IDEA research team prior to its addition to the database. As a result, students were referred to as Female Student 1, 2, etc. (rather than a pseudonym) in the transcript that was prepared by an undergraduate research assistant.

Interview with focal teachers. In order to better understand how the focal teachers viewed their teaching practices in relationship to their orientations about equity-oriented instruction, I attempted to conduct follow-up interviews with the two focal teachers, Jazmyn and Anthony. I contacted each focal teacher via email and text messaging, and was able to conduct an interview with Jazmyn. This semi-structured interview was conducted on March 31, 2016 and lasted approximately one hour. The interview questions are outlined in Appendix E, and included topics such as the instructor's SAUSES teaching philosophy and experiences; perspectives on equity and equity-focused STEM instruction; and teacher-student relationships. I recorded notes electronically during the interview, which was audio recorded and subsequently transcribed by an undergraduate research assistant. The other focal teacher of the dissertation study, Anthony, was unavailable for an interview due to becoming a new father, completing a graduate degree at East Bay University, and working full-time at a local public school site. However, he submitted informal teacher reflections, a final reflection, and other teacher materials that all case study teachers were asked to complete.

Quantitative Data Sources

Teacher pre- and post-surveys. In order to gather data about shifts in teachers' perspectives on equity-oriented instruction over time and answer research question one (Creswell, 2013), I developed an online survey for teachers to complete prior to and after the professional development sessions. I developed the pre-survey and produced iterative versions of the survey items based on pilot data and feedback collected from a teacher education-focused research group in the University of California, Berkeley Graduate School of Education. I also incorporated suggestions for revisions and additional items to the pre-survey based on feedback from the SAUSES PDT. The final draft of the pre-survey (see Appendix F for pre-survey items) included short answer items focused on teachers' professional and teaching backgrounds, rationale for choosing to work for IDEA, and their successes and challenges as STEM teachers. Additional items were included to specifically target research question one about teachers' perspectives, such as defining equity, social justice, and other terms; Likert scale items related to teacher beliefs about teaching STEM with a focus on equity, such as, *I encourage and invite the real life experiences of my students into my classroom*; and teachers' ideas about equitable teaching practices. The pre-survey was distributed electronically as a Google form to teachers only (i.e., TAs had not been hired at this point) at the first professional development session on April 11, 2015 at the two San Francisco Bay Area and Southern California sites.

Teachers completed the surveys on their own laptops, and if they did not own a laptop, they were provided with a Google Chromebook to do so. Teachers were asked to provide thoughtful responses to survey and that they would be given 45 minutes to complete the survey, and if more time was needed, it was granted. Roberta and I told instructors that the purpose of the survey was to learn more about the instructors' teaching or tutoring experiences; assess their understandings of and beliefs about social justice and equity-oriented STEM instruction prior to professional development; and would be viewed by the IDEA research team and myself for research purposes. Teachers from SAUSES East Bay who were not in attendance at the first session were asked to complete the pre-survey at their first professional development session[28].

The PDT and I revised the pre-survey to create the post-survey to distribute to teaching staffs across all three SAUSES sites. This process included removing redundant or irrelevant questions (e.g., In what ways do you think you will need to be supported in

[28] Due to changes in staffing, not all of the teaching staffs at each site were hired by the first PD session (April 11th). The majority of the teaching staffs at each SAUSES site were hired by the May 9th training date. Teachers who did not complete *both* pre- and post-surveys (n = 2) were *not* included in the dissertation study analysis.

order to teach your class [this summer] with a social justice orientation? What resources would you need?) *and* adding questions to prompt teachers' reflective thinking about their teaching experiences during the summer session (e.g., *What was the hardest part about teaching your class using critical pedagogy?*). The post-survey was distributed electronically to the teaching staffs (teachers and TAs) at each SAUSES site at the end-of-the summer debrief meeting on July 27, 2015 (see Appendix G for post-survey contents). For the dissertation study, the survey data analysis will focus on SAUSES East Bay teachers who completed both pre- and post-surveys. To reduce response bias, survey items that were not completed by participants were not included in data analysis (Creswell, 2014).

Student pre- and post-surveys. Students in the SAUSES program across all sites (N = 218) completed a pre-survey at the start of the summer session, and a post-survey during the last week of the summer session. Survey items were developed by the IDEA research team, and the majority of the items were Likert Scale items focused on attitudes about and knowledge of STEM learning and professions (e.g., *How much do you care about doing well in math?*), STEM identity and identity development (e.g., *Being successful in science is an important part of who I am.*), and the relevance of STEM learning and concepts to students' lives (e.g., *I see examples of how computer science applies to my everyday life.*). Other survey items asked students about their perceptions of academic abilities (e.g., *If you were to take a math test right now, how would you expect to do?*); college choice processes, including academic preparation for college admissions, financial aid, etc.); and beliefs about racial and gender stereotypes in STEM (e.g., *Asians and whites are more capable than African Americans and Latinos at solving computing problems.*).

For the dissertation study, I analyzed focal students' (n = 21) responses to pre- and post-survey items related to students' STEM identities and identity development. This included items such as, *I plan to major in a STEM (Science, Technology, Engineering, or Mathematics) field when I enter college*; *I am capable of doing well in science*; and *I plan to use my STEM knowledge to solve problems in my community or in society*. All quantitative analyses of the focal students' responses to pre- and post-survey items were performed using IBM's SPSS Statistics® program. Due to the small sample size of the focal cohort with complete pre- and post-survey data (n = 21), nonparametric tests (e.g., Wilcoxon Signed Rank Test) were conducted using SPSS Statistics®. This was in place of a paired sample t-test, which would have required a normally distributed sample. Due to the nature of the program (i.e., focus on high achieving students interested in the STEM fields), the variables would not be normally distributed (i.e., right-skewed distribution), thus requiring statistical analyses of nonparametric tests (IDRE website, 2016; LAERD Statistics website, 2013). For all statistical tests performed in SPSS Statistics®, an alpha level of 0.05 ($p < 0.05$) was utilized.

Data Analysis

In the following sections, I discuss the analytical methods employed for each of the findings chapters. As a reminder, Table 7 outlines each research question, unit of analysis, data sources collected to answer each question, and the analytical methods employed to answer each question.

Analysis of teachers' equity perspectives. I began my analysis by examining the pre-surveys that were completed by 25 teachers across the SAUSES sites in the San Francisco Bay Area and Southern California at the first[29] professional development session (see Appendix F for pre-survey contents). By focusing on one of the pre-survey items, "What do the terms, *equity* or *social justice* mean to you?," I coded the various ways teachers defined equity using a process of open coding (Corbin & Strauss, 2015; Glaser & Strauss, 1967; Miles & Huberman, 1994; Ritchie, Lewis, Nicholls, & Ormston, 2014; Saldaña, 2013; Strauss & Corbin, 1998) and in vivo coding (Corbin & Strauss, 2015; Strauss & Corbin, 1998). These initial codes included *resources (advanced course offerings)*, *empowerment*, *blame parents, and strategy for students from nondominant communities,* and in total 19 codes were generated; these codes are outlined in Table 14. In the next iteration of coding, I collapsed these codes and reorganized the coded data into larger thematic categories (see Table 14). For example, interrelated coded chunks of data, such as those marked with *equal opportunity or access*, *resources*, or *equal outcomes* were collapsed into the category, access to high-quality STEM instruction (see Table 14).

Table 14
Descriptive and In Vivo Codes of Teachers' Definitions of Equity

Category	Code	Description
Access to High-Quality STEM Instruction	1—equal opportunity or access 2a—resources (clean school) 2b—resources (advanced course offerings) 2c—resources (materials) 3—equal outcomes	All codes in this category identify teachers' thinking about the ways students might have access to high-quality STEM instruction.
Deficit-Model Narratives	4—minority students don't do well in X 5—students lack confidence 6—blame parents	All codes across this category identify teachers' thinking that evidenced deficit-model thinking about students from nondominant communities.
Critical Perspectives	7—relevant or relatable to students' lives 8—acknowledging students' race, ethnicity, and/or cultural backgrounds 9—empower communities/change agents 10—instructional strategy for students from nondominant communities 11—value diverse perspectives 12—aware of biases or stereotypes	All codes across this category identify teachers' thinking about equity that evidence elements of critical perspectives on STEM education.
Equitable Learning Environments	13—multiple opportunities for success 14—flexible pacing 15—teacher reflection 16—fairness/ respectful treatment 17—relationships 18—student voice 19—safe learning space	All codes across this category identify teachers' responses that indicated the characteristics of an equitable learning environment.

From the final cycle of coding, two themes emerged from teachers' explanations:

[29] Based on hire date, each teacher completed the pre-survey during her first PD session in April or May 2015; there is one exception—the elective course teacher did not complete the pre-survey due to a late hire.

> 1) *equity = equality*, where teachers defined the term, equity, interchangeably with equality, i.e., equal access to resources, which is common for practitioners and educational researchers (O. Espinoza, 2007; R. Gutiérrez, 2002); and
> 2) *empowering students for success*, where teachers' responses indicated implicit or explicit recognition of structural inequities that affect the educational opportunities for students from nondominant communities.

I discuss these two themes and highlight teachers' responses from each theme in chapter three.

After identifying these two themes from the larger data set, I returned to the eight SAUSES East Bay case study teachers who completed pre- and post-surveys. Further analysis of teachers' pre-survey responses to additional survey items supported the trends from the larger data set. This analysis included coding responses to questions such as, *What does it mean to teach STEM subjects from an equity-oriented or social justice perspective? Why is that important?* and *What ideas do you have about how you might teach your class from an equity-oriented or social justice perspective?*

Although the case study teachers were grouped according to one orientation, there was variability across each teacher's responses to pre- and post-survey items, final reflection, and other data sources. In each case, the majority of the teacher's responses were coded as one orientation (e.g., *equity is equality*), but some responses may have been coded as the other orientation (e.g., *empowering students for success*). For example, the majority of a teacher's responses to pre-survey items may have aligned with equity is equality, but two responses may have aligned with empowering students for success. Thus, teachers' orientations were determined according to how the majority of their responses were coded; member checks were conducted with two participants to resolve errors (Cohen & Crabtree, 2006; Creswell, 2007; Lincoln & Guba, 1985).

Analysis of teaching practices. To analyze data sources to reveal findings about teachers' equity-oriented teaching practices, I employed the following iterative coding procedure:

First, I utilized open, descriptive coding (Corbin & Strauss, 2015; Glaser & Strauss, 1967; Miles & Huberman, 1994; Ritchie et al., 2014; Saldaña, 2013; Strauss & Corbin, 1998) and in vivo coding (Corbin & Strauss, 2015; Strauss & Corbin, 1998) of data sources. Data that were analyzed included fieldnotes and/or transcripts of video recordings of classroom observations (N = 11) of the two focal teachers, fieldnotes and a transcript of an audio recording of the student focus group interview (N = 7 students), and students' responses to course evaluations of the focal teachers (N = 22). These descriptive codes identified the practices focal teachers utilized in their classroom instruction. In the first cycle of coding, 25 descriptive and in vivo codes were generated, such as *participation protocol*, *affirmed students*, *humor*, *note-taking*, *shared personal story*, *persistence*, and *mental break*.

The 25 descriptive and in vivo codes are listed in Table 15, and the majority of the codes were developed from the data set of the classroom observations and aligned to the research questions (e.g., fieldnotes or transcriptions of video recordings). Only one in vivo code was generated based on the student focus group interview and students' responses to prompts on course evaluations of the focal teachers (e.g., Code 25: knowledgeable/content expert). All codes were used to code transcripts of classroom observations, student focus group interview questions about classroom instruction (e.g., *What do think about your SAUSES computer science instructor?* or *What was fun or interesting in this class? What was your favorite part?*), and course evaluation items related to the instructor (*What are the instructor's strengths?* or *Describe one significant experience with this instructor (either positive or negative).*

In the next cycle of coding, I reviewed the text from each set of coded chunks of data in order to reorganize the data into broader categories. To determine these categories, I grouped the interrelated codes across the coded chunks of data. For example, coded chunks of data marked with codes, such as *popcorn*, *call and response*, or *small group/pair work*, were collapsed into a new category, *participation protocol*. This new category (e.g., *participation protocol*) represented a higher order level of classifying the interrelated codes and describing the commonalities across the codes (Corbin & Strauss, 2015). Thus, the 25 codes from the first cycle of coding were then collapsed into five categories: instructional practice; participation protocol; teacher-student relationship; discussion content; and supporting instructional outcomes. These categories are also presented in Table 15.

Table 15
Descriptive and In Vivo Codes of Focal Teachers' Practices

Category	Code	Description
Instructional Practice	1—humor 2—relevance 3—note-taking 4—explicit expectation 5—used student as teacher	All descriptive codes across this category identify the instructional practices focal teachers used to promote equity *and* support student learning.
Participation Protocols	6—call and response[30] 7—popcorn[31] 8—one-on-one support 9—small group or pair work	All descriptive codes across this category identify the protocols focal teachers used to engage students in classroom discussions and learning activities.
Teacher-Student Relationship	10—formative feedback from students 11—affirmed student(s) 12—spending time outside of class 13—teacher shared personal or professional story	All descriptive codes across this category identify the nature of relationships between focal teachers and students.
Discussion Content	14—current issues 15—STEM careers and/or pathways 16—students' lives 17—racism in STEM	All descriptive codes across this category identify topics that were discussed while focal teachers engaged students in a classroom discussion.
Supports Instructional Outcomes	18—previewed material 19—questioning strategy 20—flexible pacing 21—use of analogy	All descriptive codes across this category identify the practices that focal teachers utilized to support instructional outcomes, such as learning and identity development.

[30] A *call and response* is a method to get students' attention while they are working independently, in pairs, or in small groups. The teacher must pre-teach the call and response to students; students respond to the teacher's *call* with a verbal or rhythmic *response*. The teacher would teach the call and response, such as, "When I say, 'Fight!' you say, 'On!'" The teacher calls out, "Fight," and students respond with "On!" Teacher repeats the call until all students respond and she has the attention of the class.

[31] Popcorn means students are called upon quickly to share out ideas, similar to how quickly popcorn kernels pop. The teacher calls upon the first student to share, followed by each student calling on another student to quickly share out. See https://www.teachingchannel.org/videos/student-participation-popcorn-share

	22—mental break 23—developed and/or used habits of mind (e.g., persistence, metacognition, etc.) 24—connected prior knowledge 25—knowledgeable/content expert	

Finally, in the third cycle of coding, the reorganization of the data revealed emerging themes to characterize the focal teachers' equitable teaching practices (Creswell, 2007; Ritchie et al., 2014). In this phase, three themes emerged from the data to characterize the focal teachers' equity-oriented STEM instruction: 1) culturally relevant instructional practices; 2) develop and maintain relationships with students; and 3) emphasize diverse perspectives and participation in the STEM fields. Analyses of instructional examples across each of the three dimensions are presented in chapter four.

Analysis of identity development. To answer the next research question about student outcomes, I then completed qualitative and quantitative data analysis. To determine a relationship between the focal teachers' equitable teaching practices and student identities, specifically the varied identities available for students to take up in the learning environments, I turned to Nasir and colleagues' (Nasir, 2012; Nasir & Hand, 2008; Nasir & Cooks, 2009) frameworks about identity development. By utilizing the *practice-linked identity* framework, I was able to identify the types of identities and the identity resources (material, ideational, and relational) made available to students by the focal teachers (Nasir, 2012; Nasir & Cooks, 2009; Nasir & Hand, 2008). I used the following analytical procedure to analyze the identities and identity resources available to students:

First, I reviewed the coded fieldnotes or transcripts of classroom observations, focus group interview, and students' evaluations of focal teachers that were used to characterize teachers' equitable practices. In reviewing the coded data, I also developed new codes that were related to students' ideas about what they saw themselves becoming (e.g., "…when people go into college…") or a teacher sharing a personal story about her entrée into the STEM fields. There were 14 codes that were developed from this iteration of coding (see Table 16).

In the next coding cycle, I reviewed the text from each set of coded chunks of data in order to reorganize the data into broader categories about identity development. To determine these categories, I looked for interrelated codes across the coded chunks of data to collapse the codes into categories that were related to identity development (Corbin & Strauss, 2015). The 14 codes from the first cycle of coding were then collapsed into three categories: *student learning*, *contextualizing content and equity issues*, and *STEM pathways* and are shown in Table 16.

Table 16
Descriptive Codes for Identity Development

Category	Code	Description
Student Learning	1—used humor to lower affective filter 2—affirmed students' abilities 3—shifting role (student becomes teacher) 4—sign posts about importance of content 5—developed habits of mind (persistence, intellectual struggle, etc.)	All codes in this category describe identity development related to student learning.
Contextualizing Content and Equity Issues	6—relevance 7—teacher shared story (personal encounter with racism or other –ism) 8—classroom discussion (racism or other –isms in STEM) 9—classroom discussion (social justice issue)	All codes in this category describe identity development related to the ways in which teachers contextualized course content in equity or social justice issues.
Pathways into STEM	10—teacher shared story (personal) 11—teacher shared story (professional pathway) 12—classroom discussion (STEM careers and/or pathways) 13—classroom discussion (professional encounters with racism or other –isms in STEM 14—referred to future self (e.g., when in college…)	All codes in this category describe identity development related to preparation for majoring in or a career in the STEM fields.

Next, in the third cycle of coding, the reorganization of the data revealed emerging themes to characterize the identities made available to students in the focal teachers' classrooms (Creswell, 2007; Ritchie et al., 2014). In this phase, three identities that were made available for students to take up emerged from the data, and the resources to support the development of each identity were identified. These identities include 1) capable learners; 2) potential change agents; and 3) future STEM professionals. The analyses of the resources available to support students' identity development are presented in chapter five.

Finally, to strengthen my interpretations of the identities that were available to students in the focal teachers' classrooms and how students took up those identities based on qualitative data sources (Creswell, 2009), I performed statistical data analyses of quantitative data using SPSS Statistics®. To do so, I conducted nonparametric statistical tests of survey items from students' pre- and post-surveys rather than a t-test comparing two related samples. Nonparametric tests were selected because of the small sample size of the focal cohort with both pre- and post-survey data ($n = 21$) participating in a STEM-focused program, which would suggest that the ordinal variable being tested (i.e., Likert scale survey item related to STEM identity development) was not normally distributed (i.e., right-skewed distribution). Thus, Wilcoxon Signed Rank Tests were performed, and an alpha level of 0.05 ($p < 0.05$) was utilized in SPSS Statistics® for all tests (IDRE website, 2016; LAERD Statistics website, 2013). These analyses of survey items related to each identity are presented alongside the analyses of how teachers' supported students' identity development in chapter five.

Researcher Positionality

When I became the teacher leader at SAUSES East Bay, IDEA personnel were transparent with the teacher leaders at other SAUSES sites about my roles. In addition to performing the required job responsibilities, I was also documenting the organization's process for implementing equity-oriented STEM instruction for my dissertation study. As a new member of the organization, I welcomed the other teacher leaders' feedback about how I might best acclimate myself to working within IDEA. By doing so, I positioned the other teacher leaders as knowledgeable others inside the organization and learned from their prior experiences to navigate my dual roles as teacher leader and researcher.

Throughout the data collection period, my intersecting identities as a Black woman with extensive experiences in teaching and learning, teacher education, and doctoral research at a prestigious institution were acknowledged each week by IDEA and SAUSES staff, instructors, and/or students. Because of this, I was positioned by some as a knowledgeable other—both to rely upon as a resource for equity-oriented STEM instruction and as a teacher ally. Yet others positioned me as a highly-educated individual who was new to the organization who was brought in to ensure teachers were "really" doing equity. In the following section, I outline the advantages and limitations of this positionality as related to the dissertation study design.

Affordances to researcher positionality. In my roles as teacher leader and researcher, I was able to learn side by side with SAUSES teachers, TAs, and staff members (Erickson, 2006) and draw upon my experiences as a teacher, teacher educator, and researcher (K. Gutiérrez & Vossoughi, 2010). Although I had extensive knowledge of theoretical and practical approaches to equity-oriented STEM instruction broadly and science instruction specifically, this was an opportunity for me to strengthen my research and teaching practices. Navigating the roles of teacher leader and researcher allowed me to deepen my content knowledge in other STEM subjects, better understand how teachers utilized equity-oriented teaching practices in a range of STEM courses, and examine the types of supports teachers needed for equity-oriented STEM instruction. For example, I was able to gain insight into the particular teaching practices computer science instructors may have utilized in their courses that may not have been (as) relevant for mathematics instructors.

Additionally, part of my role as the teacher leader was serving on the hiring committee (i.e., I was on a team that conducted interviews for hiring new instructional staff for SAUSES East Bay). Therefore, I had some understandings of the instructional staff's interest in and affinity towards equity-oriented instruction, which allowed me to make inferences about teachers' predispositions to doing equity-oriented work in the STEM fields and education. In my role as a teacher leader, I was also able to draw upon my experiential knowledge of communities of color (Ladson-Billings & Tate, 1995) and easily established rapport with many of the returning and new SAUSES teachers, staff members, students, and their families who identified as members of nondominant communities.

Limitations to research positionality. Although there were benefits to my position as the teacher leader for the research design, there were also limitations to this positionality. As the immediate supervisor for all members of the instructional team, and thereby responsible for their evaluations, teachers and teaching assistants (TAs) may have felt compelled to participate in the research and/or provide responses to questions that were posed to them informally and formally. Although teachers and TAs each completed performance evaluations of me as their teacher leader, which became a part of my formal evaluation process by IDEA, this was at the end of the summer session rather than while classes occurred during the summer session (i.e., during the time period when the majority of data were collected). One way to avoid this type of bias would have been to conduct an ethnographic study where I could have collected data via participant observation (Emerson, Fretz, & Shaw, 2011). Or, if I had not been positioned as a knowledgeable other by IDEA staff, the instructors in the study may have responded differently to study recruitment processes (i.e., may not have felt compelled to participate in portions of the study, or may have been more willing to participate).

Due to the nature of the qualitative data collected (observational data, fieldnotes, etc.), it is difficult to have a completely unbiased analytical lens to the data. To strengthen my analysis of the data, increase validity of findings (Creswell, 2014), and help to expose any researcher biases of data interpretation, I conducted member checks with some of the participants (Creswell, 2014; Cohen & Crabtree, 2006). This was included as part of the follow-up interview with one of the focal teachers (conducted March 31, 2016); sharing preliminary findings with IDEA staff members and returning SAUSES East Bay teachers in Spring 2016; and having other educational researchers and practitioners review data and share their interpretations. In the following chapters of the dissertation, I discuss the findings that emerged from my analysis of the data.

Chapter 3: SAUSES Teachers' Perspectives on Equity-Oriented STEM Instruction: I'm Not *Just* Teaching Science

…Yes, you're trying to teach for chemistry molecules during this lesson plan—but how is that wrapping around to going towards including diversity and equity in the classroom? So it focuses you as an instructor, like oh yeah—there's [sic] multiple goals here. I'm not *just* teaching science or getting people interested. [emphasis added]

— Quote from Jazymn, SAUSES East Bay Chemistry Instructor, March 31, 2016

In this quote, Jazymn, a Latina chemistry teachers at the SAUSES East Bay site, described how her experiences as a teacher for the SAUSES program were different from her teaching experiences in other STEM education programs. In her response, she explicitly mentioned that teaching her students involved connecting foundational chemistry concepts to issues of equity—signaling her desire to reach broader personal and program goals of implementing equitable science instruction. Jazmyn's reflective statement evidenced her mindset about teaching for the SAUSES program. She saw equity-oriented STEM teaching as an endeavor that was multi-faceted, including strengthening students' conceptual understanding and interest in science, and providing rigorous, equitable learning opportunities for students.

Teachers' mindsets about equity-oriented teaching and learning are critical for engaging in equity-oriented instruction (Ladson-Billings, 2006b; Mensah, 2013, 2016). I use mindsets[32], to describe teachers' understandings of equity and equity-oriented STEM instruction, in addition to their beliefs about students from nondominant communities. Mindsets, in this way, do not indicate teachers' or students' beliefs about intelligence or intellectual abilities (e.g., growth or fixed mindset; Dweck, 1999, 2008). It takes time to develop an equity-oriented mindset, and scholars point out the varied methods teacher educators can use to support shifts in teachers' mindsets. For example, Bennett (2012) posits that when teachers form positive relationships in their work with students from nondominant communities *and* have multiple opportunities to reflect upon their practice, their mindsets can shift. Others recommend engaging teachers in discussions during teacher education courses or professional development sessions about how structural racism affects students' learning opportunities (Bennett, 2012; Lazar, 2007). Engaging in critical reflection on personal *and* teaching experiences, as well as critical thought about equity issues and engaging in small teacher inquiry groups, are also important for teachers in order to develop a mindset towards implementing equitable instructional practices (Bennett, 2012; Castro, 2010; Gay & Kirkland, 2003; Howard, 2003; Howard & Aleman, 2008; Ladson- Billings, 2000; A. Martin, 2013; Villegas & Lucas, 2002). Ultimately, teachers must confront and reconcile their assumptions and beliefs about teaching, learning, and students—especially meritocracy-based narratives that may be connected to their deficit views of students from nondominant communities (Howard & Rodriguez-Scheel, 2016).

Research has highlighted the ways in which the sociocultural and sociopolitical realities of students from nondominant communities influence their opportunities to learn across a variety of STEM learning settings. Teachers' mindsets about equity-oriented teaching practices can influence students' opportunities to learn in several ways. For

[32] I use the terms mindset, orientation, and perspective interchangeably throughout this manuscript.

example, deficit narratives about students from nondominant communities can inhibit or support certain students' positioning within mathematics classrooms, identity development, and opportunities to learn mathematics and science (K. Gutiérrez & Calabrese Barton, 2015; D. Martin, 2013; Nasir et al., 2012; Nasir et al., 2014; Shah, 2013). Few studies have investigated the orientations teachers have to equitable STEM instruction. Equity-focused teachers who are knowledgeable of sociocultural influences on student learning and are equipped to engage students in rigorous, inquiry-based learning are critical for transforming STEM learning environments (K. Gutiérrez & Calabrese Barton, 2015; Johnson, 2011; Sheth & Braaten, 2013). Thus, it is important to investigate teachers' mindsets about equity-oriented STEM instruction because it has implications for the success of students from nondominant communities.

In this chapter, I examine SAUSES teachers' orientations to equity-oriented STEM instruction, how their orientations shifted over time, and the types of supports they drew upon for their learning. Specifically, the findings for this chapter include the two orientations that SAUSES teachers had towards equity-oriented STEM instruction, *equity is equality* and *empowering students for success*, how their perspectives shifted over time, and the tools that facilitated teacher learning about equity-minded teaching practices. I argue that teachers' perspectives on and understandings of equity are critical for changes in practices to occur, and in this chapter, I focus on answering the following research question:

> **Equity Orientations:** What are SAUSES teachers' perspectives on equity-oriented STEM instruction, and how do their perspectives change over the course of the program?

Findings

Although SAUSES teachers had a commitment to equitable instruction, how those teachers defined equity varied based upon their teaching and educational experiences. The findings presented in this chapter highlight this variation and include

1) teachers' two main perspectives on equity-oriented STEM instruction, *equity is equality* and *empowering students for success*;

2) how teachers' perspectives changed over time such that six of the eight case study teachers held the empowering students for success perspective by the end of the program session (e.g., July 2015); and

3) the two types of supports teachers leveraged to shift their perspectives: use of artifacts and developing relationships.

The findings presented in this chapter are based upon the eight case study teachers from the SAUSES East Bay site (see Table 17). In the following sections, I first highlight the two narratives about equity that emerged from teachers' pre-survey data, and then discuss how teachers' perspectives on equity changed over the summer session based on their post-survey responses, teacher reflection statements, and annotated teaching philosophy statements. Finally, I end the chapter with a discussion of the two types of supports teachers utilized to shift teachers' thinking.

Table 17
SAUSES East Bay Case Study Teachers

Adam white male, public high school teacher	Anthony* Black male, East Bay University graduate student	Emmanuel* white male, private high school teacher	Drew* white male, graduate student
Jazmyn Latina, East Bay University doctoral candidate	Julian Latino, East Bay University doctoral candidate	Martin white male, public high school teacher	Walter* Black male, East Bay University doctoral candidate

Note. * indicates a returning teacher to SAUSES East Bay

Teachers' orientations to equity-oriented STEM instruction. Based on the thematic analyses of the data sources, the eight case study teachers (see Table 17) teachers evidenced two main orientations to equitable STEM instruction:

1) *equity is equality*, where teachers defined the term, equity, interchangeably with equality, i.e., equal access to resources. This orientation to equity is common for practitioners and educational researchers (O. Espinoza, 2007; R. Gutiérrez, 2002); and

2) *empowering students for success*, where teachers' responses indicated implicit or explicit recognition of structural inequities that affect the educational opportunities for students from nondominant communities.

Table 18 outlines the two perspectives on equity-oriented STEM instruction for SAUSES East Bay teachers. At the start of the program in April 2015, the majority of case study teachers (n = 5) evidenced the *equity is equality* orientation, and the remaining three teachers exhibited the *empowering students for success* orientation.

Table 18
SAUSES Teachers' Initial Equity Orientations

Equity Orientation	Description of Equity Orientation	Examples from Teacher Pre-Survey in April 2015 (N = 8)
Equity is Equality (n = 5) Adam Emmanuel Jazmyn Julian Martin	Equity is viewed as providing all students with equal access to opportunities (e.g., rigorous instruction, advanced courses, college visits, etc.) and resources (high-quality teachers, tutors, mentors, technology, etc.) to address disparities in access to high-quality education. Teacher may exhibit deficit-model thinking about students from nondominant communities.	"…equal access to materials, information, and other resources regardless of 'life' factors—socioeconomic status, location, outside influences…" (Adam) "…the evenness and fairness of something." (Jazmyn) "…the provision of resources that allows for equal outcomes." (Martin)
Empowering Students for Success (n = 3) Anthony Drew Walter	There is a continuum within this level, such that teachers move from less sophisticated to more nuanced understandings of equity. On one end, *Utilizing Strategies for Student Success,* equity is viewed as utilizing teaching strategies, curricula, and content known to promote the success of and/or are relevant to students from nondominant communities in order to positively affect student outcomes and decrease the opportunity gap. Teachers may draw upon equity pedagogies, such as critical pedagogy (Duncan-Andrade & Morrell, 2008), culturally relevant pedagogy (Ladson-Billings, 1995, 2006b), or culturally sustaining pedagogy (Ladson-Billings, 2014; Paris & Alim, 2014), but do not directly address structural inequities in their instruction. As teachers moved along this continuum and develop more sophisticated understandings of equity, they attempted to create *Dignity-Cultivating* (M. L. Espinoza & Vossoughi, 2014) learning experiences for and with students. In addition to utilizing equity pedagogies, equity is viewed as intentionally and explicitly addressing issues of power and structural inequities within our society in classrooms in order to provide students from nondominant communities with positive and dignified learning experiences. Success is broadly defined as being able to successfully navigate the dominant culture, but also using knowledge gained to empower historically marginalized communities.	*Utilizing Strategies for Student Success* "…if I ask a fish to climb a tree, but it can't (obviously), I don't call it stupid. … I give the fish some arms and legs so he can make it up there." (Anthony) *Dignity-Cultivating Educational Experiences* "…a commitment to advocate for the marginalized, oppressed, and voiceless people until they have the space and recognition to do so themselves." (Walter)

Equity is equality. Teachers who had an *equity is equality* perspective on equity-oriented STEM instruction viewed equality and equity as the same ideas. This explanation of equity as equal access to opportunities and resources within schools is commonplace for educators (O. Espinoza, 2007; R. Gutiérrez, 2002, 2013; Rousseau & Tate, 2003). Of the eight case study teachers included in the sample, five teachers—

Adam, Emmanuel, Jazymn, Julian, and Martin—evidenced the equity is equality perspective. Although these five case study teachers were classified as holding the equity is equality orientation, there was variability across each teacher's responses to survey items. In each case, the majority of the teacher's responses aligned with the *equity is equality* perspective, but other responses may have aligned with the *empowering students for success* perspective. Thus, the five case study teachers who exhibited the equity is equality perspective were determined to have this perspective because the majority of their responses were coded as equity is equality.

The major trends in teachers' responses included ideas about access to educational opportunities (advanced course offerings, challenging curriculum, etc.), resources (e.g., computers, tutoring, etc.), fair treatment, and references to students' racial and/or ethnic backgrounds and/or socioeconomic status (SES). For example, Emmanuel responded that students would have "access to education, resources, a clean environment…regardless of income level, family background, geographic location, gender, race, etc." Another teacher, Julian, defined equity as, "equal opportunity… students are given the chance to work hard to be who they want to be." Both of these responses, and others like it (see Table 18), evidenced implicit and explicit ideas about the success of students from nondominant communities. However, these responses did not suggest specific strategies that teachers could use in their classroom instruction to better support students from nondominant communities. Additionally, these responses lacked specific attention to the structural inequities that contribute to the disparities in outcomes between students from nondominant communities and their white or Asian peers.

Teachers' coded responses included statements that generally evidenced ideas of equality rather than equity, which was exemplified in Adam's response:

> …You (generally) have to have computers to do computing. You need lab resources for chemistry and physics experiments. Without equitable practices, large segments of the population will be left out simply because they cannot afford these resources. (Adam, pre-survey, April 2015)

Adam's focus on student access to resources indicated that he viewed access to resources (computers, lab materials, etc.) as an "equitable practice" and potential strategy to strengthen student outcomes. Although he was concerned with the success of students who have a lower SES ("large segments of the population will be left out because they cannot afford these resources") and the inequitable distribution of resources across schools, Adam's statement was problematic. He de-emphasized the inequities within school systems that contribute to the lack of resources for students, which are often rooted in deficit thinking about the capabilities of students from nondominant communities (Hilliard, 2003; Johnson & Atwater, 2014; Ladson-Billings, 2009; Noguera & Wing, 2006; Rousseau & Tate, 2003). Furthermore, simply providing students with greater access to resources does not ensure that they will have high-quality educational experiences. Although equity-oriented instructors should be concerned with the types of resources their students have access to, they should *also* be invested in the types of learning experiences they provide for students from nondominant communities (Apple, 1996; Johnson & Atwater, 2014; Nasir & Cobb, 2002; Rousseau & Tate, 2003; Varelas et al., 2012).

Empowering students for success. Within the larger data set, some teachers defined equity in broader terms than the access to resources narrative. In reviewing these teachers' responses, the other theme that emerged from the coded pre-survey data was teachers' differential attention to the structural inequities that influence educational opportunities for students from nondominant communities. From this trend, the second category of equity-oriented perspectives, *empowering students for success*, was developed. Three case study teachers' responses were aligned with this perspective: Anthony, Drew, and Walter. Each of these teachers were returning teachers to SAUSES East Bay, which may have had an influence on their perspectives on equitable STEM teaching and learning (i.e., their perspectives could have been impacted by their prior SAUSES teaching and learning experiences). Prior to the study, I did not formally capture how their perspectives aligned with views advocated by SAUSES. Anthony, Drew, and Walter were highly recommended by SAUSES and IDEA staff members for classroom observations as teachers who engaged in equity-oriented teaching. This indicated to me that their perspectives on equity-oriented STEM instruction were consistent with the views of IDEA and SAUSES.

In the empowering students for success category, teachers' responses to survey items revealed nuanced understandings of equity. For example, Anthony remarked that equity included acknowledging students' racialized, ethnic, and/or gender identities, and discussing issues of race, racism, and sexism in the classroom (e.g., "not being colorblind, gender blind, sexuality blind, or any other kind of blind"). Other teachers implicitly mentioned the use of instructional strategies designed specifically for working with students from nondominant communities to influence learning outcomes (e.g., culturally relevant pedagogy), while some implicitly referenced structural inequities. For example, Drew stated, "…equity is more easily described by its converse—that inequity describes dividing lines by which certain individuals are treated differently or denied opportunities because of circumstances beyond their control."

Taken together, the coded responses indicated that there was a continuum within the empowering students for success category, where teachers' responses ranged in how they conceptualized equity. Each of the responses included ideas representative of moving beyond the equity is equality perspective to exemplify thinking that recognized the sociopolitical contexts in which learning occurs and critical perspectives on STEM education. Thus, teachers' views were a on a continuum using *strategies for student success* (equity pedagogies specifically for working with students from nondominant communities) to providing *dignity-cultivating* educational experiences (see Table 18). The more sophisticated understandings of equity echoed the desire to create learning experiences and environments that could be classified as *dignity-cultivating* (M. Espinoza & Vossoughi, 2014), where as students endeavor to become STEM-literate, they can also be equipped to transform our society—especially their own communities.

Walter's responses to the pre-survey prompts illustrated a view of equity that aligned with fostering dignity-cultivating educational experiences:

> I believe that teaching and learning are most productive when everyone can bring their full self to the interaction, which includes race, ethnicity, and culture.

> Including these facets of teachers and students allows for a richer, more holistic conversation. … Questioning the objectivity of STEM fields is one key aspect of equity-informed pedagogy. If we have a goal of increasing diversity in the STEM fields, we have to attract and retain marginalized groups. In order to achieve that goal, day-to-day classroom affairs have to speak to these students' experiences, preparation, and interests. … I hope to do this by having more student-generated problems and more brainstorms about how calculus topics show up in scholars' everyday lives. (Walter, pre-survey, April 2015)

Walter's response provided a broad conceptualization of equity that moved beyond the access frame, and addressed how teachers should meet the needs of students from nondominant communities. Implicit and explicit in his response were ideas about how teachers should draw and build upon students' lived experiences, have a critical perspective of the STEM fields, and facilitate discussions of race and racism in the classroom. Walter pointed out that such instructional practices would increase the ability to "attract and retain" students from nondominant communities into the STEM pipeline.

Shifts in teachers' orientations. Based on the two perspectives that emerged from the data, I analyzed the post-survey data to determine if and how teachers' orientations to equity-oriented STEM instruction shifted during the SAUSES summer session. For this analysis, I used the data of eight teachers who completed both pre- and post-surveys. Two teachers—the elective and biology instructors (Fleeta and Marva, respectively)—were not included in this data analysis since pre- *and* post-survey data were not available for each teacher. Thus, no analysis could be made regarding their shifts in orientations across the summer session.

Teachers' coded explanations of equity on their post-survey demonstrated that five teachers' perspectives toward equity-oriented STEM instruction had shifted by the end of the summer session:

> 1) Jazmyn, Julian, and Martin shifted from the equity is equality perspective to empowering students for success;
> 2) Drew and Anthony developed more sophisticated understandings of equity, and shifted from empowering students for success—utilizing instructional strategies for student success to empowering students for success—dignity-cultivating educational experiences.

Each of these five teachers evidenced deeper understandings of equity-oriented STEM instruction (see Table 19). In contrast, two teachers—Adam and Emmanuel—did not demonstrate a shift in their perspectives (i.e., maintained the equity is equality perspective) across the summer session. Subsequent analytical efforts included triangulating teachers' survey responses with data sources, such as teacher materials (e.g., lesson plans, revisions of pedagogical philosophy statements, etc.), and teachers' reflection statements to better understand how and why their perspectives shifted. To better understand how the case study teachers developed deeper understandings of equity, next I discuss three cases that are representative of the types of shifts teachers exhibited.

Table 19
SAUSES Teachers' Shifts in Equity Orientations

Teachers' (N = 8) Initial Equity Orientation (April 2015)	Teachers' (N = 8) Final Equity Orientation (July 2015)	Examples of Teacher Talk from Post-Survey Responses
Equity = Equality (n = 5) Adam, Emmanuel*, Jazmyn, Julian, and Martin	*Equity = Equality* (n = 2) Adam, Emmanuel*	"Fair opportunities for all students." (Adam) "…equal access to opportunity regardless of one's position in life. …create a learning environment that *thinks* about social justice instead of just teaching facts to be memorized." [emphasis added] (Emmanuel)
Empowering Students for Success (n = 3) Anthony*, Drew*, and Walter*	*Empowering Students for Success* (n = 6) Anthony*, Drew*, Jazymn, Julian, Martin, and Walter*	"…the provision of resources for equal outcomes rather than just equal inputs. …social dynamics [of a classroom] that may be different based on race, education, class, gender, and a number of other factors." (Martin) "Having all people feel a sense of agency over their own lives. That they have access to tools for improvement (sic). …Understanding the backgrounds of different students helps inform what sorts of things will motivate and what challenges they [have] and have they faced." (Julian) "take time away from the rote curriculum and talk about STEM in its greater context. This is important since few students resonate with what is truly abstract." (Drew)

Note. * indicates a returning SAUSES East Bay teacher

Teachers' orientations: Progress made along the continuum. By the end of the summer session, six teachers evidenced the empowering students for success orientation. Of these six teachers, Walter maintained the dignity-cultivating orientation, while the other five teachers shifted their perspectives on equity-oriented STEM instruction. During the summer session, teachers specifically made the following types of progress:

1) Martin shifted from equity is equality to utilizing strategies for student success within the empowering students for success category;
2) Jazymn and Julian shifted from equity is equality to dignity-cultivating within the empowering students for success category; and
3) Anthony and Drew moved along the empowering students for success continuum from utilizing strategies for student success to dignity-cultivating.

I discuss the types of growth teachers made during the summer session by highlighting two case study teachers, Martin and Jazmyn. I chose these two cases because they each shifted from the equity is equality perspective to the empowering students for success category, where Jazmyn demonstrated more sophisticated understandings of equity than Martin along the empowering students for success continuum.

The case of Martin: From resources and deficits to strategies. Initially, Martin exhibited the equity is equality narrative in his thinking about equity-oriented STEM instruction. In one of his responses to the pre-survey, Martin defined equity as the "provision of resources that allows for equal outcomes…[and] the ability of recipients of support to achieve similar goals." This quote demonstrates his focus on students' access to resources to support equitable learning outcomes. Although it is important to consider the types of resources students have access to for learning, this viewpoint represents a narrow conceptualization of equity. In his other pre-survey responses, Martin mentioned having a "critical purpose" for teaching that should be reflected in lesson planning, types of assessments, and classroom management strategies. His ideas about what this should look like were vague (e.g., "How is the lesson planned in a differentiated and relevant manner?") and did include ensuring that students' voices were recognized (e.g., "Students are provided with structure but also with voice."). Overall, his ideas suggested that he was offering ways to critique a lesson plan rather than a critical perspective on mathematics teaching and learning. Martin also evidenced deficit views of students from nondominant communities as evidenced by low expectations of students' abilities, which is commonplace for many teachers (Bryan & Atwater, 2002; Castro, 2010; Howard & Rodriguez-Scheel, 2016; Valencia, 2012, 2015). For example, Martin wrote in his final reflection that initially he "had his own preconceived notions about the expectations of students," but found during the summer session that "students' knowledge and motivation exceeded my own expectations."

However, by the end of the summer session Martin evidenced the empowering students for success orientation. One way this was evidenced was his acknowledgement of structural inequities in his definition equity on the post-survey. He stated, "current modes of education have not served students from nondominant communities effectively to result in equitable outcomes." Implicit in this statement were ideas about how learning opportunities for students from nondominant communities have been affected by structural inequities. Martin also demonstrated an increased focus on creating learning experiences that were relevant to students' lives, and this was reflected through his ideas about how to teach his mathematics course with an equity lens. Initially, his ideas about relevance included ideas about using students' names in problems assigned during class (Final Reflection, July 27, 2015; Lesson Plans, July 2, 2015). However, by the end of the summer his ideas reflected his developing deeper understandings of equity along the empowering students for success continuum. Take, for example, his ideas about relating material to real-world contexts and creating his own problems related to students' experiences; engaging students in a discussion about interest rates and inequalities that have affected their communities during the financial crisis of 2008; and challenging students to connect a social justice issue to course content in one of their final assignments (Final Reflection, July 27, 2015; Lesson Plans, July 9 and 11, 2015). Each of these ideas demonstrated a deeper understanding of both equity *and* how to implement equitable teaching strategies, evidencing a shift in Martin's orientation from equity is equality to the instructional strategies end of the empowering students for success continuum. Achinstein and Athanases (2005) point out that teachers who have narrow conceptions of equity and exhibit deficit views of students from nondominant communities benefit from staying focused on student learning as they endeavor to shift their mindsets and teaching practices. This is reflected in Martin's case, where keeping student learning central was useful for shifting his thinking and teaching practices around equity-oriented instruction.

The case of Jazmyn: From unequal resources to a pair of shoes that fit. Jazmyn began the summer with the equity is equality perspective. In her pre-survey, she defined equity as "the fairness of something" and pointed out that "students from certain backgrounds may be more successful due to great accessibility to resources." Commensurate with others who exhibited this perspective, Jazmyn focused on access to resources and how that may affect student outcomes, suggesting a narrow understanding of equity. These ideas about equity were also reflected in the initial draft of her teaching philosophy statement; she expressed ideas about students from nondominant communities having "unequal resources" and a lack of access to high-quality STEM instruction. Jazmyn noted that there were several issues with the "way STEM field is taught," such that there is an "emphasis that if you can't keep up, it is you" rather than poor or inadequate "teaching practices" across high school or college-level courses. She also went on to say that there is "no translation of how to apply knowledge outside of the classroom." Although these are important issues in STEM education, and numerous scholars reiterate these ideas in the STEM education research literature (Breiner et al., 2012; Bryan et al., 2016; NRC, 2012; Sanders, 2009; Slotta & Linn, 2009; Yael, Linn, & Roseman, 2008), overall Jazmyn's statements reflected narrow conceptualizations of equity. Jazmyn recognized this, as reflected in her annotated teaching philosophy statement, where she reported that she would need to "strengthen" her understanding and teaching practices around "cultural cultivation, [which] shows how culture can affect the way they [students] think."

By the end of the summer, Jazmyn's perspective had shifted to the empowering students for success, with more sophisticated understandings of equity. For example, in her post-survey, Jazmyn defined equity as "providing the necessary resources and opportunities in which all students have the opportunity to succeed. These resources and opportunities must be unique to the scholar." She also expressed that her role as a chemistry instructor was to

> help students utilize chemistry in a way that can help students accomplish things that are relevant to them and their communities. Teaching STEM subjects from an equity-oriented perspective is very important because it helps students see themselves as agents of change rather than an entity that is being forced to learn a subject because someone is telling them to. (Jazmyn, post-survey response)

In both of these statements, Jazmyn was focused on students' opportunities to learn and the types of outcomes those opportunities would afford students. Unlike her pre-survey responses, she was less focused on access to resources and was instead thinking about how her instructional approaches would support "individual as well as collective student learning," (Rousseau & Tate, 2003, p. 212) indicating an important shift in her mindset about equity-oriented STEM instruction. She emphasized how her thinking had changed during the follow-up interview. During the member check portion of the follow-up interview (Cohen & Crabtree, 2006; Creswell, 2014), Jazmyn reflected on her growth and becoming more equity-minded progress and shared the following:

> When I started with the program I definitely had not thought too much particularly about various concepts of what equity and diversity mean. But by the end of the program and really just working with the students and sitting down and reflecting I realized there was so much more, and I definitely have shifted toward this empowering students for success idea. … …maybe it was one of the professional developments how…people who do well in chemistry typically have access to laptops and a lab. But if you take a whole bunch of students who've never had that before, and you give them a laptop and a lab, are you really saying that's going to achieve the same thing? You're not for a number of reasons, because I feel like there are a number of barriers to that. But…there's so much more that feeds into that: the background of the student, what they bring, what's even necessary. So it goes into the pair of shoes, and the pair of shoes that fit.

Rather than being concerned about students' access to resources, Jazmyn was more concerned with how students would be supported to not only be successful academically, but also empowered to be potential change agents in their communities. She recognized how structural inequities affect the opportunity gap (Carter, 2013; Ladson-Billings, 2006a; Moseley, 2006) for students from nondominant communities through her reference to "a number of barriers to that." Ultimately, these ideas represented how she shifted from the equity is equality perspective—a narrow view of equity—towards the dignity-cultivating end of the empowering students for success continuum.

Supports for teachers' shifts. There were five teachers who demonstrated shifts in their perspectives toward equity-oriented STEM instruction: Jazmyn, Julian, and Martin shifted from the equity is equality perspective to empowering students for success while Drew and Anthony moved along the continuum for empowering students for success. In contrast, two teachers—Adam and Emmanuel—did not demonstrate a shift in their perspectives (i.e., they maintained the equity is equality perspective). In order to understand *how* teachers' growth was either supported or constrained, I coded additional data sources, such as teachers' reflection statements[33], annotated teaching philosophy statements, and fieldnotes. Trends in the data sources revealed two categories of support for teachers' shifts in their perspectives: 1) use of cultural artifacts and 2) developing and maintaining relationships.

Use of cultural artifacts. Sociocultural theorists assert that learning processes are socially and culturally mediated, and examine how learners rely upon others, tools, and cultural artifacts for learning processes (Lave & Wenger, 1991; Nasir & Hand, 2006; K. Gutiérrez & Rogoff, 2003; Vygotsky, 1978). Cultural artifacts, such as videos or texts, are situated within sociocultural and sociohistorical contexts and can serve as a scaffold, or form of assistance, for learners (Cole, 1995; Penuel & Wertsch, 1995; Salomon & Perkins, 1998; Vygotsky, 1978). Therefore, social activities—like teacher learning—become meaningful in historically and culturally situated ways; for example, teachers develop their ideas about equitable teaching practices in sociohistorical and sociocultural notions of what equity means (Johnson & Golombek, 2003). By drawing upon cultural artifacts, teachers can be supported to reconceptualize their ideas, teaching practices, and understandings (Johnson & Golombek, 2002, 2003; Putnam & Borko, 2000). There were several cultural artifacts that SAUSES East Bay teachers utilized to support their

[33] Teachers completed final reflection statements at the end of the summer session (July 27, 2015).

understandings of both equity and equity-oriented STEM instruction both prior to and during the summer session. These cultural artifacts were represented in three different ways:

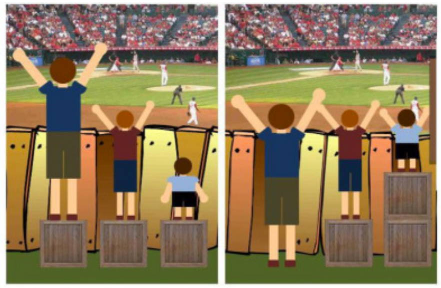
1) pictorial representation of equity;
2) reading and responding to scholarly publications (e.g., educational research journal articles, book chapters, etc.), where the text is understood as the cultural artifact;
3) the SAUSES guiding pedagogy document (i.e., the ABCs) to revise the teaching philosophy statements, where the ABCs document *and* annotated teaching philosophy statement is understood as the cultural artifacts that mediates reflection and learning.

In the following section, I focus on how the pictorial representation of equity and the annotated teaching philosophy statements were useful for supporting teachers' shifting mindsets.

Pictorial representation of equity. In December 2012, Professor Craig Froehle created a picture to convey his beliefs about equality in response to an online debate with conservatives after President Barack Obama was re-elected. He shared it on Google+, and his original picture has been shared over a million times[34] since then. It was recently adapted in January 2016 by the Interaction Institute for Social Change for use by the "world of equity practitioners" (IISC website, 2016), and has become a tool for better understanding equity in professional development with teachers, education advocates, and others working towards ameliorating inequities and social injustices in our society. One representation of this cultural artifact was used in the professional development sessions with teachers (see Figure 2). The equality vs. equity picture shown in Figure 2 displayed two pictures of a baseball game where three young students were standing on boxes next to a fence surrounding a baseball stadium. The left side of the picture represented equality: students were standing on top of boxes of equal height that allowed two of the three students to see over the fence and enjoy the baseball game. The right side of the picture—which represented equity—featured each of the three students getting what he needed to see over the fence to view the baseball game. Although the tallest student did not receive a box while the other two students received boxes, yet each of the students could view the game.

[34] Froehle's blog post describes how his picture has been shared and adapted across the world since its debut in 2012 at https://medium.com/@CRA1G/the-evolution-of-an-accidental-meme-ddc4e139e0e4#.dbttgr4q2

Figure 2: Equality vs. Equity



Picture courtesy of Striving for Change/Knowledge Works Foundation[35]

This picture was particularly powerful for certain teachers, and helped them to better understand the meaning of equity, and ultimately support shifts in their perspectives on equity-oriented instruction. For example, in her follow-up interview, Jazmyn, a focal teacher, specifically mentioned the equality vs. equity picture. Others, such as Martin—a mathematics teacher—noted it in their annotated teaching philosophy statements, whereas other teachers referred to it during professional development meetings (Fieldnotes, July 1 and 15, 2015). What teachers seemed to draw upon from this cultural artifact was the idea that one of the students in the equality picture was tall enough to see over the fence without the addition of the resource (a box)—but was still given a resource. However, the other two students each received this same resource (a box) to reach the same outcome (seeing over the fence). The box was sufficient for the student in the middle to achieve the goal, yet insufficient for the shorter student on the far right (see left side of Figure 2). In contrast, the equity picture on the right of Figure 2 demonstrated fair treatment, such that each student received what he needed to be "successful"—though not equal treatment.

This pictorial representation of equity prompted teachers to not only debate the types of instructional resources students need to be successful, but to also discuss macro-level explanations of why many students from nondominant communities do not have access to certain instructional resources (Fieldnotes, April 11, 2015). This idea was reiterated in Jazymn's interview:

> Yeah, I remember the biggest thing that impacted me was when we were talking about equality versus equity. …we were talking about the fence and that diagram on the fence. There were three people and they all had certain height boxes, there was equity versus equality. We were talking about as instructors whether or not equality meant you would redistribute your amount of boxes so that everyone was the same height so they could look over the fence versus whether or not everyone gets the same size boxes. … So I think that analogy really stuck with me because it kind of really [made] me question, "Where are those fences in the traditional classroom?" So it's not just a matter of everyone has different resources, let's

[35] Picture retrieved from http://www.strivetogether.org/blog/wp-content/uploads/2015/05/equality-vs-equity.jpg

> redistribute resources. It becomes a question of *why* are there different barriers? Kind of taking a step back and [asking], *What* are those barriers and why do those barriers [exist]? …as an instructor…*how we can work towards tearing those barriers down?* [Follow-up Interview, March 31, 2016]

This quote demonstrates how the equality vs. equity picture was a tool to facilitate Jazmyn's thinking about structural inequities and how they affect students' learning opportunities. Rather than simply focusing on how resources are distributed inequitably to students, an important issue to investigate in education, Jazmyn began to examine the existing structural inequities that contribute to this phenomenon. Engaging in this type of discussion is important for teachers' shifts in their perspectives on equity-oriented instruction. Researchers point out that discussions about how structural racism affects students' learning opportunities during teacher education courses or professional development sessions is important for shifting mindsets (Bennett, 2012; Lazar, 2007).

Revisions to teaching philosophy statements. In their final reflection statements, three teachers—Jazmyn, Martin, and Walter—mentioned how their teaching philosophy statements were important tools for supporting their implementation of equitable teaching practices. Subsequent analysis of all eight teachers' responses to the teaching philosophy statement prompts exposed teachers' ideas about the degree of alignment between their educational philosophies and the SAUSES guidelines for pedagogy, the ABCs. Two of the teaching philosophy statement prompts aimed to facilitate teachers' reflection on their ideological and pedagogical understandings of equity-oriented instruction: *In what ways do your pedagogy and teaching philosophy mirror the ABCs of the SAUSES program? In what ways do your pedagogy and teaching philosophy differ from the 3 core pedagogical principles of the SAUSES Program?*

In my analysis of these two prompts, an interesting trend in the data was teachers' identification of how their individual teaching philosophies were different from the SAUSES guidelines for pedagogy. One of the guidelines for pedagogy—*critical thinking*—required teachers to contextualize STEM content in larger sociopolitical issues relevant to students' communities. For example, math teachers may have facilitated a lesson about identifying and graphing trends in data to issues such as racialized violence against Black or Latin@ communities committed by police (e.g., Tamir Rice or Jessica Hernandez[36]) or workplace discrimination about natural hairstyles worn by Black men and women[37] (e.g., dreads, natural Afros, etc.). In so doing, students would not only better understand how to summarize, interpret, and represent data,[38] but would have done so with data that was relevant to students' interests[39] *and* their communities.

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[36] Tamir Rice—a 12 year old boy in Ohio—and Jessica Hernandez—a 17 year old LGBTQ girl—were each shot to death by police officers in 2015. Their killings contributed to the ongoing national and international debates about racialized violence committed by police officers in the U.S. For more details, see http://www.cnn.com/2016/04/25/us/tamir-rice-settlement/ and/or http://www.westword.com/news/inside-das-decision-to-clear-officers-in-jessie-hernandez-shooting-6785531

[37] Natural hairstyles worn traditionally worn by Black men and women have become more commonplace in the 21st century, and continue to be a mechanism for workplace discrimination in the U.S. See http://www.ebony.com/style/fighting-for-our-hair-in-corporate-america-032#axzz4DwBp138v

[38] CCSS-M standard CONTENT.HSS.ID.A.1 See http://www.corestandards.org/Math/Content/HSS/ID/

[39] A teacher may have relied upon this article, as a discussion starter or to gather data for students to analyze: http://qz.com/556988/here-are-four-charts-on-race-and-murder-in-america-to-tweet-back-at-

This reconceptualization of critical thinking required teachers to think outside of the traditional STEM curriculum and move beyond traditional meanings of rigor (i.e., the level of task difficulty or the cognitive demand for students engaging in a particular task). Indeed, instruction that supported students' development of critical thinking was a difficult task for many teachers (Fieldnotes, April 12th and July 8th, 2015), and teachers' orientation to equitable STEM instruction was important for achieving this goal. Walter's response to the prompt exemplified how the teaching philosophy statement was an artifact that was useful for supporting his and other teachers' shifts in their perspectives and teaching practices:

> The balance of my focus on STEM application is more towards canonical examples than those explicitly relevant to marginalized students. … My balance of rigor may prepare students better for the examples and paradigms they will see in college, but a critical lens is also necessary to change the canon to reflect these students' lived experiences.

This statement demonstrated Walter's recognition that he tended to draw upon calculus examples from the traditional canon rather than those that were relevant to students' lives. In turn, he was more conscientious about making explicit connections between calculus concepts and skills, students' lives, and sociopolitical issues important to them and their communities. In his final reflection statement, Walter specifically mentioned that he had made progress toward this goal during the summer session. Based on his final reflection statement (July 27, 2015) and lesson plans (July 7th, 9th, and 14th, 2015), Walter addressed this in his course by having students engage in tasks where they investigated data and analyzed graphs. To make this content more rigorous according to the SAUSES guidelines for pedagogy (i.e., the ABCs), Walter chose data sets and graphs related to sociopolitical issues. These issues included gender inequities in computer science, racial disparities in the STEM fields, and disparities in access to sanitation services in developing countries. Students utilized and strengthened their developing graphing and analytical skills in the calculus course by finding trends in the data. Walter felt that "connecting calculus reasoning with trends and events in graphs helped students see the importance of calculus and connect it with issues that affect all of us." (Final Reflection Statement, July 27, 2015)

Ultimately the use of these cultural artifacts enabled teachers to develop new ways of thinking and engaging in their roles as teachers. However, as the data suggests, teachers can rely upon the artifacts to re-envision their views on equity-oriented STEM instruction and related teaching practices, but must still grapple with these ideas internally in order to actually shift their thinking and practices (Johnson & Golombek, 2003).

Developing and maintaining relationships. The third trend revealed in the data was the development and maintenance of relationships with others—both with students and with colleagues. Teachers developed relationships with their students by having informal conversations with them both in and out of their classroom spaces. Recall that

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donald-trump/. Police shootings were a topic SAUSES students expressed interested in during Summer 2015, particularly the developments in the Tamir Rice case during the summer session. See http://www.cnn.com/2015/06/11/us/tamir-rice-judge-recommendation/

in the methods chapter, I shared that teachers and students often walked together to and from classes, the dining hall at the dorm for lunch, and other daily events. This was one way that teachers developed relationships with their students—by engaging in informal conversations with students to share personal stories about their lives, both inside and outside of SAUSES.

Teachers also formed relationships with each other during their tenure as SAUSES teachers. The idea of collegiality—working together with colleagues toward a common goal—was an idea that resonated with case study teachers. In particular, the collegial relationship formed between Anthony and Jazymn was important for shifting teachers' mindsets about equity-oriented instruction. Jazymn and Anthony co-taught the engineering course together for six hours each week, and planned together for the course during their non-contracted time. Jazymn also reflected upon her collegial experiences during the interview:

> SAUSES is very community-based and so it was like everyone who worked with the SAUSES program had a similar goal and were very passionate about what they were going into and kind of just ready to have this revolutionary, let's change how science was taught vibe to it…

In this quote, Jazymn implicitly discussed how she felt other teachers wanted to shift their teaching practices to align with SAUSES' broader goals of implementing equitable teaching practices. Having similar professional goals encouraged teachers to foster collegial relationships in order to support each other to meet those goals. As Jazmyn also pointed out in the interview, there were "multiple goals" for teachers to reach (Follow-up interview, March 31, 2016). Among these goals were for teachers to not only develop students' conceptual understandings of STEM content, but to also strengthen their equitable teaching practices, which required a shift in their thinking. This was supported through the development of a collegial relationship with Anthony and others (Kelly, 1999; Oakes, Welner, Yonezawa, & Allen, 2005), which also prompted some teachers, like Jazmyn, to reflect further on their teaching practices. Research suggests that teacher reflection is important for teacher growth and learning (Achinstein & Athanases, 2005; Bennett, 2012; Harford & Mac Ruairic, 2008), especially as they endeavor to engage in equity-oriented STEM teaching and learning (Rousseau & Tate, 2003).

Discussion

I began this chapter by sharing Jazmyn's ideas about how there are multiple goals to equity-oriented STEM teaching, and indeed, teaching with equity in mind to promote the success of all students is a complex, multifaceted, and important endeavor (Bennett, 2012; Riegle-Crumb, Moore, & Ramos-Wada, 2011). Implementing equity-oriented instruction does not happen organically (Oakes et al., 2005) and must be a deeply embedded and intentional goal of professional development, teacher education, or school change efforts (Achinstein & Athanases, 2005). In so doing, the success of all students—particularly for students from nondominant communities—is brought to the fore of our goals for education. Critical perspectives on STEM teaching and learning highlight why the equity agenda is especially important for the success of students from nondominant communities. Equity-focused teachers who are not only knowledgeable of sociocultural influences on student learning, such as race, ethnicity, and/or socioeconomic status—but are *also* equipped to engage students in rigorous, inquiry-based learning—are critical for transforming STEM learning settings (K. Gutiérrez & Calabrese Barton, 2015; Johnson, 2011; Sheth & Braaten, 2013).

The findings presented in this chapter based on SASUES East Bay case study teachers contribute to the field's understanding of equity-oriented STEM instruction. I do not argue that the findings from this dissertation study are generalizable to all teachers working in informal STEM learning environments. The research findings do, however, contribute to the research literature that documents teachers' perspectives on equity-oriented STEM instruction. One of the research findings suggests that the case study teachers held two main perspectives teachers on equitable STEM teaching and learning: *equity is equality* and *empowering students for success*. Researchers suggest it is important to develop teachers' mindsets about equity-oriented pedagogies and that this process takes time (Achinstein & Athanases, 2005; Ladson-Billings, 2006b; Mensah, 2013, 2016). Discussing issues of race, racism, and other –isms in our society are important experiences for teachers if they are to work with students from nondominant communities in our increasingly racially, ethnically, and linguistically diverse society (Bennett, 2012; Castro, 2010; Lazar, 2007; Mensah, 2016). Understanding how –isms and other structural inequities affect learning opportunities for students from nondominant communities is an important goal for all teachers (Carter, 2013; K. Gutiérrez & Calabrese Barton, 2015; Ladson-Billings, 2006a, 2009; Nasir, 2012; Nasir, Snyder, Shah, & ross, 2012; Noguera & Wing, 2006; Rousseau & Tate, 2003), especially for those who endeavor to implement equity pedagogies. In so doing, teachers become more aware of the sociopolitical and sociocultural realities of students from nondominant communities that influence student learning (Gutstein, 2006; D. Martin, 2013; Nasir, 2012; Rahm & Moore, 2016; A. Rodriguez, 2015; Rosebery et al., 2015; Tan & Calabrese Barton, 2012), and can work towards providing equitable and rigorous learning opportunities for these students.

Shifting teachers' mindsets is an important, "multidimensional, and complex" task for teacher educators, mentor teachers, and professional development facilitators (Bennett, 2012, p. 408). Prior research findings posit that teachers become increasingly equity-minded via critical dialogue, critical reflection, reflective journals, collaboration, and positive teaching experiences with students from nondominant communities

(Bennett, 2012; Kelly, 1999; Rousseau & Tate, 2003;). In this study, many of the case study teachers were supported to shift their perspectives on equity-oriented STEM instruction through the use of cultural artifacts, reflection, and collegial relationships. These results build upon and extend previous research findings about how to support equity-minded teacher learning. Much of the equity-oriented research literature points to the importance of teacher reflection as a key component of shifting teachers' mindsets and practices (Achinstein & Athanases, 2005; Bennett, 2012; Howard & Aleman, 2008; Kelly, 1999; Mavhunga, 2016; Mensah, 2016; Merryfield, 2000; Nasir et al., 2014; Rousseau & Tate, 2003). This case study revealed that the use of cultural artifacts, specifically documents that aligned with the organization's ideas about equity-oriented pedagogies (e.g., SAUSES ABCs), was particularly helpful for developing equity-minded teachers in this study. Future research in this area will provide better understandings about how drawing upon both cultural artifacts and reflection can support shifts in teachers' mindsets.

In addition to supporting shifts in teachers' mindsets, it is also important to equip teachers to engage in equity pedagogies. Teacher educators, mentors, and professional development facilitators must be able to draw upon a repertoire of equity-oriented instructional strategies to support students from nondominant communities that are based in both research and experiential knowledge (Achinstein & Athanases, 2005). In so doing, they can model for teachers how to implement these strategies *and* provide targeted feedback about to strengthen teaching practices. Ultimately, this can not only support shifts in teachers' mindsets, but also strengthen their equity-focused instructional practices. Numerous scholars assert that promoting equity in STEM teaching and learning is important for the success of students from nondominant students (C. Morrell & Parker, 2013; Nasir et al., 2012; Nasir et al., 2014; Riegle-Crumb, et al., 2011; Rousseau & Tate, 2003; Wright, 2011). In the following chapter, I describe how two focal teachers—Anthony and Jazmyn—endeavored to implement equity-oriented STEM instruction. Both of these focal teachers evidenced the empowering students for success perspective by the end of the summer session, and in the next findings chapter, I highlight their teaching practices.

Chapter 4: What Would Be Different? Utilizing Equitable Teaching Practices to Strengthen Student Outcomes

> I began each class with a "current issue," usually something related to race, gender, or some other social [justice] matter. These were often in the form of videos. For example, one video was "A Day in the Life of a Software Engineer[40]." It turns out, the person in the video was a female. My students said they didn't expect this. However, she was also an Asian female, and it was interesting that she didn't mention what being Asian was like in her field. She only talked about what it was like being female. I asked students if they had any ideas about why she didn't emphasize being "Asian and female." Through our discussion, we came to the conclusion that she isn't necessarily a minority as an Asian in her field, so perhaps this part of her identity isn't as pronounced. *I asked them to think about what would be different if they, being Black and Latino, male or female, were in her situation.* (emphasis added, Anthony, Final Reflection Statement, July 27, 2015)

Anthony, a Black male computer science teacher for SAUSES East Bay, reflected on one of his teaching practices—beginning his class session with a discussion about an issue related to –isms (e.g., racism, sexism, etc.) and/or structural inequities in our society. In this instance, Anthony engaged students in a discussion about what it would be like for students to be an engineer as a Black or Latin@ individual, and how that would differ from other people of color in the STEM fields. In his classroom, it was commonplace for students to engage in these discussions and other types of activities where they made connections to inequities and course content. This quote not only illustrates the importance that Anthony placed on connecting social justice issues to course content and having these discussions in his computer science course, but also demonstrates his explicit attention to how students' multiple identities will influence their experiences as future STEM professionals.

With this teaching practice, Anthony encouraged his students to envision what would be different about their lives as students from nondominant communities[41] engaging in the STEM fields. By enacting this type of pedagogy, he embodied the *empowering students for success* mindset towards equitable STEM instruction, and in this chapter I explore how teachers' mindsets about equitable instruction influenced their teaching practices. In this findings chapter, I examine the teaching practices of two focal teachers—Anthony and Jazmyn—at the SAUSES East Bay site. Specifically, I discuss the three dimensions of the focal teachers' equitable teaching practices: 1) utilized culturally relevant instructional practices; 2) developed and maintained relationships with students; and 3) emphasized diverse perspectives and participation in the STEM fields. The chapter concludes with a discussion of the implications of these findings for equity-oriented teaching in STEM classrooms.

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[40] Available at https://www.youtube.com/watch?v=vt79JcPfZQA

[41] This term, *students from nondominant communities*, is chosen because it implies the power dynamic inherent in race and ethnicity within the United States. Terms, such as minorities or students of color, ignore these important and influential power relationships (K. Gutiérrez & Rogoff, 2003).

Theoretical Framework

As equity-minded teachers better understand their students' strengths, resources, and varied racialized, ethnic, and linguistic identities, teachers can make connections between this knowledge and their own repertoires of teaching practices to meet the needs of their diverse students (A. Ball, 2016). Ultimately, with a mindset for equitable instruction, teachers can become better equipped to implement equity-oriented teaching practices and decrease the opportunity gap for students from nondominant communities. The burgeoning body of scholarship on equity pedagogies, such as CRP or CP, in STEM learning environments has primarily focused on research in mathematics and science learning. The research literature suggests that strategies like CRP can benefit students by developing their self- confidence, affinity, and awareness of their contributions to and capacity to engage in science learning and practices (Goldston & Nichols, 2009; Milner, 2011; Patchen & Cox-Petersen, 2008; Tsurusaki et al., 2013). Other scholars posit that equity-oriented STEM teaching and learning across formal and informal learning settings can have a positive influence on student engagement, support students' STEM identity development, and recognizes students' sense-making and varied ways of knowing across STEM content areas (Bang & Marin, 2015; Bang & Medin, 2010; Bricker & Bell, 2014; Nasir et al., 2014; Rahm & Moore, 2016; Rosebery et al., 2015; Tsurusaki et al., 2013; Vakil, 2014; Wright, 2011). Equity-focused teachers link STEM content to students' lived experiences and funds of knowledge (Bang & Marin, 2015; Bang & Medin, 2010; Emdin, 2010, 2011; Tsurusaki et al., 2013); address issues of race and acknowledge students' multiple identities (Emdin, 2010, 2011; Hargrave, 2015; Nasir et al., 2012; Nasir et al., 2014); engage students in project-based learning that is culturally relevant (Young, Young, & Hamilton, 2013); and build and support authentic and meaningful relationships with students (Johnson, 2011; Milner, 2011; Nasir et al., 2014; Vakil, 2014). In so doing, teachers can increase student achievement in mathematics (Hubert, 2013) and science (J. Rodriguez, Bustamante Jones, Peng, & Park, 2004); increase students' engagement and interest levels in STEM courses (Ensign, 2003; Tate, 1995); and support students' academic identity development (Nasir, 2012; Nasir et al., 2014). This growing body of literature examines the use of equity pedagogies in STEM learning environments, but as researchers point out, the field needs more research that documents how teachers can learn to use equity pedagogies in their classrooms (Dimick, 2016; Sleeter 2011, 2012).

The findings from this chapter are based upon qualitative and quantitative data sources collected in the focal teachers' classrooms across the five week summer session and from the focal cohort of students at the SAUSES East Bay site. This chapter focuses on a *case within* the case study (Paterson, 2010; Yin, 2003, 2014), which is an "in-depth exploration of a single case" within a broader case study (Paterson, 2010, p. 971), to demonstrate the complexities of equity-oriented instruction and to provide an in-depth description and understanding of the focal teachers equitable STEM instructional practices. This allowed me to determine the three dimensions of their teaching practices in order to build upon the field's understanding of how teachers implement equity-oriented instruction. In so doing, this study contributes to the field's understanding of how teachers implement equitable STEM teaching practices and the varied roles teachers take up as they endeavor to teach with equity in mind. In this chapter, I present findings that answer the following research question:

> **Teaching Practices:** As SAUSES teachers aim for equity-oriented STEM instruction, in what ways are their perspectives on equity implemented in their teaching practices? What successes, tensions, and challenges do teachers experience?

Findings

I argue that the focal teachers' equity-oriented STEM instruction can be characterized by three main dimensions: 1) utilized culturally relevant instructional strategies; 2) developed and maintained relationships with students; and 3) emphasized diverse perspectives and participation in the STEM fields. Based on excerpts from classroom observations, the student focus group interview, and students' evaluations of the focal teachers surveys, I present and analyze instructional examples from each dimension of the focal teachers' equitable and rigorous instruction.

Equitable STEM instruction

The two focal teachers, Anthony (computer science) and Jazymn (chemistry), demonstrated equitable and rigorous STEM instruction. Based on the iterative coding procedures used to analyze the data sources, there were three dimensions of the focal teachers' implementation of equity-oriented STEM instruction, including:

1) Utilized culturally relevant instructional strategies
2) Developed and maintained relationships with students
3) Emphasized diverse perspectives and participation in the STEM fields.

Instructional examples across each of the three dimensions are outlined in Table 20, and are highlighted in the following sections.

Table 20
Dimensions of Focal Teachers' Equitable STEM Instructional Practices

Dimension	Instructional Examples
Utilized Culturally Relevant Instructional Strategies	• Used clear participation protocols and classroom management strategies (e.g., call and response, popcorn, etc.) • Development of students' sociopolitical consciousness • Explicit high expectations for students • Used humor related to students' cultural referents
Developed and Maintained Relationships with Students	• Shared stories about his/her pursuit of becoming a STEM professional • Shared stories about his/her personal life • Knowledgeable of students' personal interests and activities • Sought and utilized formative feedback about classroom instruction from students • Spent time with students outside of classroom (e.g., eating meals with students, walking with them to/from class, etc.) • Relatable • Provided one-on-one assistance to students outside of classroom • Used humor
Emphasized Diverse Perspectives and Participation in the STEM Fields	• Engaged students in discussions about how and why diverse perspectives matter in the STEM fields • Provided students with opportunities to learn about a variety of careers in the STEM fields • Made connections between students' personal interests and/or lived experiences to course content

Utilized culturally relevant instructional strategies. The first dimension of the focal teachers' equitable and rigorous instruction is utilized culturally relevant strategies, which draws upon Ladson-Billings' (1995, 2006b) seminal work on culturally relevant pedagogy (CRP). Teachers with a CRP mindset engage student in learning that is guided by three tenets: 1) set high expectations for student success; 2) develop cultural competence (utilizing students' cultures and teaching them about the dominant culture); and 3) develop students' sociopolitical consciousness. The two focal teachers, Anthony and Jazmyn, employed several strategies that can be characterized as culturally relevant, and those are summarized in Table 20. In this section, I focus on two of the four practices listed in Table 20: participation protocols and development of students' sociopolitical consciousness.

Participation protocols and classroom management strategies. One way the focal teachers demonstrated culturally relevant classroom management strategies was through the use of participation protocols, which are explicit directions for how a teacher expects students to respond during whole or small group interactions (LAUSD Protocols Website, ND). For example, each time that Anthony was observed (N = 8), he utilized a *call and response* to gather students' attention. A call and response is a signal to students that the teacher needs their attention (i.e., an attention-getter) while they are engaged in learning activities, and requires participation from both the teacher and students (Hollie, 2015). A call and response can be used to transition between parts of an activity, end an activity or class session, and/or give new or clarify previously given directions (Hollie, 2015). For example, while students are working in pairs on an assignment, a teacher may call out, "Peace," and students respond with, "Quiet." The teacher can repeat, "Peace," until s/he has the attention of all students.

In this first excerpt, Anthony used song lyrics from a popular hip-hop artist, Juvenile[42], for the class session's call and response:

> Anthony: So the callout for today is—How many of y'all know Juvenile?
> Students (In Unison): Yeah…oh yeah, I know him. [Some students start mumbling song lyrics.]
> Anthony: So this is the callout, [dancing as he demonstrates the call and response] 'Whatchu doin' huhhhh?'
> [Laughter from students.]
> Anthony: And the response is simply, 'Ahhhhhhh!'
> [Anthony leads the students in rehearsing the call out.]
> (Transcription of video recording of Anthony's 2nd period computer science class, June 29, 2015)

As students worked individually or in pairs throughout this class period, Anthony used this attention-getter. The majority of students responded immediately and looked up to find where Anthony was located in the classroom each time he called out, "Whatchu doin' huhhhh?" (Fieldnotes, June 29, 2015). By using a call and response to get students' attention, Anthony was able to increase students' engagement levels during their work time and decrease classroom management issues since students were aware of the expectation prior to its use and were taught how to use the call and response (Hollie, 2015; Muhammad & Hollie, 2012). Furthermore, research suggests that utilizing this strategy can foster a positive learning environment, and promote the success of students from nondominant communities (Muhammad & Hollie, 2012).

During another observation, Anthony first shared the agenda for the class session, and then introduced the call out of the day. He explained to his class that the students in his first class period designed the call and response, which was connected to course content:

> **Anthony:** Alright, we'll have two different call outs. You guys can have your own call out.
> Male Student: What was theirs [in the first period class]?
> **Anthony:** Theirs was " Down with O-O-P!"
> Female Student: Ooh, I like that!
> **Anthony:** Yeah, O-O-P. What does O-O-P stand for?
> Female Student 1: Something, something programming.
> Female Student 2: Object oriented programming.
> **Anthony:** Say it again.
> Female Student: Object-oriented programming.
> **Anthony:** Yes!

[42] Juvenile was a popular hip-hop artist in the early 2000s. See http://www.imdb.com/name/nm1175788/bio for more information.

Female Student: Boom! That was cute though.
Anthony: Can we do that today?
Students (In Unison): Yeah!
Anthony: I promise, I promise we will get yours. But we just finished object oriented programming, so it makes sense.
Female Student 1: That's so cute though.
Anthony: The call out is, 'Down with O-O-P.' Y'all gotta say, 'Yeah, you know me…' Y'all know that. You down with O-O-P?
Students (In Unison): Yeah, you know me.
Anthony: You down with O-O-P?
Students (In Unison): Yeah you know me!
(Transcription of video recording of Anthony's 2nd period computer science course, July 8, 2015)

Here, students in his second period class decided to use the call and response designed by their peers in the first class session. Students in the first period class had made the connection between object-oriented programming (OOP) to another famous, classic hip-hop song entitled, *O.P.P.*, by Naughty by Nature[43]. After introducing the call and response of the day and teaching it to students in his second period class, Anthony also used part of this interaction to pose a comprehension question to students. By asking students, "What does O-O-P stand for?" he checked for understanding of the computer science concepts students learned the prior day in an engaging format. With this practice, Anthony was not only able to draw upon students' cultural identities, but also their computer science knowledge, thus providing a connection for students to access course content.

One way this management strategy was culturally relevant was that it was based upon a familiar sociocultural communication pattern for some students from nondominant communities (Hefflin, 2002; Ladson-Billings, 1995). This is particularly true for some Black students, as the call and response has been used traditionally in African American churches and literature (Smith, 1995), and is a "cultural norm for many cultures with deep relevance" (Hollie, 2015, p. 27). In the first excerpt, students responded to Anthony by laughing and starting to sing the lyrics to songs by Juvenile, signaling that the artist and his songs were cultural referents they understood. Students in the first period class connected course content to a classic hip-hop song when they were given the opportunity to create their own call and response. Thus, the use of these call and responses were also culturally relevant for students in the class who identified with hip-hop culture (Emdin, 2010). Anthony's use of call and response —including teaching it to all students at the start of the class, setting the expectation for how students were to respond when he needed their attention, and the consistent use of the call and response across the class period—evidenced an equitable learning environment. Furthermore, this method of engagement created a communal learning environment where students understood and recognized their roles in the classroom.

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[43] The song, *O.P.P.*, was made famous in 1991 by the hip-hop group, Naughty by Nature and quickly became one of Billboard's Top 10 songs. See http://www.spin.com/2011/12/naughty-nature-look-back-20-years-opp/ for more information.

Development of students' sociopolitical consciousness. Another way that the focal teachers demonstrated culturally relevant instructional strategies was through the development of students' sociopolitical consciousness. This required focal teachers to facilitate student understanding of sociopolitical issues in our society, develop students' critical thinking skills, and engage students in critical analyses of course content and the STEM fields (Ladson-Billings, 1995, 2006b). Both Jazymn and Anthony engaged students in discussions that fostered students' sociopolitical consciousness. For example, in her chemistry class, Jazmyn had students discuss issues such as disparities in the number of scientists from nondominant communities in the United States, particularly in the Bay Area; incidence rates for Type 2 Diabetes and healthcare options for communities of color; and how low-income communities are affected by chemical waste disposal (Chemistry Lesson Plans, June 25/July 1/July 6/July 22, 2015). Anthony engaged students in discussions about disparities between the number of computer science professionals from nondominant communities and Asian and white backgrounds; experiences of computer science professionals, including encounters with racism; and other –isms that individuals may encounter in the field (Classroom Observations June 29/July 8, 2015; Final Reflection, July 27, 2015).

In their focus group interview, a few students reflected on these classroom conversations. When asked what stood out about their computer science course, one female student responded,

> Being able to discuss topics in social justice with our [computer science] teacher, and it's not like we're just sitting there and learning about topics. I like being able to have a class discussion with him about what's going on in the world.

Later in the interview, another female student remarked how Anthony connected computer science content to social justice issues:

> Female Student: Overall the teachers were teaching us the power of computer science but they were also teaching us how to use that power responsibly.
>
> Facilitator: Can you say more about that?
>
> Female Student: So with computer science you can basically do anything with anything that runs on technology. So you can operate streetlights, computers, projectors, cell phones, anything. But then with that, *there has to be the responsibility within us to not abuse that and use it for malicious purposes in order to affect others*. So we need to learn from early on that this can help people who may not have as much experience with it. That as soon as they learn to do something, they'll try to use it even if it's not necessarily for the good of other people. [emphasis added]

Students' feelings about discussing social justice issues in the chemistry and computer science courses were also reiterated in their evaluations of the focal teachers. One student even remarked that Anthony "talks a lot about social justice and opens my mind to things I didn't think about." Taken together, these excerpts suggest that students not only appreciated having these conversations about social justice issues in their computer science and chemistry courses, but were also exposed to new ideas, inequities within our society, and closely examined the experiences of STEM professionals. These techniques fostered a level of engagement in the content in helping students recognize how the content extending beyond the classroom. By discussing social justice issues related to course content, the focal teachers allowed students to examine issues that they will face as future STEM professionals, made learning more relevant to students' lives (Gay & Kirkland, 2003), and empowered them to better understand the sociopolitical factors and racist structures in our society that affect their communities (Diemer & Li, 2011; Watts, Williams, & Jagers, 2003). In so doing, the focal teachers were able to further develop students' sociopolitical consciousness—a culturally relevant instructional practice—which can not only support students' academic growth (Gay, 2010; Gay & Kirkland, 2003; Ladson-Billings, 2006b), but can also support their civic, social action, and political engagement (Diemer & Li, 2011; Watts et al., 2003).

Developed and maintained relationships with students. Having positive teacher-student relationships was the third dimension of the focal teachers' equitable and rigorous instruction. One way this was demonstrated by both focal teachers was by each teacher sharing personal stories with their students. For example, as students filed into the classroom at the start of a class session, Anthony shared how he played football in high school. In this brief interaction, he shared part of his identity as a student athlete, which was intriguing to many of his students and helped them to better understand the sport of football (Fieldnotes, Classroom Observation of Anthony's Second Period Class, July 2, 2015). In another observation, Anthony retold the story of the experience he and his wife[44] had with an officer at the United States Citizenship and Immigration Services. He recounted details with his students about the interview process to obtain his wife's green card that had occurred the previous day:

> **Anthony**: Whenever we had interviews he was just like—
> Female Student 1: —Who's the president? [jokingly]
> [Students laugh in unison.]
> **Anthony**: No, he didn't say that. He said, 'So how'd you guys meet?' The only tricky questions he asked that were like— [Students start to murmur.]
> Female Student 1: —Guys! Shhhh!! What was the question?
> **Anthony**: What is her father's name? What is her mother's name?
> Female Student 1: Did you know it?
> **Anthony**: I just happened to know it. What if it was in a language I couldn't even pronounce?
> Female Student 2: Yeah, see? You'd be caught up.
> **Anthony**: Yeah. The thing is I don't think he [the officer] even knew how to speak Chinese. Like he didn't even—
> Female Student 1: —Yeah he could've just been like—

[44] Anthony and his wife were married in December 2014, and had to undergo an interview process in early July 2015 in order for his wife to obtain her green card from the U.S. Citizenship and Immigration Services Office.

Anthony: —Because he was reading like the Pinyin[45], like the English version, so even then, it's not like the average person knows that the "c" sounds like "tz."
Male Student 1: Are you fluent in Chinese?
Anthony: Who me? Nah.
Female Student 1: You speak Chinese?
Anthony: A little bit. I can have little conversations.
Female Student 1: Can you count to ten?
Anthony: That's easy. But anyway, what I'm trying to say is those were the tricky questions. He asked birthday ones. That's not technically tricky, but she has two birthdays.
Female Student 1: Ooh, so does my friend. She's [East] Asian, too, and I don't get why that is.
Female Student 2: Because their year is different.
Anthony: See the thing is, they have their own calendar. So her actual birthday on our calendar, the day she was born, was December 12, 1984.
Female Student 1: Whoa, that's young!
Anthony: But according to…'84.
Female Student 2: That's like 29.
Anthony: Well, thank y'all. I'm the same age as her, she's 30.
Female Student 1: That's my age. I'm just playing.
Anthony: I'm 30, so we're the same age. But her other birthday is January 16, 1985. So when he asked me that, I was like which one? And I was like oh, the one I wrote on the thing. And he looked at me and he was like [Anthony makes a scowling face]. I was like oh crap!
[Students laugh in unison.]
(Transcription of Classroom Observation of Anthony's Second Period Class, July 8, 2015)

In this excerpt that occurred over several minutes of class time, Anthony shared a very personal story with his students. Anthony shared what he was nervous about during the interview, his knowledge of the Mandarin language, and ultimately allowed his students to access intimate details of his personal life that many teachers may not have felt comfortable sharing with their high school students. In so doing, he continued to build positive teacher-student relationships, deeply connect with his students, and foster a familial classroom environment. Furthermore, by sharing his personal story of the process of obtaining a visa for his wife, he also made a connection to a sociopolitical issue—immigration status—which some of his students related to based on their personal and familial experiences (Fieldnotes, July 8, 2015).

Reflecting on their relationship with Anthony, students shared the following in the focus group interview:

Female Student 1: Everybody has that one teacher that they love and they know for a fact cares about us. I know a lot of the teachers here [at SAUSES] do.

[45] Hanyu Pinyin is the Romanization of Mandarin Chinese so that Chinese words and names can be written in languages that are based on the Latin alphabet. See http://www.pinyin.info/index.html

> Facilitator: And how does that feel as compared to… do you have teachers at your school where that's the case or do you not. What's the difference—
> **Female Student 1:** —You can tell the difference.
> Female Student 2: At my school I don't have a lot of teachers that I like, you know, connect with on a personal level.
> **Female Student 1:** Because Anthony is similar, he understands what we go through and he sees himself in us, and I feel like not many teachers at my school can really have that same feeling.
> Female Student 2: They're just there to give you the information and say fine. There's no personal life.
> **Female Student 1:** *He shares his personal life*. He shares information about him, and we share information about us. *It kind of creates a bond and family environment*. [emphasis added]
> Students in Unison: Yeah!

This excerpt demonstrates the positive teacher-student relationships between Anthony and his students. Students described how they had a close, familial-like relationship with Anthony; this is similar to what researchers have termed as fictive kinship, a common phenomenon for some nondominant communities (see Ebaugh & Curry, 2000; Kim, 2009; or Stack, 1974 for studies of fictive kinship in nondominant communities). As students pointed out, because Anthony shared so much of his personal life, they felt safe sharing their personal lives with him; ultimately, having such a safe academic space served as an academic support and relational resource for some of the focal students (Salerno & Reynolds, 2016). Furthermore, researchers posit that having positive student-teacher relationships can support students' academic identity development, academic achievement, and interest in STEM course content (Johnson, 2011; Milner, 2011; Nasir, 2012; Nasir et al., 2014; J. Rodriguez et al., 2004).

Emphasized diverse perspectives and participation in the STEM fields. The fourth dimension of the focal teachers' equitable instruction was their emphasis on diverse perspectives and participation in the STEM fields. One of the main ways this was exemplified was through classroom discussions, which often focused on race, racism, or structural inequities in our society as related to the STEM fields. For example, it was commonplace for Anthony to engage his students in discussions around racism within the STEM fields and our society at the start of each class session. In the vignette below, I highlight one particular discussion that was particularly engaging and emotional for students; in the vignette, Anthony and his students discussed how racism played out in a successful attempt to geo-tag a prominent location on Google Maps (Fieldnotes, June 29, 2015).

> Anthony begins the class session by reviewing the call and response for the day and then shared the schedule for today's class session, which included a discussion based on a video, reviewing homework and binary numbers, and learning more about hexadecimals. He and I also reiterate that donors for the program will be visiting their classroom today, and students get excited about this. Anthony then tells the students that they will watch a video about racism on

Google Maps[46]. In response, students yell out comments, such as, "Whaaaaat?!?!," "I didn't know that!," and "That's crazy!" Others are murmuring to each other as Anthony explains that the incident occurred earlier in the year—he thinks that it happened sometime late in the spring of the year—and expresses his disbelief and anger about the incident.

Anthony begins the video clip, which describes how an individual geo-tagged the White House on Google Maps with the n-word, resulting in the White House being geo-tagged as the ni**#@ House. After viewing the video clip, Anthony shares his thoughts with students. He says, "So I don't know about you guys, but every time I see something like that...I mean, you know, it kinda hurts, but at the same time I just wonder…I guess I'm just kinda curious why people are not afraid to say [trails off and shakes his head in amazement]…" He takes a moment to refocus students' attention to the comments section of the video. The students notice the Confederate flag as a screen picture of one of the commenters, and are visibly disappointed and begin murmuring again.

Anthony then asks students, "Do you think Google can stop people from being racist?" Almost immediately, all of the students answer, "No!" He then poses a problem-posing question to his students: "What should Google do to solve this kind of problem?" Students take a moment to think, and seem to be interested in the topic based on their murmuring and attention given to the conversation; several still seem to be shocked and in disbelief about the content of the video. One male student suggests, "It probably goes through a computer algorithm or something like that…" Some of the students nod in agreement and/or yell out, "Yeah…the algorithm."

In response, Anthony asks, "So if it once was an algorithm, it seemed that the algorithm would have a filter right?" The male student replies, "Maybe…but they probably put it in a context that didn't seem like that…it's kinda confusing." Anthony acknowledges how this may be confusing for students, and then asks, "If you were Google what would you do to address this kind of problem? What would you do?" He then models for students how he tried to geo-tag a place on campus using Google Maps, and another male student responds that this is impossible because Google has restricted it. Anthony counters this statement by saying that he had done it in his first period class, but that it hadn't shown up because "it has to go through a review process." He then asks, "So how the heck did *that* [n-word geo-tag] get past [the algorithm]? That stuff with the White House? And if you were Google, what would you do [long pause] to address it?"

This time, a female student responds with her idea, stating, "It's probably often based on how many submissions it gets so it was probably submitted a lot of

[46] The clip utilized for the class session is no longer available on YouTube, but similar videos about the incident are available at https://www.youtube.com/watch?v=cX0wQDmnUng, https://www.youtube.com/watch?v=bcqm5MLDPnU, or https://www.youtube.com/watch?v=-RM0DiGiwbQ

> times so then they thought 'Oh, a lot of people can verify that this is what it also goes by or that's what its called'…so maybe that happened?" Anthony replied, "That could have been what happened. I'll just let this simmer because we are going to talk about a lot of stuff like this in this class…about computer science culture and about how people use technology to further whatever cause, you know, trying to further [it]—be it good or bad." (Fieldnotes, June 29, 2015)

In this vignette, Anthony and his students engaged in a discussion about a very sensitive topic—the use of a racial slur to geo-tag the White House on Google Maps. Students were surprised by the severe nature of the racial slur and how it could have been used in conjunction with the White House, President Barack Obama, and the First Family. Throughout the vignette, Anthony expressed his emotions to students about this incident; he was especially vulnerable with students when he made the comment, "So I don't know about you guys, but every time I see something like that...I mean, you know, it kinda hurts." In so doing, he allowed his students to see how the incredibly racist incident affected him personally, such that he was angered, hurt, and in disbelief. His level of vulnerability and this discussion topic not only served as a way for Anthony to further build relationships with students (Milner, 2011), but also allowed him to acknowledge the ways in which racism affects their lived experiences (Milner, 2011), and can play out in unexpected ways in the STEM fields (Pinkerton, 2016). He also built upon students' prior knowledge of the use of algorithms in computer science, and was able to engage students in thinking about how algorithms sometimes fail, the need for human intervention, and how companies, like Google, deal with racist acts. Thus, Anthony emphasized to his students the need for diverse perspectives and participation in the STEM fields.

Having these discussions consistently across the summer session helped students to see how their perspectives on the STEM fields were important and how to make connections to social justice issues. This was exemplified in the focus group interview; take, for example, one female student's comment about Anthony's class. She remarked that in his class, students were not "just sitting there and learning about [computer science] topics." Instead, according to this female student, they made connections between course content and "what was going on in the world." Other students shared that in their computer science course with Anthony, they had discussed current events in the world, including the White House incident described above, as well as a Google photos incident that classified pictures of Black people as gorillas and disparities in the number of people from diverse backgrounds in the STEM fields. Students remarked that they enjoyed having these discussions, and also expressed how their coursework helped them to see the personal relevance of course content to their lives and connections to social justice issues and STEM content. This was exemplified in the following excerpt:

> Male Student 1: I interviewed Regina [a TA for the Year 1 engineering course] and she was talking about her experience at Cali South University[47] for science. Her science and math classes were really hard science but they didn't really connect with social justice. At my school I see the same thing, my science

[47] Cali South University is the pseudonym used for a large, public university that was also a SAUSES site in Southern California.

> teachers and math teachers they just teach. They don't really show emotions. …So I think instead of making STEM a hard science, it should be more social justice like how can you use STEM to better the world instead of just plugging in equations and figuring out the answer. …
>
> Female Student 1: That's the big thing, there's no wrong answer—
>
> Female Student 2: —He allows you to have imagination.
>
> Students in Unison: Yeah.
>
> Female Student 2: A lot of schools take away imagination and creativity; this gives it back by them not giving you the answer.

In this excerpt, students expressed how their SAUSES teachers allowed them to be creative about problem-solving and make connections to social justice issues in their courses, which were in stark contrast to their STEM coursework experiences during the academic year at the focal students' high schools. In so doing, the focal teachers allowed students to see the relevance of course content to their personal lives and express their creative solutions to solving problems in courses, which reiterated for students the importance of diverse perspectives and participation in the STEM fields.

Taken together, students' ideas expressed in these excerpts suggest that students felt their perspectives and creativity were valued in the academic spaces created by the focal teachers, and began to better understand how structural racism affects and is embedded within the STEM fields. The content of classroom discussions supported some students to become better equipped with the tools to process and make sense of the racism that they will undoubtedly encounter in the STEM fields, which is imperative for students from nondominant communities. Furthermore, these resources can serve as tools that the focal students can draw upon to persist as undergraduates and future professionals in the STEM fields. Ultimately, by emphasizing diverse perspectives and participation in the STEM fields, the focal teachers allowed students to see how and why their voices, perspectives on STEM content and innovations, and potential contributions to the STEM fields matter.

Discussion

In an eloquent piece about race, equity, and education in the Obama Era, Prudence Carter (2009) points out, "…we cannot fully rectify the systematic racial and ethnic inequalities affronting our nation and our schools without paying attention to *both* equity in resources and heightened consciousness and care for one another across myriad social lines." (p. 295). To make progress toward this goal, it is imperative that educators utilize equity-oriented pedagogies for the success of students from nondominant communities. Equity-minded teachers who are equipped to engage students from nondominant communities in equitable, rigorous, and inquiry-based learning are critical for providing transformative STEM learning experiences. Culturally relevant instruction, an equity-oriented pedagogy, can be a powerful tool for ameliorating these inequities for students from nondominant communities (Aronson & Laughter, 2016). As Sleeter (2012) points out, the field would benefit from more examples of what equity pedagogies look like in classrooms and the influences on student achievement, especially in STEM learning environments (Dimick, 2016) as well as how teachers learn to become culturally responsive (Jackson, 2015).

In this chapter, my aim was to examine the focal teachers' equity-oriented teaching practices. The findings from this chapter revealed the three dimensions of their equitable instruction, including utilized culturally relevant instruction, developed and maintained relationships with students, and emphasized diverse perspectives and participation in the STEM fields. I do not argue that these findings are generalizable; rather, the findings represent an important case (Yin, 2014) of the potential to create and foster equity-oriented STEM learning environments to diminish the opportunity gap for students from nondominant communities.

The three dimensions of the focal teachers' equitable instruction that were revealed through this study are similar to and build upon prior research findings about equity-oriented STEM instruction. For example, one way that Anthony emphasized diverse perspectives and participation in the STEM fields was by addressing issues of race and racism in his computer science course. This is similar to Milner's (2011) findings about a male middle school science teacher who facilitated discussions about race, racism, and other sensitive topics with his students. Engaging in these discussions can be difficult for teachers, and some teachers shy away from discussing issues of race due to students' ages (Young, 2010) or their own level of discomfort and/or a lack of awareness of these issues (Ladson-Billings, 2006b; Sleeter, 2011, 2012). There was evidence that Anthony, a Black male teacher who had previously taught for the SAUSES East Bay site, felt more comfortable engaging in these conversations than Jazmyn, a Latina teacher who was new to SAUSES East Bay. Anthony's prior teaching experiences at the site, and lived experiences as a Black man in America, likely supported his abilities and comfort level with these discussions. The differences between the two focal teachers reiterates that although teachers from nondominant communities bring with them their lived experiences and encounters with racism or other structural inequities (Foster, 1997; Irvine, 2003; Merryfield, 2000; Milner, 2006; Villegas & Lucas, 2004; Young, 2010), it does not make them inherently equipped to implement equity-oriented pedagogies (Achinstein & Aguirre, 2008; Jackson, 2015). Thus, this case represents one example of the multifaceted nature of utilizing equity-oriented teaching practices, and suggests that the field will benefit from more studies that document how teachers from nondominant communities develop and become adept at implementing equity pedagogies (Jackson, 2015; Sleeter, 2012).

Limitations

There were several limitations to these findings, including the small sample size of focal teachers and students for the case study. Although the findings revealed a case of how equity-minded teachers endeavored to engage in equity-oriented STEM instruction, they are not generalizable. This is because the findings are based on a case study with a small sample size, which is similar to other studies on culturally relevant instruction; having small sample sizes can not provide sufficient evidence to support the widespread use of equity pedagogies in classrooms (Sleeter, 2012). Another limitation was the short duration of classroom observations, which occurred over a five-week period; a potential solution would be to collect data across all of the SAUSES sites in California in order to strengthen both the research methodology and findings. In so doing, there would be more examples of the pedagogies of equity-minded teachers.

Chapter 5: "Remarkable!" How Equity-Oriented Instruction Can Shape Students' Identity Development

Anthony: Let's give her a 'Remarkable.'
Students [in unison]: Remarkable.
Kimberly [smiling]: Thank you.
—Excerpt from Anthony's Computer Science Second Period Class, June 29, 2015

In this excerpt, Anthony encourages his students to affirm Kimberly, a Black female student in his computers science course who has just successfully shared her strategy for solving a problem, with their typical affirmation: "Remarkable." Affirming the abilities and capacity of students from nondominant communities to engage in rigorous learning is one way that teachers can be explicit about their high expectations for students. Anthony and Jazmyn, the focal teachers of this study, each made affirming students a routine part of their classroom environments, and in so doing, evidenced the use of culturally relevant instructional strategies as discussed in the previous chapter.

In this chapter, I examine how the focal teachers' equity-oriented instruction shaped learning outcomes for their students. This chapter specifically discusses students' identity development, and first, I provide the theoretical framework guiding the analysis of the data sources and subsequent findings presented in this chapter. Then I discuss the findings about how certain academic and STEM identities were made available to students in the focal teachers' classrooms. Specifically, the three identities made available to students were: 1) *capable learners*; 2) *potential change agents*; and 3) *future STEM professionals*. I also discuss the three types of resources (Nasir, 2012; Nasir & Cooks, 2009) available to students to take up each of these identities and present the results of statistical analyses of survey items related to identity development. The chapter ends with a discussion of the findings.

Theoretical Framework

In the previous chapter, I examined two focal teachers' equitable teaching practices, and now turn to the learning outcomes as measured by the academic and STEM identities made available to their students in their learning environments. Numerous scholars have defined identity development as engagement or participation in an activity or practice (Holland, Lachiotte, Skinner, & Cain, 1998; Nasir, 2012; Nasir & Hand, 2008), noted the fluid and dynamic nature of identities (Esmonde, 2009; Hall, 1990, 1991; Nasir, 2012), and have examined the role of resources in identity processes (Collett, 2014; Nasir, 2012; Nasir & Cooks, 2009;). Identities are not innate characteristics of individuals, are shaped by the varied settings students are a part of (i.e., their families, schools, neighborhoods, places of worship, etc.), and can shift in their salience and meaning according to these settings (Esmonde, 2009; Hall, 1990, 1991; Nasir, 2012).

I draw upon the *practice-linked identity framework* (Nasir & Hand, 2006; Nasir & Hand, 2008; Nasir, Hand, & Taylor, 2008), which describes an individual's development of participation in a particular practice (e.g., activities that engage a group of participants). Practice-linked identity is the extent to which an individual takes up the practices of a field, such as math, track, or dance. In the context of science learning, for example, practice-linked identity refers to the ways in which students view themselves as science learners, take up the practices of science, and become more prominent members of the science classroom (Nasir & Cooks, 2009; Nasir & Hand, 2008; Varelas et al., 2012). This identity is negotiated by the social sphere (e.g., how others position the individual within a particular context) and individual agency (how the individual sees herself as part of the particular community) across learning contexts (Brickhouse, Lowery, & Schulz, 2000; Brickhouse & Potter, 2001; Holland et al., 1998; Nasir, 2012; Nasir & Cooks, 2009; Wenger, 1998). For example, others' positioning and the individual's ideas of herself play a role in how a student is recognized as a science learner or scientist engaging in the practices of science.

To shape students' practice-linked identities, there are three types of resources available in learning spaces (Nasir, 2012; Nasir & Hand, 2008; Nasir & Cooks, 2009). These three resources include material resources (physical artifacts like textbooks or curriculum materials or the physical space), relational resources (relationships with others), and ideational resources (ideas about what is valued about the practice, and the individual's relationship to the practice). In the learning environment, students have varied access to these three types of resources for identity development, and resources can serve as supports or constraints for students' identity development (Nasir, 2012). In this chapter, I examine the three academic and STEM identities made available to SAUSES focal students through the focal teachers' equitable STEM instruction, and the material, ideational, and relational resources that supported students' identity development. The findings presented in this chapter answer the following research question:

> **Student Outcomes:** How are learning opportunities and academic and STEM identities made available to SAUSES students through teachers' equity-oriented instruction?

Findings

STEM Identity Development

Based on their equitable STEM instruction, there were three identities available to students in the focal teachers' classrooms: 1) capable learners; 2) potential change agents; and 3) future STEM professionals. In the following sections, I report the material, ideational, and relational resources made available to students in the learning environments to take up these three identities (see Table 21). I also report findings from the statistical analyses of students' pre- and post-survey items related to each identity; an alpha level of 0.05 ($p < 0.05$) was used for all statistical tests performed to determine if gains in the focal students' identity development were significant from Summer 2014 to Summer 2015.

Table 21
Practice-Linked Identity Resources Available for SAUSES Students

Identities Available to Students	Material Resources Available to Students	Ideational Resource Available to Students	Relational Resource Available to Students
Capable Learners: Students are capable of and successful at engaging in STEM learning experiences	• Teachers provided students with opportunities for self-reflection *and* to provide feedback to teacher. • Teacher provided sign-posts about the importance of certain course content. • Teacher used analogies to make course content accessible.	• Teacher emphasized that learning occurs over time. • Students in the program are referred to as scholars rather than students. • Teachers affirmed students' abilities and positioned them as talented and capable.	• Teachers and students affirmed and encouraged each other. • Teachers shared personal stories of academic and personal struggles. • Teachers re-defined roles for students (e.g., student becomes teacher, tutor, etc.). • Teachers used humor to lower students' affective filters. • Students depended on each other as resources for learning.
Potential Change Agents: Students are empowered to use their STEM knowledge and skills to address and affect change in their communities	• Teachers and students shared ideas about racism in society and STEM professions during classroom discussions. • Teachers connected social justice issues to course concepts and assignments.	• Teachers and students shared ideas about racism in society and STEM professions during classroom discussions. • Teachers pointed out the importance of using STEM knowledge and skills in socially just and responsible ways. • Teachers connected social justice issues to course concepts and assignments.	• Teacher shared how they handled personal encounters with racism or discrimination with students.
Future STEM Professionals: Students will enter and remain in the STEM pipeline as undergraduates and professionals	• Teacher provided students with information about a variety of careers in the STEM fields. • Teachers and TA invited STEM professionals into the classroom to share their personal stories.	• Teachers affirmed that students are capable of having future careers in the STEM fields. • Teachers and students engaged in discussions about being STEM professionals, encounters with racism, Imposter Syndrome, etc.	• Teachers shared personal stories of pursuing professions in the STEM fields. • Teachers affirmed students' identities as future STEM professionals. • Teachers and TA invited STEM professionals into the classroom to share their personal stories.

Capable learners. One identity that was available to students was a *capable learners*. The capable learners identity was characterized by students who were able to successfully engage in STEM learning experiences. There were several material, ideational, and relational resources available to students to shape this identity, and I highlight three resources: an ideational resource, teachers' affirmations of students' abilities; and two relational resources, teachers redefining students roles and students' interdependence on each other for learning.

One ideational resource to support students' capable learners identity development was that focal teachers affirmed students' abilities within the classroom spaces. Anthony and Jazmyn implicitly and explicitly communicated their beliefs about students' abilities. For example, during one classroom observation, Anthony encouraged students to "contact each other before you contact me" when they had questions about assignments (Transcription of Classroom Observation of Anthony's Second Period Class, July 2, 2015). Rather than deferring to him as their instructor for assistance, he asserted that students could rely on each other to solve problems—an implicit affirmation of students' academic abilities. This also became a relational resource for students to draw upon for developing a capable learner identity. By affirming students' abilities in this way, Anthony also positioned students as capable of tutoring and/or teaching course content to each other.

The focal teachers also redefined students' roles in the classroom, which served as a relational resource for students' identity development. Teachers accomplished this by creating opportunities for students to shift from a learner role to a teacher or tutor role and provide explanations to the class. This was demonstrated in a classroom observation where Anthony reviewed a homework assignment with the class about hexadecimals[48], a way to represent large integers using a base-16 system (Fieldnotes, June 29, 2015). He asked Kimberly, a Black female student in the class, to explain to the class how to solve a homework problem:

> **Anthony:** Yeah, that person can be next. Since you said it, maybe you should do it—
> Female Student 1: —Hmmm….
> **Anthony:** You can do it.
> Female Student 1: No, I got that one wrong.
> Kimberly: I can do it! I'll take it.
> **Anthony:** Alright, here we go!
> Kimberly: So we have 4B…
> **Anthony:** So how do we make sure…If it's hex what do we do?
> Kimberly: Oh we write...I think it's 0 X maybe?
> **Anthony:** Yeah you can do that. Or you can write hashtag.
> Kimberly: Yeah. So then we have our exponents right here. We go 0 and then 1. [Turns to class.] You guys good?
> Students (in unison): Yeah.
> Kimberly: And then what did I do? So our base number is 16.
> **Anthony:** That's right.
> Kimberly: So we take 16 and our first exponent 0, and put it right here. And then we would multiply by B and B is 11.

[48] For more information on hexadecimals (hex), see https://sites.google.com/site/dtcsinformation/data-representation/number-systems/hexadecimal-numbers

> **Anthony [to class]:** Is that right?
> Students (in unison): Yeah.
> Kimberly: So B is 11. So 16 to the 0 power is equal to 1 and we multiply that by 11 and we get 11. [Turns to class.] You got it? Okay, so now we take 16 to the first power and multiply it by 4.
> **Anthony:** You should be a teacher.
> Kimberly [smiling]: I know.
> [Everyone laughs.]
> **Anthony [to Kimberly]:** You have this teacher presence.
> Kimberly: Now 16 to the first power is 16, and we would multiply that by 4 and then we get 64. And now we take these two numbers and add them and you get 75.
> [Students clap.]
> **Anthony:** Let's give her a 'Remarkable.'
> Students [in unison]: Remarkable.
> Kimberly [smiling]: Thank you.

In this exchange, Kimberly shared her problem-solving strategy and correctly demonstrated how to convert the number to a hexadecimal. Near the end of her explanation, Anthony affirmed her by stating, "You should be a teacher." In so doing, he explicitly affirmed Kimberly's ability to explain course content to her peers, and allowed her to take on the role of the teacher. Students were also included in this affirmation of Kimberly, and recited one of their class routines, which was to affirm a peer's academic progress by stating, "Remarkable." In this excerpt, Anthony made an explicit reference to his high expectations for students and their identities as capable learners, but also signaled to students that they were able to provide explanations of course content. He allowed Kimberly to shift to a role as a teacher in the classroom space, which not only affirmed her academic capabilities, but also reiterated the student-centered nature of Anthony's classroom (Jones, 2007), offered an opportunity for the teacher and students to co-construct knowledge (K. Gutiérrez & Rogoff, 2003; Rogoff, 2003; Vygotsky, 1978), and contributed to the academic success of other students in the classroom (Jones, 2007; Rousseau & Tate, 2003).

Students utilized this ideational resource as part of their capable learners identity development. In the focus group interview, some of the students expressed their feelings about how the focal teachers affirmed that they were talented learners:

> **Female Student 1**: I can't see it with the other teachers [at my school], but it's a two way street for respect. …
> Male Student 1: Yeah they [teachers] don't look down at us; they look equally at us if you know what I mean.
> **Female Student 1:** He [Anthony] believes in us and our work.
> Students in Unison: He does—he tells us that everyday.

In this exchange, one student points out that she does not feel as if other teachers at her school site during the academic year affirms her academic abilities, but is certain that Anthony "believes in us." These sentiments were also shown in students' evaluations of their focal teachers. For example, one student specifically mentioned that Jazmyn was "encouraging" about her academic abilities in chemistry, and another remarked that Anthony "told me that I am really good with computer science." These excerpts from the focus group interview and students' evaluations of focal teachers are instantiations of the focal teachers' high expectations of students' capabilities, and served as ideational resources for students' capable learners identity development.

A relational resource available for taking up the capable learners identity was students seeing each other as resources for learning. For example, in the focus group interview, when asked about how students work together in their computer science class, one student remarked, "We all challenge each other, help each other—it is part of being [in the] SAUSES community." In response, another student said, "Yeah, if a person gets stuck on one part, there is always someone who can help you." In this exchange, students' comments indicate that in their classroom and the broader SAUSES community of students, it was a norm that students supported the learning of others. This was reiterated later in the focus group interview; when asked about how students relate to each other, one student responded, "…we are here for each other, we can do this." One of the focal teachers, Jazmyn, also noted during the follow-up interview how this type of student-student relationship was demonstrated in her chemistry classroom. While reflecting on a classroom activity, Jazmyn stated, "…you could see that people had already been talking to each other about different things and their expertise…[and asking], 'I don't really know what this means, can you help me understand?'" Students in her classroom began to see each other as resources for learning, and depended on each other for their academic growth. Furthermore, this academic space not only created a space where students fostered and nurtured relationships with other students, but also had shared experiences as successful learners, accessed scientific ideas and understandings, and were positioned as STEM content experts—experiences that students from nondominant communities are not often given access to in academic spaces (Varenne & McDermott, 1998).

This type of student-student relationship served as a material resource available to students in the learning environments for developing the capable learners identity. To provide complementary support of this qualitative data, statistical analyses were performed to determine if these resources shaped students' development of the capable learners identity. Items related to the capable learners identity to compare gains from the pre- to the post-survey were selected, and are shown in Table 22. Wilcoxon Signed Rank Tests of students' responses on the pre- and post-survey were performed using the SPSS Statistics® program[49]. All of the capable learner items tested were found to be significant for the focal cohort, including *capable of doing well in science* ($Z = -2.121$, $p = 0.034$); *capable of learning computer science concepts* ($Z = -2.373$, $p = 0.018$); and *capable of doing well in computer science* ($Z = -2.496$, $p = 0.013$). These results suggest,

[49] Due to the small sample size of the focal cohort with complete pre- and post-survey data ($n = 21$), nonparametric tests (e.g.,) were conducted using This was in place of a paired sample t-test, which would have required a normally distributed sample. Due to the nature of the program (i.e., focus on high achieving students interested in the STEM fields), the variables would not be normally distributed (i.e., right-skewed distribution), thus requiring statistical analyses of nonparametric tests (IDRE website, 2016; LAERD Statistics website, 2013).

that for the focal cohort of students, students' capable learners identity development during Summer 2015 (i.e., from Summer 2014 to Summer 2015) was significant.

Table 22
Paired-Samples Wilcoxon Signed Rank Test Results, by Capable Learners Identity Item

Scale	*Z*	Significance (2-tailed)
I am capable of doing well in science.	-2.121	**0.034**
I am capable of learning computer science concepts.	-2.373	**0.018**
I am capable of doing well in computer science.	-2.496	**0.013**

Potential change agents. Another identity that was available to students in classrooms with focal teachers was being a *potential change agents* in their communities. As potential change agents, students were able to not only see the relevance of course content to their lives, but also use their STEM knowledge and skills to solve problems in their communities[50]. Of the varied material, ideational, and relational resources available to students to shape this identity development, I highlight one resource, using STEM knowledge and skills in socially just and responsible ways, an ideational resource.

Earlier in the chapter, I discussed the types of classroom discussions that students engaged in with their teachers; these discussions supported the development of students' sociopolitical consciousness. The focal teachers added to this development by also highlighting the importance of using STEM knowledge and skills in ways that promote social justice and responsibility. This idea was reflected during the focus group interview with students. One female student commented that she enjoyed the computer science class because they learned about:

> the power of computer science, but how to use it responsibility. You can do almost anything with computer science. There has to be a responsibility to learn that computer science can help people. We are learning that while we actually use computer science.

A male student chimed in, and added the following later in the interview:

> I interviewed Regina [a TA for the engineering course] and she was talking about her [undergraduate] experience at Cali South University for science. [She said] her science and math classes were really hard science but they don't really connect with social justice. At my school I see the same thing, my science teachers and math teachers, they just teach—they don't really show emotions. *…So I think instead of making STEM a hard science, it should be more social justice like how can you use STEM to better the world instead of just plugging in equations and figuring out the answer.* [emphasis added]

These quotes demonstrate the development of students' potential change agents identity and their reflections on how they viewed their roles as STEM learners. In the first quote,

[50] I intentionally use communities, rather than community, to reflect the varied communities students belong to, including their racial, ethnic, neighborhood, school and/or other communities.

the female student shared how she learned the importance of using computer science skills in a responsible way that can help others. In the male student's reflection, he expressed the understandings he had developed during the summer program, such that he could use the knowledge he gained across his STEM courses to solve issues related to social justice and "better the world." He pointed out that these ideas were not reflected in his science and math classes at his high school during the academic year, and implied that this was an idea explored in his SAUSES classes. His reflection suggests that he saw the personal relevance of STEM content to his life, and saw himself as a potential change agent in his communities. Each student's statement reflects their implicit and explicit developing ideas about how to use their STEM knowledge and skill sets to affect social change.

Tests (i.e., Wilcoxon Signed Rank Tests) were performed using the SPSS Statistics® program to determine students' identity development as potential change agents. Analysis of students' responses to the related pre- and post-survey items (i.e., potential change agents survey items) revealed that students' identity development as potential change agents from Summer 2014 to Summer 2015 was significant (see Table 23). Specifically, the results of the survey item, relevance of computer science to students' lives, was significant ($Z = -2.066$, $p = 0.039$), indicating that students showed significant growth in seeing the relevance of computer science to their lives from the pre- to the post-survey. Additionally, the item related to students' use of STEM knowledge to solve problems in their communities, was significant ($Z = -2.968$, $p = 0.003$).

Table 23

Paired-Samples Wilcoxon Signed Rank Test Results, by Change Agent Item

Scale	*Z*	Significance (2-tailed)
I see examples of how computer science applies to my everyday life (i.e., relevance of CS to personal lives).	-2.066	**0.039**
I plan to use my STEM knowledge to solve problems in my community or in society.	-2.968	**0.003**

Future STEM professionals. Another identity that was made available to students in the focal teachers' classrooms was *future STEM professionals*. This identity was characterized by students taking up ideas about entering the STEM pipeline as undergraduates and becoming professionals in the STEM fields post-graduation. I focus on one main resource made available in the learning environment for this identity: information about STEM careers, a material resource.

In her chemistry course, Jazmyn had students present research they had conducted on a variety of STEM careers related to an undergraduate degree in chemistry (Lesson Plan, June 26, 2015). As part of the assignment, students researched careers in fields such as biotechnology, pharmaceutical development and testing, medicine, pharmacy, physical therapy, and nursing (Lesson Plan, June 24, 2015). In the next class session, students presented their research in expert panels; each panel showcased numerous careers, and one group even made connections to the application of STEM knowledge to fields like marketing and law (Fieldnotes, June 26, 2015). The knowledge that students gained from this experience served as a material resource for shaping their identities as future STEM professionals. By framing students' presentations as "expert panels," Jazmyn not only supported students' positive STEM identity development, but also affirmed their academic abilities. In so doing, she supported their academic success (Nasir, 2012), and further shaped their capable learners identity development.

One way that some students evidenced development of the future STEM professionals identity was in their interest in pursuing computer science or science concentrations as undergraduates or aspirations to become computer scientists or scientists. For example, in the focus group interview, one female student expressed a desire to pursue a career in computer science, while another remarked that she wanted to "minor in it [computer science] when I'm in college" based on her learning experiences across the SAUSES program, particularly Anthony's course. Three students specifically mentioned how Jazmyn supported their development of future careers in the STEM fields in their evaluation of, their chemistry teacher. One student's response stood out amongst the three responses:

> Jazmyn taught well and found what I was interested in majoring in…she helped me find careers with that major. …she really helped me find out what I can do in the future and helped spike my interest in chemistry.

These responses provide a qualitative view of students' identity development as future STEM professionals. Additionally, statistical analyses of survey items related to students' identity development as future STEM professionals were conducted; the results of analyses of students' pre- and post-survey responses are shown in Table 24. Only one item was statistically significant from the pre- to the post-survey, *knowledge of STEM careers* (Z = -2.137, p = .033), which indicated that students gained significant knowledge of STEM careers during the SAUSES summer session. The remaining survey items were not shown to be significant between the pre- and post-survey.

Table 24
Paired-Samples Wilcoxon Signed Rank Test Results, by Future STEM Professionals Item

Scale	*Z*	Significance (2-tailed)
I plan to major in a STEM (Science, Technology, Engineering, or Mathematics) field when I enter college.	0.000	1.000
I know a lot about careers people can have with degrees in Science, Technology, Engineering, and Math.	-2.137	**0.033**
I plan to pursue a career in science, technology, engineering, or math.	-1.000	0.317
In the future, I can imagine myself working in the field of science, math, engineering, or technology.	-1.155	0.248

Discussion

The findings presented in this chapter revealed the three identities made available for focal students: *capable learners*, *potential change agents*, and *future STEM professionals*. Within the learning environments, students had varied access to the three types of resources for identity development, material, ideational, and relational resources (Nasir, 2012; Nasir & Cooks, 2009). The findings extend the literature on how equity-minded teachers can support students' sociopolitical consciousness development and empower them to become potential change agents. Students' multiple identities, which can include race, gender, class, sexuality, and socioeconomic status, shape how they are able to engage in their learning (Carter, 2006). Thus, educators and researchers alike should acknowledge and build upon these multiple and intersecting identities as they design equity-minded STEM pedagogy and curriculum. In so doing, they can provide learning opportunities that meet the needs of students from nondominant communities. Anthony and Jazmyn each exemplified this by exploring sociopolitical issues relevant to their students' identities and making connections to course content. The findings revealed that the focal teachers supported students' sociopolitical consciousness development through classroom discussions and research topics, and that students' identity development as potential change agents was significant ($p = 0.003$). This finding is similar to other studies that that some students from nondominant communities enter the STEM fields to work for social change, particularly for their own communities (Garibay, 2015; Hurtado, Newman, Tran, & Chang, 2010)). For example, Furthermore, this finding supports the idea that STEM learning should empower students to engage in civic and political engagement (Dimick, 2016; Rudolph & Horibe, 2016). Rudolph and Horibe (2016) argue for "expanding the targeted learning outcomes of science education beyond the conceptual or even epistemological to the social and political, which could happen with the school curriculum or…in concert with other school subjects" (p. 816). To determine if focal students' identity development as potential change agents persists over time, and examine if and how their sociopolitical consciousness has been further developed, it would be useful to collect follow-up data with the focal cohort.

Chapter 6: Concluding Thoughts on Creating Spaces for Utilizing Equity Pedagogies

As the United States continues to focus on improving STEM education across a variety of learning settings, many of the initiatives are focused on supporting students from nondominant communities to increase diversity within the STEM fields (NAS, 2007, 2011; NSTC, 2013; PCAST, 2012). Although there is much agreement about fostering diversity within the STEM fields and education, some researchers argue that focusing on high quality-learning experiences is not enough. Rather, greater emphasis should be placed on the experiences of and learning opportunities for students from nondominant communities (Emdin, 2010, 2011; D. Martin, 2013; Nasir et al., 2014; Welner & Carter, 2013) since race, racism, and education have been "intricately linked" for hundreds of years (Ladson-Billings, 2016, p. 3; D. Martin, 2013; Welner & Carter, 2013). Critical perspectives on STEM education illuminate why focusing on the equity agenda and the use of equity pedagogies are necessary for students from nondominant communities to succeed.

In this dissertation study, I sought to examine the orientations equity-minded teachers have to equitable STEM instruction, how teachers implement equity pedagogies, and how academic and STEM identities are made available to students. I now return to the three research questions that my dissertation study takes up:

1) **Equity Orientations:** What are SAUSES teachers' perspectives on equity-oriented STEM instruction, and how do their perspectives change over the course of the program?
2) **Teaching Practices:** As SAUSES teachers aim for equity-oriented STEM instruction, in what ways are their perspectives on equity implemented in their teaching practices? What successes, tensions, and challenges do teachers experience?
3) **Student Outcomes:** How are learning opportunities and academic and STEM identities made available to SAUSES students through teachers' equity-oriented instruction?

Review of Findings

The major findings from this dissertation study include:

1) Eight case study teachers exhibited two main perspectives on equity-oriented STEM instruction: *equity is equality* and *empowering students for success*.
2) Two focal teachers implemented equitable teaching practices in their STEM classrooms. Their teaching practices can be characterized across three dimensions: utilized culturally relevant instructional strategies, developed and maintained relationships, and emphasized diverse perspectives and participation in the STEM fields.
3) Three academic and STEM identities were made available for students in the focal teachers' classrooms: *capable learner*, *potential change agent*, and *future STEM professional*.

In the following section, I elaborate on each of the three major findings.

Teachers' perspectives on equity-oriented STEM instruction. By examining eight case study teachers, I was able to answer research question one and determine their perspectives on equity-oriented STEM instruction. Findings revealed that teachers have two perspectives: *equity is equality*, and *empowering students for success*. Teachers who exhibited the *equity is equality* perspective had narrow views of equity that aligned with the meaning of equality (i.e., equal resources, access, etc.). In contrast, teachers who exhibited the *empowering students for success* perspective acknowledged structural inequities that influence learning opportunities for students from nondominant communities. At the start of the summer session, five of the eight case study teachers (n = 5) exhibited the equity is equality perspective, and three teachers (n = 3) exhibited the empowering students for success perspective. By the end of the summer session, six case study teachers (n = 6) exhibited the empowering students for success perspective, and two teachers did not shift and still exhibited the equity is equality perspective.

Developing deep understandings of equity to engage in equity pedagogies is a process that takes time for teachers (Achinstein & Athanases, 2005; Ladson-Billings, 2006b; Mensah, 2013, 2016). Over the summer session, the six case study teachers who exhibited the empowering students for success perspective strengthened their understandings of how race, racism, and other structural inequities can limit learning opportunities for students from nondominant communities (Carter, 2013; K. Gutiérrez & Calabrese Barton, 2015; Ladson-Billings, 2006a, 2009; Nasir, 2012; Nasir et al., 2012; Noguera & Wing, 2006; Rousseau & Tate, 2003). In so doing, these case study teachers became more aware of the sociopolitical and sociocultural realities of students from nondominant communities that influence student learning (Gutstein, 2006; D. Martin, 2013; Nasir, 2012; Rahm & Moore, 2016; A. Rodriguez, 2015; Rosebery et al., 2015; Tan & Calabrese Barton, 2012), and were better able to provide equitable and rigorous learning opportunities for their students.

Research has shown that shifting teachers' mindsets to become equity-minded is difficult and multi-faceted (Bennett, 2012; A. Martin, 2013). The findings from this study also suggest that teacher learning can be supported by the use of cultural artifacts, including a pictorial representation of equity, the SAUSES guiding pedagogy (i.e., the ABCs) based on teachers' reflection statements. Additionally, responding to scholarly publications and developing relationships with colleagues and students can support teachers' reflective practices. Scholars have pointed out that engaging in reflective practices is an important tool for shifting teachers' mindsets and practices (Achinstein & Athanases, 2005; Bennett, 2012; Howard & Aleman, 2008; Kelly, 1999; Mavhunga, 2016; Mensah, 2016; Merryfield, 2000; Nasir et al., 2014; Rousseau & Tate, 2003). Thus, this research finding builds upon and extends prior research that documents how shifts in teachers' mindsets can be supported by positive teaching experiences with students from nondominant communities, in addition to the use of reflective journals, critical reflection and dialogue, engaging in small inquiry groups, and collaboration in teacher education courses or professional development (Bennett, 2012; Kelly, 1999; A. Martin, 2013; Rousseau & Tate, 2003).

Equitable teaching practices. The second set of findings for this study was developed from answering the second research question about equity-oriented teaching practices. In exploring the two focal teachers'—a chemistry teacher and a computer science teacher—instructional practices, the three dimensions of teachers' equitable instruction were revealed. The three dimensions of their instructional practices included: 1) utilized culturally relevant instructional strategies; 2) developed and maintained relationships; and 3) emphasized diverse perspectives and participation in the STEM fields. These findings extend the burgeoning scholarship on the use of equity pedagogies in STEM learning environments (Bang & Marin, 2015; Dimick, 2016; Emdin, 2010, 2011; Garibay, 2015; Johnson, 2011; Mensah, 2013; Milner, 2011; Nasir et al., 2014; Tsurusaki, 2013) by offering explicit instructional examples of the two focal teachers' implementation of equitable STEM instruction. For example, Anthony addressed issues of race and racism in his computer science course by engaging students in discussions. These conversations were often prompted by the use of videos or posing questions to his students. Many teachers can find navigating these conversations difficult because of their own level of discomfort or unawareness of sociopolitical issues (Ladson-Billings, 2006b; Sleeter, 2011, 2012). However, it is important to engage students in learning activities that allow them to see the relevance of course content to their lives (Hurtado et al., 2010).

Identity development. The third research question focused on the academic and STEM identities made available to students, and the final set of findings highlight the three identities the focal teachers made available to their students in their classrooms. The identities include 1) capable learners; 2) potential change agents; and 3) future STEM professionals. This set of findings builds upon the extant literature on identity development for students from nondominant communities across STEM learning environments (Garibay, 2015; Nasir, 2012; Nasir et al., 2014; Visintainer, 2015).

Focal students had varied access (i.e., each student did not have the same access to each resource) to the three types of resources for identity development: material, ideational, and relational resources (Nasir, 2012; Nasir & Cooks, 2009). Despite varied access, students' identity development was supported in the two focal teachers' classrooms. For example, the two focal teachers, Anthony and Jazmyn, explored sociopolitical issues to their students' multiple and intersecting identities (e.g., racial, gender, class, etc.) through classroom discussions and research topics and made connections to course content. In so doing, the teachers supported students' sociopolitical consciousness development. Statistical analysis of students' pre- and post-survey items related to students' identity development as potential change agents was shown to be significant ($p = 0.003$). Thus, these findings extend the literature on how equity-minded teachers can support the development of students' sociopolitical consciousness and empower their students to become potential change agents (Nasir, 2012; Visintainer, 2015). This finding is also similar to Garibay's (2015) study, which suggested that some students from nondominant communities enter the STEM fields to work for social change, especially in their own communities.

Limitations

Although this study contributes to the extant literature on equity-oriented STEM instruction, there were several limitations to this research project. One of the study limitations was the use of case study methodology to provide a descriptive narrative of how teachers implemented equitable instruction (Stake, 2006; Yin, 2014). Due to the small-scale case study (e.g., small sample size over a short duration of five weeks) as part of a mixed methodology approach, the study cannot be generalized. Other limitations of this study include the exclusion of the teaching practices of other case study teachers, and an incomplete exploration of the constraints focal teachers experienced while implementing equitable instruction. Also, observations of the focal students in other classrooms were not included in the study. Thus, the scope of this study was limited by not incorporating these perspectives and experiences. By following the focal students across learning and social environments (i.e., observing in other classrooms, during meals at the dining hall, social spaces, etc.) and collecting other data sources about their learning experiences, attitudes toward learning, and perspectives on the focal teachers, the study findings could have been strengthened. In so doing, there would have been more data sources that could have been triangulated to strengthen the analysis of student learning outcomes.

Implications for Teaching and Future Research

Despite its limitations, this study offers theoretical and empirical contributions to the extant literature on equity pedagogies, particularly in STEM learning environments. In exploring the two perspectives teachers have on equity-oriented STEM instruction (e.g., equity is equality and empowering students for success), this study provides a theoretical contribution to the burgeoning scholarship on equitable STEM instruction. This study was unique in that it explicitly investigated the varied orientations teachers have to equity-oriented STEM instruction. Teachers' mindsets can shift when they are in a collegial working environment that not only values equity pedagogies, but also provides supports for teacher learning and growth. In this study, teachers were able to draw upon cultural artifacts, (e.g., SAUSES ABCs, pictorial representations of equity, and scholarly publications) and their developing relationships with colleagues and their students to support their learning.

By employing a mixed methods approach, this study contributes empirically to the extant literature on utilizing equity pedagogies in formal and informal STEM learning environments. Although the small-scale study included two focal teachers and 24 focal students, it provides an empirical link between equity-focused teaching practices and students' identity development. Specifically, this study offers an examination of the implementation of equity pedagogies *and* the academic and STEM identities available to students from nondominant communities. Researchers point out the need for more empirical examples of implementing equity pedagogies (Bennett, 2012; Sleeter, 2012), especially in STEM learning environments (Dimick, 2016). Thus, this study contributes to diminishing this gap in the literature by providing empirical data for equitable STEM teaching practices *and* identity development. Equity-minded teachers can also draw upon the instructional examples presented in the study. In so doing, teachers can develop their equity-focused teaching practices.

It is critical to create learning spaces and structures that allow equity-minded teachers to utilize pedagogies that are designed to support and promote the success of students from nondominant communities (e.g., culturally sustaining pedagogy, critical pedagogy, complex instruction, etc.). In so doing, students can be supported to redefine who they are as STEM learners, and imagine their futures as STEM professionals and potential change agents. This is in stark contrast to the dominant narratives about students from nondominant communities in many learning environments, which often do not 1) acknowledge their ability to critique inequities and affect social change across a variety of settings (Burke, Green, & McKenna, 2016; Dimick, 2016; Rudolph & Horibe, 2016), 2) attend to their lived experiences (Burke et al., 2016; K. Gutiérrez & Calabrese Barton, 2015), or 3) value their multiple and developing literacies (Ladson-Billings, 2016).

Based on this study's findings, there are several directions for research endeavors. One line of research could focus on teachers' orientations to equity-oriented STEM instruction. This would include an investigation of the types of supports teachers draw upon for shifting their perspectives about equity, and how and why certain supports, such as pictorial representations, reflective practices, or scholarly publications, are more useful for some teachers than others. This line of research would contribute to the field's understanding of the variation across the types of supports teachers draw upon as they develop a mindset towards equity, and how these supports influence teachers' learning. An important component of this future research would be to have teachers document their thinking and learning via reflective journals, semi-structured interviews, or other methods that will explore how teachers develop metacognitive awareness.

A future mixed methods research project to further explore equitable teaching practices would include a study that occurs over an academic year, or multiple academic years, to study equity-minded focal teachers in their classrooms. In so doing, this research effort would provide an empirical contribution that details how equity-focused teachers endeavor to make systematic changes. Additionally, the study findings could be extended in a future research project by exploring students' identity development. To incorporate student voices and perspectives on how instruction has influenced their identity development, students could participate in the research by collecting data, sharing their stories, and positing solutions for how to improve STEM teaching and learning for nondominant youth (Seiler & Elmesky, 2005).

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Appendix A: SAUSES Teachers Final Reflection

Please write a 1-2 page reflection on your experience. Looking back at your teaching philosophy statement, how were you able to implement it during SAUSES? How would you revise the plan, in retrospect? How did the implementation of your plan (your pedagogy) change over the five weeks? What resources and support (IDEA or non-IDEA) enabled you to effectively implement your plan? Describe how the focus on teaching philosophy statements during SAUSES has informed the way that you think about your work as a teacher.

Appendix B: SAUSES Teaching Philosophy Statement Prompts

Teaching Philosophy
Describe your teaching philosophy.

-

Pedagogy
How will you put your teaching philosophy into practice this summer in SAUSES?

-

Assessment
How will you know or measure the extent to which your practices in the classroom are consistent with your teaching philosophy?

-

AFTER TEACHERS ARE PRESENTED WITH SAUSES PEDAGOGICAL PRINCIPLES (the ABCs)

Please examine your pedagogical plan and answer the following questions:

1. In what ways do your pedagogy and teaching philosophy mirror the ABCs of the SAUSES program?

2. In what ways do your pedagogy and teaching philosophy differ from the ABCs of the SAUSES Program?

3. How do these differences strengthen/build upon the ABCs? How do these differences conflict with the ABCs?

4. What is your plan for developing your current philosophy/pedagogy so that it is commensurate with SAUSES ABCs?

Appendix C: SAUSES Teachers Reading Reflection Assignment

1. Each instructor will read two readings by May 9th: one reading focused on equitable teaching practices and one reading focused on equitable instruction in a particular content area. The readings are available via your Google Drive account associated with your SAUSES email account.
    - Duncan-Andrade (2009): Note to Educators: Hope Required When Growing Roses in Concrete
    - Please choose one (or more) of the following content-focused readings:
        - Wart, Vakil, and Parikh (2014): computing/app development
        - Jilk (2014): math
        - Gutstein (2003): math
        - McKinney de Royston, Madkins, and Nasir (2015): science

2. After reading and reflecting, please complete the following reflection for EACH reading:
    - Write a letter to the author(s) of the reading. As a SAUSES instructor, offer your ideas about the reading, including ideas that it generated for you, wonderings or questions you have, ways in which the reading influenced your (prior) thinking, critique, and the relevancy of the reading to your work as a classroom instructor.
    - Please share each of your reflections with your teacher leader via Google Drive by May 9th.

Appendix D: SAUSES Student Focus Group Interview Protocol

SAUSES Computer Science Focus Group Protocol
SUMMER 2015

If they provide a course-specific answer, be sure to note what class they are in.

1) Do you like computer science? Why or why not?
2) How, if at all, did your SAUSES computer science course affect how you feel about computer science ?
3) What have you learned in this course that really stands out to you?
4) What was fun or interesting in this class? What was your favorite part?
5) Has taking this SAUSES computer science class had an impact on whether you want to study computer science or be a computer scientist? Why or why not?
6) Does your class involve any connections between computer science and the real world or current events?
7) Do you get to choose some of the topics or content based on your own interests? If yes, please give examples.
8) What do think about your SAUSES computer science instructor?
9) What do you find challenging about your SAUSES computer science class?
10) What would you change about the class?

If extra time:

1) What, if anything, are you most proud of yourself for learning in this class? [Learning, confidence]

Appendix E: Focal Teacher Interview Protocol

Semi-Structured Interview Protocol (Focal Teachers)

I am going to start off with some questions about your and your teaching background/experiences, and will then move into questions about the your SAUSES teaching experiences.

1. What's your own background education-wise and teaching-wise?

2. How would you describe your teaching with SAUSES?

3. How would you describe your teaching philosophy?

4. The Engineering Design Challenge (EDC) course—what was it like? How did working as part of an instructional team influence your teaching and learning and growth?

5. What does it mean for a student to achieve? For a teacher to achieve?

6. Tell me about your relationships with students. Feel free to include examples.

7. Thinking about equity...what did you learn about teaching for equity in SAUSES?

Appendix F: SAUSES Teacher Pre-Survey

* Required Question

1. How long have you been an instructor for SAUSES Academy? *
   - 1st Year as a SAUSES Instructor
   - 2nd Year as a SAUSES Instructor
   - 3rd Year as a SAUSES Instructor
   - 4th Year (or more) as a SAUSES Instructor

2. Which SAUSES site are you teaching at this summer? *
   - East Bay
   - Silver Hill
   - Cali South

3. Describe your teaching or professional experiences and/or background in the STEM (science, technology, engineering, and mathematics) fields? *

4. What kind(s) of teaching experiences have you had in any K-16 or graduate level learning space (in/formal, teacher, graduate student instructor/TA, etc.)? *

5. Why did you choose to take this teaching position with SAUSES Academy? *

6. Describe a lesson that you implemented as a teacher or tutor that you feel went well in your experiences in STEM-related subjects. Why do you think that lesson went well?

7. Based on your teaching or tutoring experiences in STEM-related subjects, what has been especially hard to do? How so? * What has been challenging for you as a teacher (outside of classroom management, etc.)?

8. I teach course content while, simultaneously, focusing on equity and social justice.*

   1 = Strongly Disagree 5 = Strongly Agree

   1 2 3 4 5

9. What do the terms equity or social justice mean to you? *

10. Why do you think it might be important for you as a teacher to consider your students' racial/ethnic and cultural backgrounds when it comes to learning in your classroom?

11. What does it mean to teach STEM subjects from an equity-oriented or social justice perspective? Why is that important? *

12. Working towards an understanding of culture is important to my pedagogy (i.e., teaching).*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

13. I understand and practice the principles of critical pedagogy in my teaching?*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

14. The teaching of STEM content necessitates criticality (i.e., critical, contextual understanding of larger socio-historical/political realities).*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

15. Access to STEM is the most exigent matter for traditionally marginalized students.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

16. What is agency?

17. I encourage and invite the real life experiences of my students into my classroom.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

18. What ideas do you have about how you might teach your class from an equity-oriented or social justice perspective? *

19. Critical Pedagogy and STEM education are mutually exclusive.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

20. Critical Pedagogy and STEM education are mutually beneficial.*

1 = Strongly Disagree 5 = Strongly Agree

1 2 3 4 5

21. In what ways do you think you will need to be supported in order to teach your class with a social justice orientation? What resources would you need? *

Appendix G: SAUSES Teacher Post-Survey

* Required Question

1. How long have you been an instructor for SAUSES? *
   - 1st Year as a SAUSES Instructor
   - 2nd Year as a SAUSES Instructor
   - 3rd Year as a SAUSES Instructor
   - 4th Year (or more) as a SAUSES Instructor

2. Which SAUSES site are you teaching at this summer? *
   - East Bay
   - Silver Hill
   - Cali South

3. What kind(s) of teaching experiences have you had in any K-16 or graduate level learning space (in/formal, teacher, graduate student instructor/TA, etc.)? *

4. I teach course content while, simultaneously, focusing on equity and social justice.*

   1 = Strongly Disagree 5 = Strongly Agree

   1 2 3 4 5

5. What do the terms equity or social justice mean to you? *

   1 = Strongly Disagree 5 = Strongly Agree

   1 2 3 4 5

6. Why is it might be important for you as a teacher to consider your students' racial/ethnic and cultural backgrounds when it comes to learning in your classroom?

7. What does it mean to teach STEM subjects from an equity-oriented or social justice perspective? Why is that important? *

8. I understand and practice the principles of critical pedagogy in my teaching?*

   1 = Strongly Disagree 5 = Strongly Agree

   1 2 3 4 5

9. The teaching of STEM content necessitates criticality (i.e., critical, contextual understanding of larger socio-historical/political realities).*

   1 = Strongly Disagree 5 = Strongly Agree

   1 2 3 4 5

10. Access to STEM is the most exigent matter for traditionally marginalized students.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

11. What is agency?

12. I encourage and invite the real life experiences of my students into my classroom.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

13. What ideas do you have about how you might teach your class from an equity-oriented or social justice perspective? *

14. Critical Pedagogy and STEM education are mutually exclusive.*

    1 = Strongly Disagree 5 = Strongly Agree

    1 2 3 4 5

15. What was the hardest part about teaching your class using critical pedagogy?

Appendix H: Descriptive and In Vivo Codes of Teachers' Definitions of Equity

Category	Code	Description
Access to High-Quality STEM Instruction	1—equal opportunity or access 2a—resources (clean school) 2b—resources (advanced course offerings) 2c—resources (materials) 3—equal outcomes	All codes in this category identify teachers' thinking about the ways students might have access to high-quality STEM instruction.
Deficit-Model Narratives	4—minority students don't do well in X 5—students lack confidence 6—blame parents	All codes across this category identify teachers' thinking that evidenced deficit-model thinking about students from nondominant communities.
Critical Perspectives	7—relevant or relatable to students' lives 8—acknowledging students' race, ethnicity, and/or cultural backgrounds 9—empower communities/change agents 10—instructional strategy for students from nondominant communities 11—value diverse perspectives 12—aware of biases or stereotypes	All codes across this category identify teachers' thinking about equity that evidence elements of critical perspectives on STEM education.
Equitable Learning Environments	13—multiple opportunities for success 14—flexible pacing 15—teacher reflection 16—fairness/ respectful treatment 17—relationships 18—student voice 19—safe learning space	All codes across this category identify teachers' responses that indicated the characteristics of an equitable learning environment.

Appendix I: Descriptive and In Vivo Codes of Focal Teachers' Practices

Category	Code	Description
Instructional Practice	1—humor 2—relevance 3—note-taking 4—explicit expectation 5—used student as teacher	All descriptive codes across this category identify the instructional practices focal teachers used to promote equity *and* support student learning.
Participation Protocols	6—call and response 7—popcorn 8—one-on-one support 9—small group or pair work	All descriptive codes across this category identify the protocols focal teachers used to engage students in classroom discussions and learning activities.
Teacher-Student Relationship	10—formative feedback from students 11—affirmed student(s) 12—spending time outside of class 13—teacher shared personal or professional story	All descriptive codes across this category identify the nature of relationships between focal teachers and students.
Discussion Content	14—current issues 15—STEM careers and/or pathways 16—students' lives 17—racism in STEM	All descriptive codes across this category identify topics that were discussed while focal teachers engaged students in a classroom discussion.
Supports Instructional Outcomes	18—previewed material 19—questioning strategy 20—flexible pacing 21—use of analogy 22—mental break 23—developed and/or used habits of mind (e.g., persistence, metacognition, etc.) 24—connected prior knowledge 25—knowledgeable/content expert	All descriptive codes across this category identify the practices that focal teachers utilized to support instructional outcomes, such as learning and identity development.

Appendix L: Descriptive Codes for Identity Development

Category	Code	Description
Student Learning	1—used humor to lower affective filter 2—affirmed students' abilities 3—shifting role (student becomes teacher) 4—sign posts about importance of content 5—developed habits of mind (persistence, intellectual struggle, etc.)	All codes in this category describe identity development related to student learning.
Contextualizing Content and Equity Issues	6—relevance 7—teacher shared story (personal encounter with racism or other –ism) 8—classroom discussion (racism or other –isms in STEM) 9—classroom discussion (social justice issue)	All codes in this category describe identity development related to the ways in which teachers contextualized course content in equity or social justice issues.
Pathways into STEM	10—teacher shared story (personal) 11—teacher shared story (professional pathway) 12—classroom discussion (STEM careers and/or pathways) 13—classroom discussion (professional encounters with racism or other –isms in STEM 14—referred to future self (e.g., when in college…)	All codes in this category describe identity development related to preparation for majoring in or a career in the STEM fields.