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Making Community Curricular: Designing for the Integration of Community and Culture in Science Learning

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Making Community Curricular: Designing for the Integration of

Community and Culture in Science Learning

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Education

by

Symone Alexandra Gyles

2022

ABSTRACT OF THE DISSERTATION

Making Community Curricular: Designing for the Integration of

Community and Culture in Science Learning

by

Symone Alexandra Gyles

Doctor of Philosophy in Education

University of California, Los Angeles, 2022

Professor Kimberley Gomez, Chair

K–12 curriculum often presents science as a mundane and irrelevant subject in the lives of urban students of color. As such, researchers have begun to investigate the use of place-based methods to support meaningfulness and relevancy in science learning. This study provides an in-depth examination of features of design that can be used in science curriculum to ground learning in students' lives and communities. Building on a funds of knowledge framework and Indigenous models of community-based science, this qualitative investigation examined the impact of these features of design on students' conceptualizations of environmental and social justice issues in their communities. By examining the development and implementation of a year-long community-based science curriculum in one urban middle school, this study sought to illustrate an approach to support educators who seek to make community curricular, and to connect science concepts and learning more succinctly to the contexts of their students' lives, knowledge, and experiences. Data from this dissertation revealed strategies of curricular design that embed students' communities and attune to their funds of knowledge as assets to the learning space, both in written materials and dialogue structure. Additionally, findings also provided a description of how students conceptualize and express their understandings and interpretations of community environmental and social justice issues, and their effects, when engaging in community-based curriculum. As the "why" regarding the use of funds of knowledge in science has been thoroughly explored in prior research, this study sought to speak to "how" science can be reimagined as a subject connected to students' everyday lives and experiences through collaborative design. As such, this study also aimed to add to the literature that redefines ideas of what counts as scientific knowledge, and who holds scientific knowledge. Collectively, this work provides educators with curricular and pedagogical structures and practices to ground science learning in more meaningful and relevant contexts for urban students of color. As such, this dissertation offers recommendations for research, practice, and design for future work that explores the use of community-based science curricular and pedagogical strategies in urban school settings.

This dissertation of Symone Alexandra Gyles is approved.

Louis M. Gomez

William A. Sandoval

Elizabeth C. Koslov

Kimberley Gomez, Committee Chair

University of California, Los Angeles

2022

DEDICATION

This dissertation is dedicated to my students from Benjamin Syms Middle School. Thank you for entrusting me with your hopes, dreams, aspirations, highest of highs, and lowest of lows. The laughs you provided me and lessons you taught me will forever live in my heart. Because of you all, I started this work and continue to show up each day.

To Darius Daily, Jr., whose journey was cut too short, your spirit continues to live on in us all. To my "babies," as you continue your journeys, remember that you are worthy, intelligent, and capable. Whatever you desire is already at your fingertips. You are destined for greatness.

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It would take another dissertation to thank every person who has touched me and supported me along this journey, so collectively, I say thank you. I am blessed beyond measure.

VITA

Education

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Manuscripts under Review
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Manuscripts in Preparation
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I collected and managed data for a LAUSD wide research initiative improving mathematics learning.

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CHAPTER 1: INTRODUCTION

Framing the Issue: Disconnects in Science Education for Students of Color

As I sat in Ms. V's seventh-grade science class, I watched as she tried to help a student struggling to finish a worksheet on matter cycles and energy flow. Visibly upset, the student threw down his pencil in frustration and yelled, "I don't plan on being a scientist or teacher, so why do I need to learn about this?" as he huffed, crossed his arms across his chest, and put his head on his desk. With this short description, I aim to offer an illustration of a far too common frustration students express and experience in science classrooms around the country. "How is this relevant?" is a question asked far too often by students, but not nearly enough by teachers. The abstract, and often dull, nature of curricular content and pedagogical practices used in science teaching play a significant role in disengaging students, particularly students of color, from science learning. Over the last two decades, researchers and educators have begun to engage in many discussions around the purpose of, and student engagement in, science education. Questions such as (a) Should science serve as a means to teach students about the natural world?, (b) Should science serve to help students better understand their own surroundings and environment?, (c) What curricular designs and pedagogical practices should teachers use to engage student prior knowledge in science learning?, and (d) How can we reexamine current science practices and curriculum to help all students see the significance of science outside of school contexts? have commonly been discussed among community members.

Current K–12 education often dissociates curricular content from the lived experiences of students, leading to incorrect distinctions between students' interpretations and understandings of the scientific world and the social world (Davis & Schaeffer, 2019). Curriculum frequently frames science as objective and established, with little to no room for diverse accounts and interpretations of phenomenon. Brickhouse et al. (2000) described this system of learning as "school science," where content is presented in a manner that is not meaningful to many students, as it lacks relevance and congruence to their everyday lives (Bang et al., 2010; Basu & Barton, 2007; Davis & Schaeffer, 2019; Dillon, 2009; Gilbert, 2006; Holbrook 2008; Lee & Fradd, 1998; Rosebery et al., 2005).

Carlone and Johnson (2007) defined *school science* as, "practices that imply that science consists of narrowly defined tasks and emphasize science as a finished body of knowledge" (p. 1189). School science does not allow for varieties in approaches to learning, understanding, and engaging in science learning (Brickhouse et al., 2000), and continuously leaves out the experiences of historically marginalized students of color (SoC; Bang et al., 2010; Davis & Schaeffer, 2019; Ferguson & Mehta, 2002; Kober, 2001; Lim & Barton, 2006). As a result, school science has become a system of teaching and learning that eschews nonhegemonic funds of knowledge (FoK) and everyday practices (Bang & Vossoughi, 2016; Emdin, 2016; Patchen & Cox-Peterson, 2008; Philip & Azevedo, 2017; Tan & Barton, 2010), at times, even directly contradicting the experiences and worldviews of students. Consequently, when entering school science learning spaces, oftentimes students dismiss their cultural practices (Brown, 2019; Emdin, 2016) and reconstruct their conceptualizations to assimilate to western ways of thinking and knowing (Aikenhead & Michell, 2011) to succeed in school science spaces. This version of science learning favors disconnected content over the contexts of students' diverse experiences through which they come to understand phenomena. Such constructions disassociate science learning and the natural world and can lead to the alienation of SoC from engaging in scientific instruction, discovery, and learning.

In response, researchers have argued the need for science education to move away from the goal of simply increasing students' sense of understanding about the natural world and toward increasing their awareness and comprehension of environmental justice (EJ) and social justice (SJ) related to their everyday ecological contexts (Bellino & Adams, 2017; Emdin, 2016). Thus, science education research has begun to focus on the disconnect between science learning and students' everyday lives and experiences, particularly for SoC (Bang et al., 2010; Basu & Barton, 2007; Bellino & Adams, 2017; Davis & Schaeffer, 2019). In practice, school science fails to include students' everyday FoK (Moll et al., 1992) and experiences to help conceptualize scientific phenomena (Patchen & Cox-Peterson, 2008; Tan & Barton, 2010).

Current curricular standards disconnect science from daily life practice and do not recognize nor draw upon the multiple forms of community cultural wealth students bring to the learning environment (Yosso, 2014). As such, some researchers have argued for the reframing of school science curriculum, concepts, and practices for immediate usefulness and local relevance (Bouillion & Gomez, 2001; Gutiérrez & Rogoff, 2003; Roth & Lee, 2002; Tan & Barton, 2010). As further discussed in Chapter 2, the Next Generation Science Standards (NGSS) present ambitious and innovative benchmarks to repudiate abstraction in science learning. The standards, however, fail to emphasize students' present and historical cultures and communities in practice, and do not address how science can be culturally responsive to the social contexts through which students understand and interpret science concepts (Seimears et al., 2012).

Community-based practices have come to light as one possible solution to addressing this concern (e.g., Aickenhead & Michell, 2011; Bang & Medin, 2010); however, these strategies have not been thoroughly researched in urban school settings (Brkich, 2014). My research aimed to provide an empirical example of the ways in which a codesigned community-based science

(CBS) curriculum, focused on investigations of socioscientific justice issues, can be designed to use the wealth of student FoK as assets to learning, and create stronger connections between in-and-out of school science contexts. As such, this work sought to support teacher practice by providing structures of support in curricular and pedagogical design that assist educators in more succinctly integrating the everyday context of their students' lives and experiences into school science learning. I claimed curriculum designed in these contexts should yield active participation in school science by positioning students to "believe that their work can affect improvements for themselves, their friends, and their families" (Reiss, 2003, p. 2). Therefore, the following research questions guided my study:

1. Design Question: What are the features of codesigned artifacts that support the engagement of students' funds of knowledge in science learning?
    a. How does a teacher structure dialogue to support the engagement of students' funds of knowledge?
2. Implementation Question: How are students of color conceptualizations of environmental and social justice issues in their everyday lives reflected during the enactment of a community-based codesigned curriculum?

Study Purpose

This dissertation sought to explore how using a CBS framework in curriculum design can (a) support science learning that engages students' everyday FoK in practice, (b) support a teacher in integrating those funds in curriculum and practice, and (c) legitimize student knowledge and conceptualizations as they study and explain science in their own communities. This study, conducted in Ms. V's seventh and eighth grade "Energy and the Environment" elective science classes (approximately 99% Black or Latinx) at The Community School (pseudonym) in South Los Angeles, was a practical environment to initiate this study due to the circumstances of the school and community and the historical lack of engagement in science learning among students. The goal of this study was to investigate how a codesigned curriculum, in a CBS framework, can be organized to support the integration of students' FoK in science learning by investigating local environmental and SJ issues. I also sought to understand how, when engaging with this designed curriculum, students conceptualized these EJ and SJ issues to support using science to engage in sensemaking of their everyday lived experiences. Through this effort, I endeavored to provide teachers with curricular and pedagogical strategies to position science as a relevant and engaging subject that can be used to understand their everyday environmental and social contexts.

Through this work, this study sought to support four major claims: (a) codesigning is a valuable methodological approach to more clearly translate education theory into practice; (b) codesign can support the development of curricular materials and pedagogical practices that ground science learning in community contexts to help students better understand science concepts and their experiences in the world; (c) students have understandings of scientific phenomena that are not historically recognized as scientific (Emdin, 2016), but are important sense-making resources that should be capitalized on (Irish & Kang, 2018); and (d) science, in general and classroom science in particular, is a medium to discuss the political, social, and environmental implications of issues of EJ and SJ, particularly among marginalized students. These claims, grounded in the literature and based on findings from a pilot study enacted during the early years of my research-practice partnership (RPP) with Ms. V, formed the basis of this study's curriculum design.

In 2019, Ms. V and I piloted the second iteration of a codesigned CBS-framed unit on air and water pollution. Our aim was to leverage students' FoK that we saw anecdotally, in the third space (Gutiérrez, 2008), and occasionally in teaching and learning moments. Our codesign efforts were organized around the belief that science should engage students in and beyond the classroom setting and be locally situated to provide opportunities for students to use their conceptualizations of their environment to inform learning. Findings highlighted the benefits of inquiry-based projects to support student connections between science and their community, and the inclusion of family and community members in learning. These findings played a significant role in the design of the curriculum for this dissertation study.

Theoretical and Conceptual Framing

This dissertation was theoretically grounded in sociocultural theory and guided by a FoK conceptual framework. Sociocultural theory postulates learning and development take place in socially and culturally shaped contexts (John-Steiner & Mahn, 1996; Nasir & Hand, 2006; Vygotsky, 1978) because of engaging in the practices of a certain community (Lee, 2008). Operationalizing sociocultural theory as a theoretical framework, this study grounded CBS curriculum in the nonhegemonic (or nonwestern) and noncolonial ways of knowing of students and the local community to support diversity in science and foster equitable participation and inclusion in science learning. The central tenets of sociocultural theory, which are further discussed in Chapter 2, were used to address how a CBS framework can rearrange traditional norms and practices that have enveloped science classrooms and alienate SoC in science learning. Using this theoretical lens, I explored how CBS practices can help a teacher legitimize students' FoK in science learning to support their understandings and conceptualizations of both science content and their lived experiences.

Conceptually, an FoK framework was used in this study to bound curricular design in contexts relevant to students' lives by connecting learning across school, home, and community spaces (Bouillion & Gomez, 2001; Davis & Schaeffer, 2019). Studies have pointed toward the value of using students' prior knowledge to combat a "narrow agenda that does not recognize the lived experiences of youth living in socially and ecologically complex urban environments" (e.g., Bellino & Adams, 2017, p. 270). An FoK framework guided my understanding of how grounding teaching in CBS practices can cultivate connections through students' investigations of their own worlds.

To examine how a codesign approach can support the development of curricular features that elicit, recognize, and affirm the lived experiences of students, and how a CBS-focused curriculum supports SoC in using these funds of knowledge to develop conceptualize their everyday lives, I used participant observations, researcher–practitioner meeting artifacts, semistructured interviews, and student work artifacts. Analytically, I engaged in three rounds of coding starting with deductive coding using a variety of codes from existing literature to generate initial categories, followed by open coding, and then axial coding to classify these categories into larger themes. These themes are examined in depth in Chapter 4, which evaluates features of curricular design, and Chapter 5, which evaluates students' conceptualizations of environmental and SJ issues in their local community.

Assumptions

This study, as further discussed in Chapter 2, is grounded in a constructivist epistemology. Every epistemology, or theory of learning, has particular ways of viewing and conceptualizing knowledge and knowledge acquisition (i.e., learning; Duit, 1996). At its core, constructivism views knowledge as "a process of personal cognitive construction," (Taylor, 1993, p. 268), meaning learning is not an individual serving as a passive receiver, but instead, is an active constructor of knowledge. As such, constructivism views learning as the reconstruction of knowledge, rather than the transmission of knowledge (Papert, 1986). My epistemological stance, specifically, was grounded in social constructivism, which views learning as a social, cultural, and motivational process derived from interactions and discourse among individuals (Atwater, 1996; Lemke, 2001), and unity and interdependence in learning and development (Barak, 2017).

Social Constructivism guided my use of sociocultural theory as a theoretical framework, and FoK as a conceptual framework in this study. Employing sociocultural theory, I assumed knowledge construction is "internalized, appropriated, transmitted or transformed in formal and informal learning settings" (John-Steiner & Mahn, 1996, p. 196); therefore, the contexts of students' knowledge construction of scientific phenomena in informal settings is just as relevant as those learned in formal school settings. Additionally, using a FoK framework helped question hegemonic interpretations of who holds knowledge and where knowledge derives from in science learning. This study's design and analysis was grounded in six assumptions that represented the value I place on students' home, cultural, and community knowledge (Hogg, 2011) to redefine what is considered a valid source of science knowledge and scientific data (Cowie et al., 2011):

1. Learning occurs in social environments where individuals bring their cultural perspectives and engage in interactions that lead to a common consensus (John-Steiner & Mahn, 1996).
2. Students have developed epistemologies based on their life experiences, and these epistemologies are relevant to science learning (Hammer & Elby, 2013).

3. Students and families are sources of information and learning that can serve to better inform classroom practices (Moll, 1990; Moll et al., 1992).
4. Students' stories and experiences are valid sources of scientific data, whether they can be generalized or not (Barton, 2003)
5. Classrooms should serve as spaces for student empowerment by providing new perspectives on science learning and ways of science teaching (Dimick, 2012).
6. Students should engage in real-world scientific investigations and problem-solving about issues important to them and their communities (Bellino & Adams, 2017).

As presented, these stated assumptions were not only grounded in and supported by existing literature, but they were also driven by my own experiences as a Black woman scientist, science educator, and community researcher. Accordingly, the subsequent section provides a synopsis of my history in science and positionality in this work, followed by an overview of the significance of this study, and concludes with an outline of this dissertation.

How I Come to This Work

I obtained my bachelor of science from Hampton University, a historically Black university in Hampton, Virginia, where I studied marine and environmental science. In the confines of my university—where the people around me were all shades of Black and Brown—I felt as though my voice, experiences, and cultural identities were heard and recognized in relation to my science research. When I attended larger science conferences, however, I felt as though these aspects were habitually ignored and overshadowed by the experiences, cultures, and identities of my white colleagues. In these spaces, I realized science itself is not acultural (Bang & Medin, 2010) and traditionally reflects Eurocentric values that did not relate to me or my life. As a result of these experiences, I began to struggle with the idea of science as an unbiased field and I began to question my place in it. I took these sentiments into the classroom with me when I began to teach seventh-grade life science at a predominately Black Title 1 school.

Early on in my 1st year of teaching, I came to realize many of my students were disinterested in science learning. As a subject that was so exciting for me personally, I struggled with the idea that students perceived it as their least favorite class. As I conversed with my students about their past experiences in science, I realized many had failed to be taught the relevance and necessity of science outside of passing a class or statewide test. Students described seeing science and their personal lives as two independent entities that did not connect. These students were failed; failed to be taught the significance and application of science in multiple aspects of their lives.

While spending time lesson planning, I sat baffled at the district-mandated curriculum map for the next unit—high-level abstract concept after high-level abstract concept. Growing frustrated the further I read, I said to out loud, “This is so boring.” At that moment, I realized the curriculum I was engaging my students in was monotonous, lackluster, and frankly completely unrelated to almost anything they would find useful. As a result, I began to work toward restructuring my curriculum to meet district standards, while also using pedagogical and curricular practices that engaged my students in investigations of scientific phenomena in the context of their community. For example, when teaching the water cycle, students investigated water pollution as an issue of environmental justice. Students collected and analyzed water samples from a local water basin and compared the results to an analysis of samples from a lake located in a predominantly white neighborhood in a neighboring city. Not only were students engaged in the work, but they expressed disgust in water quality differences between the sites. Students provided me with their interpretations about why they believed these differences existed and possible solutions on how to address the issues. After this lesson, students were fueled by a newfound understanding of the effects by site pollution sources on the water quality in their neighborhood.

Based on this experience, bounding phenomena in the context of the local community has become important to my conceptualizations of effective and relevant science teaching and learning. I come to this work grounded in a SJ lens, and view science education to address issues of equity, power, and institutionalized oppression in the context of scientific phenomena. Further, I believe in using student prior knowledge and including a multitude of epistemologies in classroom learning, educators "position youth as transformative intellectuals poised to see and leverage science as catalyst for change" (Davis & Schaeffer, 2019, p. 369) by "centering what youth bring – rather than what they lack – [to] recourse how we think about the purposes and goals of science education" (Barton, 2003, p. 33). My SJ lens provided the foundation for critical research that challenges ingrained assumptions in traditional science education spaces by empowering teachers to transform their curricular and pedagogical practices to support grounded student learning. Further, this work empowers students with authority, autonomy, care, support, and validation to see their knowledge and experiences as significant to science learning; all essential elements of an effective community-based science classroom.

Science educators, like me, have long recognized prominent issues of equity, particularly among students from marginalized communities regarding their participation in science education and pursuing science as a career (Barton & Upadhyay, 2010). Addressing power dynamics in science—including the power of knowledge, voice, and interpretation—can change the way SoC make meaning of science, engage in science, and negotiate space for themselves in science (Aikenhead, 1996; Barton et al., 2008; Emdin, 2016; Tan & Barton, 2010). As such, I sought to develop curricular and pedagogical features that employed students' prior knowledge as resources in learning to engage students in active learning where science has meaning in multiple settings through the CSB curriculum. Overall, my view of science education views learning not as a process where the teacher transmits information to students, but instead as a space where learning is reciprocal, and all classroom community members are engaged in knowledge construction.

Study Significance

There has been a vast amount of research that has alluded to the need for critical science learning through a lens of culture, power, and justice, along with research that has critiqued and investigated depoliticized and decontextualized pedagogies (Aikenhead & Michell, 2011; Bang et al., 2010; Bellino & Adams, 2017). However, Davis and Schaeffer (2019) called for more research that investigates the process of creating, and the impact of designed curriculum and pedagogies that promote the development of a justice-focused science agency and increased meaning-making for students, especially in locally specific ways. As Dimick (2012) noted, existing literature presents "few examples of attempts to teach with social-justice oriented pedagogies or curricula in science education school settings," (p. 993). This study sought to address this much needed area of research. Although strategies (e.g., culturally relevant pedagogy, place-based education, and community-based education) have made great strides to include students' prior knowledge and local environments in science teaching (a point of which I elaborate on in Chapter 2), a discontinuity in the goals of these strategies and populations they serve remains in the field (Brkich, 2014). Collectively, too little is known about how students who grow up in complex urban environments view and experience their world (Bellino & Adams, 2017). Educators and researchers fail, by and large, to identify and consider the oftdifferentiating historical cultural practices and relationships with nature that students and their families hold; thus, this study further sought to understand these views and experiences through an investigation of students' conceptualizations of local EJ and SJ issues.

Although the "why" has been thoroughly investigated in science education literature regarding the benefits of the inclusion of students' FoK and locally relevant issues in science education, evidence of the how—especially in the urban setting—remains few and far between. With research calling for locally centered science curriculum through SJ lenses, there is a need for more empirical studies that investigate these practices in different environmental contexts (Davis & Schaeffer, 2019; Lim & Barton, 2006). Prior research still leaves researcher–practitioners with unanswered questions about how community-based, justice-centered curricular approaches actively impact Black and Latinx students, and how historically Indigenous community-based practices can be transformed and contextualized in urban schools (e.g., Brkich, 2014).

This study addressed this under-theorized and under-researched area of science education by centering community-based EJ and SJ curricular and pedagogical practices in the context of an urban school of color. In supporting student investigations of the intersecting and multifaceted ecological and social factors comprise urban spaces, and the systemic political practices and decisions that perpetuate pollution in these communities, I further empirical understandings of how curriculum can be designed to use and affirm students' FoK in science learning, and how students conceptualize these FoKs to connect school science and their out-of-school lives. As such, this work empowers teachers with structures and strategies to ground their curricular and pedagogical practices in more relevant and meaningful contexts for their students and create classroom environments where students' outside lives and experiences are viewed as assets, rather than deficits, in the contexts of formal learning.

Dissertation Overview

The dissertation provides empirical evidence of innovative science curricular design that supports the inclusion of the community cultural wealth (Yosso, 2014) found in urban communities of color in learning, and an overview of how students use this wealth to conceptualize local issues of EJ and SJ. In Chapter 2, I provide an overview of my theoretical framework, sociocultural theory, epistemological framework, constructivism, and conceptual framework, FoK that supported the design of this curriculum, and my approaches to data collection and data analysis. I also provide an overview of empirical research on the current state of "school science" for students of color, followed by a discussion of curricular strategies in research and practice that work to include students' everyday experiences in science learning. Chapter 3 provides a description of my methodological approach of codesign and my data collection methods, sources, and analytic approach. Findings in Chapter 4 present an in-depth analysis of the features of the curriculum designed by Ms. V and me, specifically examining their purpose in practice and how they served to engage students' FoK in science learning. Following this analysis, I explore how, based on these designs, Ms. V and I developed what I characterized as "communicative signals" in dialogue to support students' use of their FoK in classroom talk. In Chapter 5, I present evidence of the ways students' conceptualizations of environmental and SJ issues in their communities were reflected when they engaged in community-based curriculum. Lastly, Chapter 6 offers a recap of my efforts and aims to connect findings from this study to relevant literature. In this chapter, I also present suggestions for research, practice, and future work that investigates the use of community-based science practices in urban school environments. Collectively, through this dissertation, I aim to demonstrate how we, science educators, can advance our understanding of how to design science curriculum to support relevance, agency, and engaged learning opportunities for Black and Brown students through investigations of science in their own backyards.

CHAPTER 2: LITERATURE REVIEW

In this chapter, I provide an overview of the theoretical and conceptual frameworks that guided this study, as well as relevant empirical research on science education for students of color. I begin with an overview of sociocultural theory, and how it promotes equitable science teaching and learning, followed by an overview of my guiding epistemological framework, constructivism, and my conceptual framework, funds of knowledge (FoK). Following, I provide a synopsis of the Next Generation Science Standards (NGSS), examine relevant empirical literature around school science practices, the political nature of science learning, linguistic and cultural resources use in learning, and current strategies for the inclusion of students' everyday lived experiences in science. Lastly, I rationalize my conceptualization of community-based science (CBS) learning. The methodological approach to this study, design-based research, as well as the relevant literature that informs this approach, is discussed in Chapter 3.

Theoretical and Conceptual Guidance

> In the sociocultural view, what matters to learning and doing science is primarily the socially learned cultural traditions of what kinds of discourses and representation are useful and how to use them. (Lemke, 2001, p. 298)

In this section, I argue the benefits of sociocultural and constructivist perspectives in science to position learning as a social process that uses and validates the cultural understandings and conceptualizations of all students in knowledge construction. Further, I analyze how the use of FoK in science classrooms can serve to connect the lived experiences of students of color (SoC) and school science content.

Sociocultural Theory: A Theoretical Framework

Considering sociocultural perspectives to investigate the role of culture, interaction, and collaboration in learning is important for practitioners when investigating learning processes and knowledge construction for SoC (Polly et al., 2017). Sociocultural theory emphasizes the interaction and interdependence of social and individual processes in the construction of knowledge in cultural contexts (John-Steiner & Mahn, 1996; Polly et al., 2017; Ryu & Sandoval, 2011; Vygotsky 1978). Culture, in this sense, is defined as historical practices developed and shaped by communities using certain tools, social norms, and social practices in activity to which individuals enculturate (John-Steiner & Mahn, 1996; King, 2012; Lave & Wenger, 1991; Nasir et al., 2006; Polly et al., 2017; Saxe, 2004; Vygotsky, 1978).

Educational systems, specifically, reflect the larger social systems where they are situated (Brown, 2019; John-Steiner & Mahn, 1996). When students enter educational systems, they are often forced to abandon their own cultural views that challenge dominant and hegemonic educational thinking and enculturate into the norms and practices of the system (Nasir et al., 2006). Sociocultural approaches to learning problematize this enculturation by considering ways in which knowledge construction is “internalized, appropriated, transmitted or transformed in formal and informal learning settings” (John-Steiner & Mahn, 1996, p. 196), and used by individuals to cross cultural barriers (Leach & Scott, 2003). The situative perspective of sociocultural theory furthers this problematization, by positioning learning and knowing as situated in students’ social and material contexts (Brown et al., 1989; Lave, 1993).

In science education, sociocultural theory has been conceptualized through three perspectives. First, sociocultural theoretical perspectives can be used in research and practice to actualize diversity and inclusion in science education. Science classrooms can serve as spaces of cultural conflict, implying western ways and cultural norms that benefit a particular group as the "right" way of understanding, while viewing the language and culture of those outside that group as not having intellectual depth or scientific value (Brown, 2019; Meyer & Crawford, 2011). Sociocultural practices, however, recognize the varied historical and cultural communities that influence student knowledge construction (Brand et al., 2006; John-Steiner & Mahn, 1996; Miller, 2010), and acknowledge how these differences lead to variations in knowledge development and learning (Polly et al., 2017).

Second, sociocultural theory can support individuals in conceptualizing the reorganization of norms and practices in science classrooms. Science curriculum is often accompanied by a hidden curriculum that includes certain participatory structures with clear social norms and roles (Apple, 1986; Cobb et al., 2001) that privilege normative and hegemonic discourse and knowledge (Brown, 2019). Sociocultural perspectives challenge these dominate norms in favor of including the linguistic, cultural, and community practices of all students (Meyer & Crawford, 2011). As such, traditional classroom structures are shifted from positioning teachers as the primary sources of knowledge, to student-centered approaches where teachers serve as facilitators of learning (Brown & Crippin, 2017; Meyer & Crawford, 2011; Nasir et al., 2006). The reorganization of norms and practices form dynamic classroom cultures that invite and validate all cultural and linguistic backgrounds and understandings (Meyer & Crawford, 2011; Nasir et al., 2006), and household and community FoK in instruction (Barton et al., 2004; Gonzalez et al., 2006; Moll, 1990).

Lastly, a sociocultural lens can be used to theorize equitable and just participation in learning. According to the situative perspective, where something is learned shapes where it is used (Nasir, 2002). As science learning is often viewed as occurring only in formal classroom settings, students are positioned to view science concepts as only relevant in classroom spaces. A sociocultural lens in science situates learning in students' everyday social practices and activity to avoid separating the individual as a science learner from science learning as participation in a social world and practice (Lave & Wenger, 1991). Unfortunately, science learning in the social world often direct contradicts the concepts, culture, and language used in formal school science (Barton & Tan, 2009; Brickhouse et al., 2000; Leach & Scott, 2003; Lee, 2003), discouraging SoC participation due to difficulties in cultural "border crossing" (Aikenhead, 2001; Brand et al., 2006). Sociocultural theory serves to validate and encourage student participation (Brand et al., 2006) by deconstructing and negotiating classroom roles (Meyer & Crawford, 2011), positioning knowledge construction as shared among all members (King, 2012), and viewing learning is a dynamic exchange (Polly et al., 2017).

My conceptualization of CBS learning, as further described in this chapter, bridges sociocultural theory in practice by not only connecting community, culture, and school science, but also creating more equitable participation structures through reframing notions of who holds knowledge, who learns, and who is considered scientifically literate. The foundation of community-based design lies in the collective, active participation of all members in the learning process (Bang & Medin, 2010), allowing for the negotiation of participation roles and valuing different cultural and social ways of learning (Barton et al., 2008). Through new forms of legitimate participation in CBS, students work together to generate science knowledge and discourses (Barton et al., 2008), and foster negotiations between traditionally privileged forms of school science knowledge and nonhegemonic forms of knowledge that arise from daily participation in community life (Roth & Lee, 2004).

Constructivism: An Epistemological Framework

Researchers and educators alike have described a primary criticism of current science teaching and pedagogical practice as the passiveness of the learner in the learning process (Baysen & Baysen, 2017). Despite this criticism, students are expected to understand concepts from "ready-to-use" formats (Seimears et al., 2012) to perform well in their science class. Constructivism, as an epistemological framework, disputes this model of learning by concerning itself with the ways knowledge and knowledge acquisition are conceptualized (Amineh & Asl, 2015; Atwater, 1996; Duit, 1996). Contesting passive notions of learning, constructivism views knowledge acquisition as a dynamic activity where students participate in the construction of knowledge, and interpret new concepts based on their existing beliefs and experiences instead of reconstructing previously developed knowledge (Amineh & Asl, 2015; Atwater, 1996; Duit, 1996; Gil-Perez et al., 2002; Seimears et al., 2012). In science education, specifically, constructivist perspectives view learning as an "active, social process of making sense of experiences" (Seimears et al., 2012, p. 269), as opposed to traditional notions that view science as the learning of absolute truths.

Based on Vygotsky's (1978) view that cognitive development transpires, first, on a social level and then in the individual, social constructivism—a subset of constructivism—views learning as a social process where conceptual understanding, meaning, and significance develop along with others in sociocultural contexts, based on the norms of the communities of which the person is a member (Amineh & Asl, 2015; Atwater, 1996). When students enter a science classroom, they come bearing knowledge based on their life experiences through which they conceptualize science concepts. Classrooms, therefore, should serve as social spaces where students can use their knowledge to foster collective learning experiences. A social constructivist epistemology lent itself to my essential reasoning behind the importance of collective participation in science learning over the individual attainment of concept knowledge, and the valuing of student's prior knowledge and experiences in CBS. Participating in sociocultural-based, community-relevant, CBS practices sets students up for lifelong participation in science by situating learning as closely associated with participation in their social worlds (Lave, 1993).

Funds of Knowledge: A Conceptual Framework

Traditionally, SoC learn universal views of science through curricula that reproduce dominant culture by dismissing social scientific practices learned through cultural contexts (Verdin et al., 2016). Often, this dismissal results in student success in science at the expense of their cultural identity (Hogg, 2011). In response to these observations, science education research has endorsed the use of students' lived experiences to foster learning in classroom contexts (Bang et al., 2010; Bang & Medin, 2010; Barton & Tan, 2009, Barton et al., 2008; Basu & Barton, 2007; Bellino & Adams, 2014, 2017; Bouillon & Gomez, 2001; Brkich, 2014; Emdin, 2016; Hogg, 2011; Roth & Lee, 2004; Silseth & Erstad, 2018) and has called for curriculum and instruction to engage student in relevant investigations (Bricker et al., 2014; Brown, 2019) that create authentic experiences in science (Verdin et al., 2016).

A FoK framework has been used in much of this research to address the disconnect between school, home, and community life (Bouillion & Gomez, 2001). Coined by Moll et al. (1992), FoK capitalizes on the multigenerational knowledge and skills students acquire from their households and communities that go untapped in schools. Based on the idea that individuals have knowledge based on their life experiences (Gonzalez & Moll, 2002), the use of FoK in schools serves to redefine students and families as sources of learning that can inform classroom practice (Moll, 1990). In using student FoK, educators contextualize instruction in the understandings students develop from their life experiences (Irish & Kang, 2018), and the issues students see as relevant to their lives (Gonzalez & Moll, 2002; Silseth & Erstad, 2018), to validate their knowledge and life values (Hogg, 2011).

FoK, in relation to science, has been conceptualized in the literature two ways. First, the use of student FoK in the third space (Barton & Tan, 2009; Moje et al., 2004) has been theorized to provide a clearer transition between students' lives and science learning by challenging the boundaries and confines of school science. The third space is defined as a socially coconstructed "navigational space" that expands the boundaries of official school discourse by linking marginalized FoK and discourses with academic FoK and discourses to make meaning of academic content (Moje et al., 2004). The socially coconstructed third space allows for everyday discourse to mobilize in formal school discourse (Silseth, 2018), and creates new means of participation and engagement in science learning.

In another perspective, FoK are used in science learning as a function to better understand canonical concepts by serving as "cognitive and cultural resources that might support students when they are dealing with academic content" (Silseth & Erstad, 2018, p. 6). In a study by Silseth and Erstad (2018), which looked at the different ways teachers created learning situations that mediated student FoK in the classroom, they found teachers most frequently and successfully were able to orient instruction to the local community and students' everyday practices as resources to support concept learning. Their study backed our understanding of the importance of FoK to scaffold science learning through engagement in locally contextualized instruction to support the learning of formal science content. The inclusion of FoK in teaching and learning serves to dismantle pedagogical and curricular models that silence students in instruction (Seiler, 2001) by viewing students' FoK as powerful and valued capital in learning

(Basu & Barton, 2007). By bridging in-and-out of school science learning to enhance student engagement in science (Grant & Sleeter, 2007), we break traditional barriers of "what counts as science, and who can do science" (Cowie et al., 2011, p. 358) in classroom instruction.

In conjunction with González (2006), it is important to note that by using student's FoK, I was not trying to simply reproduce knowledge they developed in their social worlds. Instead, I drew upon that knowledge to legitimize and validate their experiences and build upon these forms of community cultural wealth (Yosso, 2014) to inform their science learning. As this study examined the features of design that supported the engagement of students' community and cultural capital, and how students conceptualize environmental justice (EJ) and social justice (SJ) issues in their community using that capital, a FoK framework served in emphasizing the integration of "everyday resources with disciplinary learning to construct new . . . practices that merge the different aspects of knowledge and ways of knowing offered in a variety of spaces" (Moje et al., 2004, p. 44).

Empirical Research Insights

> Yet, the problem for many students from nondominant groups is that they find school science curricula, instructional practices, and school science culture to be rigid, predetermined, and exclusionary of their values and experiences. (Upadhyay et al., 2017, p. 2530)

In this first section of this chapter, I provided insight into the theoretical and conceptual guidance of this dissertation study. I offered evidence as to how sociocultural theory and constructivism serve as lenses to view learning as a social process that values the structures and circumstances through which knowledge is constructed, and how the inclusion of student FoK in teaching and learning can serve as a bridge between students' lived experiences and school science education. In this next section, I describe the goals of the NGSS, a set of research-based science standards, in relation to this study, discern how relevant empirical literature around school science has used these theoretical and conceptual ideologies in practice, and provide critiques of current classroom practices that I believe our CBS curriculum can address.

NGSS

The NGSS advocate for teachers to adapt instructional practice to address problems in the world by providing educators with the flexibility to design classroom-learning experiences that stimulate students' interest, and appeal to their surrounding environments. Appendix D of the NGSS (2013) states:

> Strategies that involve the community underscore the importance of connecting the school science curriculum to the students' lives and the community in which they live. It is through these connections that students who have traditionally been alienated from science recognize science as relevant to their lives and future. (p. 9)

NGSS' attention to the centrality of students' lives and community in formal science learning points to the recognized need to create further connections between classroom and community to support students in taking intellectual agency over what counts as knowledge in their classroom (Pruitt, 2014). Connecting classroom and community is especially important for Indigenous students and students of color, as their worldviews and experiences have traditionally been alienated in favor of a Eurocentric version of school science (Aikenhead & Michell, 2011).

Despite NGSS' attempts to demonstrate the importance of in-and-out of school connections in science, like many of the standards currently guiding K–12 teaching, the standards fail to specify how pedagogy and curriculum design can bridge school science and students' lives, as well as how teachers can navigate the social, political, and ethical dimensions of science learning. Specifically, the NGSS fall short of supporting transformative educational opportunities for SoC in three ways. First, the NGSS presents harms of scientific enterprise and the distribution of those harms in the neoliberal ideologies; thus, it can be argued that when teachers use these standards in instruction, they are also maintaining the status quo (Morales-Doyle et al., 2019). Second, the standards do not address the social and political facets of environmental issues, as environmental challenges are undertaken from the universal perspective (Feinstein & Kirchgasler, 2015). As such, the conceptualization of the environment is presented as an entity separate from people, with agency is ascribed to action rather than people (Hufnagel et al., 2018). Finally, the NGSS aligns accessibility with equality, maintaining configurations in instruction that do not interrogate structural inequities nor represent diverse perspectives or epistemologies (Bang & Marin, 2015; Hoeg & Bencze, 2017; Rodriguez, 2015). Combined, these shortcomings in the NGSS create gaps in instruction that teachers are forced to fill in hope to create curricular materials and lessons designed to be relevant for SoC.

The CBS codesigned curriculum developed for this study sought to fill these gaps by designing specific curricular features that connect classroom concepts to the contexts of the everyday lives of SoC, specifically focusing on the spaces students and places students inhabit and interact in in science. In using these approaches, our goal was to help students *scientize* their daily lives. Drawing from Clegg and Kolodner (2014), to scientize students' lives means to recognize the relevance of science in the everyday activity's students participate in by engaging in inquiry-based thinking around these activities. As further described in Chapter 4, scientizing students' lives includes developing a set of practices and a disposition in teaching and learning that students can use as the encounter new world experiences. These practices include pursuing interests, asking questions, considering causality in phenomenon, and investigating hypotheses (Ahn et al., 2016).

Contextualizing "School Science" for Students of Color

Mary Montel Bacon has presented a theory in education research known as the generational education dilemma. This theory claims current educational system conditions, which have led to the norm of inequitable education for SoC, are a result of historical oppression (Brown, 2019). In science education, specifically, the validity of this theory can be examined through the historical "stereotyping, linguistic prejudice, and cultural conflict that undermine a school's capacity to provide an effective education for all . . . [with] science that is taught today reflect[ing] generations of science teaching taught with a single audience in mind" (Brown, 2019 p. 4). Therefore, models of teaching "reinforce a tradition that does not do right by all students" (Emdin, 2016, p. 7). Despite society's increasing diversity, diversity in the teaching force has begun to decrease (Brkich, 2014), leading to classroom spaces where the lives of teachers and students are incongruent. In urban schools specifically, there are often a high number of white, middle-class teachers in majority SoC classrooms. These teachers often do not understand SoCs "unique ways of constructing knowledge, use[ing] distinct modes of community . . . and hold[ing] cultural understandings that vary from established norms" (Emdin, 2016 p. 8).

Many urban SoC share similar perceptions of their school science experiences, similar to the testament of one student who told me how science was not important to him because he "doesn't want to be a scientist or biologist" (Field Notes, March 15, 2019). The current conditions of school science (Brickhouse et al., 2000) define narrow and objective forms of expertise, leading to cultural misalignments between community and school (Dillon, 2009; Emdin, 2016; Gilbert, 2006). These cultural misalignments often lead to the mischaracterization of SoC as uninterested in schooling and education (Gorski, 2013). Barton (2003) argued, however, educators must consider the whole lives of the children they teach to teach science from an SJ perspective—including the experiences and prior knowledge they bring to the classroom—and know how that knowledge is "tied to the very sociopolitical power structures that drive science education and society" (p. 118).

In education, curriculum is usually described as a process that helps plan formal educational activities; however, curriculum can also be defined as a praxis, which has "embodied values, thinking abilities and intended actions" (Bell et al., 2016, p. 4). In curriculum, there is often a "hidden curriculum" with unintended influences on activity, dialogue, and learning. How educators view expertise in this hidden curriculum can disenfranchise certain groups of students due to cultural misalignments, while simultaneously attempting to advocate for equity and school improvement (Emdin, 2016). Linking community to the curriculum and teaching framework, however, has been put forward to construct science as relevant in local contexts (Bell et al., 2016; Brown & Crippin, 2017), embrace the convolution of space and place and their collective impact (Emdin, 2016) and promote equity in teaching and learning. In these links, the inclusion of linguistic and cultural resources as capital for learning has been seen as essential steps toward making school science a more applicable topic for SoC (Silseth & Erstad, 2018).

Linguistic and Cultural Resources in Science

Irish and Kang (2018) posited the facilitation of student connections with their FoK must begin at the curricular level and be supported by the discourse practices of the teacher. The terms "scientific" and "everyday" are often framed in dichotomous terms, with the first seen as a privileged form of objectivity, and the latter seen in terms of ambiguity and subjectivity (Warren et al., 2001). For children who grow up being labeled as disadvantaged, these dichotomies devalue their methods of knowing and verbalizing, and see them as juxtaposed to those traditionally esteemed in school science. In out-of-school contexts, students develop ways to talk about, and explain, scientific phenomenon through colloquial, nonscientific language (Brown, 2019; Gomez, 2007). Although this language may not be considered 'scientific,' their descriptive ways of justification have logic, despite their vocabulary and conceptual framing (Gomez, 2007). In failing to respect idiomatic understandings in classroom discourse, teachers fail to understand the intelligence of those who have incredible ideas "simply because they are using language that we do not associate with brilliance" (Brown, 2019, p. 86).

The language used in science is often in juxtaposition to students' idiomatic understandings and can serve as a gatekeeper to interactions that produce inequities in science education (Brown, 2019). Too frequently, canonical science concepts and curricular materials illustrate the language and culture of SoC are not valued, and do not hold scientific depth or intellectual benefit (Boutte et al., 2010). Science curriculum and instruction, therefore, necessary for science curriculum and instruction to reorganize the ways in which language, culture and cognition are valued in shaping teaching and learning (Warren et al., 2001) to extend knowledge beyond the walls of the classroom (Tolbert et al., 2017). Science teachers must understand how to interpret and translate scientific discourse into colloquial language (Gomez, 2007) to redefine what counts as scientific literacy and who is seen as scientifically literate.

In science classroom learning and conversation, students are often bombarded with foreign scientific terms they are expected to understand and use in classroom discussion (Brown, 2019; Warren et al., 2001). This can limit student participation in classroom dialogue, as they are unable to articulate knowledge in expected linguistic formations (Gomez, 2007). Teachers, however, can use pedagogical practices that recognize the linguistic and cultural resources of their students, leading to increased participation through the inclusion of FoK in learning (Moje et al., 2001). Although a student's verbalization of a concept may not be considered scientifically correct, the student's conceptualizations can be used as a pathway toward understanding (Boutte et al., 2010).

Students' accounts of everyday experiences to support their understanding of scientific phenomenon cannot only help to uncover previously unnoted aspects of the phenomenon, but also generate space to see and interpret phenomenon differently (Warren et al., 2000). diSessa and Sherin (1998) argued when students are allowed to produce their own understandings, their descriptions often mirror the scientific concepts intended to be taught. Brown's (2019) work has documented students are often able to describe scientific concepts and phenomena without the use of complex science language. He described how the challenge is not always students' understanding the scientific concepts themselves, but the teacher's ability to recognize their understandings by disaggregating language and concept. When a teacher's epistemological and curricular practices agree with the idea that scientific concepts can be represented through multiple discourses and value students' social and cultural capital, they can begin to change their views of SoC as scientists and science learners. Although I recognize the social and cultural capital, knowledge, and conceptualizations students bring to science classrooms are not unproblematic nor one-directional (Gutiérrez & Arzubiaga, 2012; Philip et al., 2013), teaching and learning must not negate the necessity of supporting and situating expertise in students and communities.

Curricular design must work toward valuing the social and cultural capital and relevant linguistic assets students use to express themselves (Brown, 2019) to make community curricular (Zipin et al., 2012). In "valu[ing] the cognitive resources embedded in students' modes of communicating” (Brown, 2019, p. 58), educators no longer view their cultural understandings in competition with scientific conceptualizations of phenomenon, thereby reorganizing instructional practice to support learning (Meyer & Crawford, 2011). Science educators and researchers should not privilege disciplinary science, but instead foster situations that allow for different linguistic assets to be negotiated, used, and affirmed to address problems of community life (Roth & Lee, 2002) and support lifelong participation and learning in and about collective community issues (Roth & Lee, 2004). In respecting community and culture in learning, educators and researcher create an atmosphere that breaks the contested boundaries of what language is considered scientifically acceptable, and how we value different identities, beliefs, realities, and histories in science learning (Boutte et al., 2010).

Science as Political

Science is not only a way of thinking about the world, but also a political activity—meaning “the doing of science” (Barton, 2003 p. 136) is framed around power, status, and influence in its history, practice, and implications. As such, the political nature of science teaching and learning affects: (a) opportunities for youth to apply scientific ideas to the contexts of their lives; (b) students’ ability to demonstrate and investigate the ways science is connected to larger environmental, cultural, political, and social issues; and (c) the value of students’ personal and community stories as significant contributions to how, why, and when science is done. Stories, as described by Witherell and Nodding (1991), are powerful tools that afford researchers insight into the realities of people’s lives. In science learning, stories provide educators with an understanding of one’s personal identity and cultural context to communicate understanding and experience. The enactment of these stories, along with the inclusion of students’ FoK in science learning, allow students to negotiate power dynamics in the classroom by countering hegemonic notions through the inclusion of their prior knowledge and community resources to support active learning (North, 2015).

In this study, my approach toward curriculum design centered the ways in which scientific phenomena are experienced by the students in their community. This approach included the cultural, historical, and sociopolitical dimensions of these phenomena that interact with the scientific dimensions. I speculate the use of CBS, as further defined later in this chapter, can work toward dismantling political hierarchies of power, status, and influence in science practice by situating learning and productive practice as generating new forms of engagement and knowledge (Bang et al., 2010) with the goal of creating larger social transformation (Morales-Doyle, 2017).

Strategies for the Inclusion of "Everyday Lived Experiences" in Science Education

> Viewing the funds and discourses students have as valuable resources that can be recruited for school science allows not only for a smoother transition between students' life worlds and the science classroom, but more importantly, it also challenges the tight boundaries of school science funds and discourse to be more fluid and porous. (Barton & Tan, 2009, p. 3)

Traditionally, studies that have explored the inclusion of students' everyday lived experiences in science education have used one of three approaches: (a) culturally relevant pedagogy, (b) place-based science, or (c) community-based design. Despite differences in methodology, all three approaches concur that students' social, linguistic, community and cultural FoK should be used to support SoC understanding of science in their everyday lives (Tan & Barton, 2010); teach science that develops from, and reflects the goals, values and resources of the local community context (Bouillon & Gomez, 2001); and generate a school science environment in which knowledge is not static, but instead, “shared, recycled and constructed” (Ladson-Billings, 1995, p. 481).

Culturally Relevant Pedagogy

The concept of culturally relevant pedagogy (CRP) was developed by Ladson Billings (1995) to “empower students intellectually, socially, emotionally and politically by using cultural referents to impart knowledge, skills and attitudes” (p. 18). Currently, CRP is used in classroom contexts to make learning more relevant and meaningful for linguistically and culturally diverse students by using their conceptualizations, prior experiences, cultural knowledge, and performance styles as resources for learning (Bonner, 2009). Using an antideficit framework, CRP contextualizes the cultural capital of students’ community and identity as valuable resources that challenge inequitable school and societal structures and promote academic achievement (Ladson-Billings, 2002). CRP has been used in a variety of studies on science education in connection with SoC (Boutte et al., 2010; Brown et al., 2019; Brown & Crippen, 2017; Emdin, 2011), specifically focusing on how CRP validates students’ experiences and worldviews, elicits their interest to make science relevant, and uses activities that explore and draw upon the scientific FoK of their community spaces.

Boutte et al.’s (2010) study investigated the use of CRP in science instruction for Black students to bridge school science instruction and their community realities and ways of knowing. In one activity, they asked students to use personal references to develop analogies for scientific terms of the cell structure. Students referenced the Black church using the theme Let the Cells Say Amen, and pop culture using the theme What’s a Cell to a Cello? In another activity on DNA sequencing, the researchers reinforced students’ knowledge and promoted cultural relevance by having students identify selected blood disorders relevant to the Black community, such as sickle cell anemia. They then engaged in discussions around the implications of DNA sequencing for activities such as paternity testing and crime solving. Overall, their use of CRP served to move beyond the idea of a neutral, apolitical stance in science education, and instead recognized there is no singular nor normative scientific viewpoint, but a "wide range of scientific skills and ways of knowing that people display in their lived experiences in diverse communities." (p. 2010).

In Brown et al.'s (2019) study on teachers' use of CRP science practices in an all-Black urban school, they found teachers' conceptualizations of CRP were often centered around using real-life examples when teaching, and starting lessons by centering a problem in a context that was applicable to students' lives. For example, when one teacher taught a lesson about the sun and energy, the foundational problem centered around students being made fun of for having darker skin and more melanin. Their goal was to use students' knowledge about melanin as a resource for learning the beauty and value of having darker skin. They argued using CRP allowed students to "gain a richer understanding of STEM and its connection to their local communities" (Brown et al., 2019, p. 778).

Overall, these studies have all pointed to the benefit of using CRP as an antideficit framework to engage the community and cultural resources of diverse students in science education (Boutte et al., 2010). Although studies have eluded to Ladson-Billings (1995) laying the theoretical groundwork for including the cultural ways of SoC in education, and working toward dismantling dominant power structures, it has been argued that more work needs to go "beyond rationalizing the need to include the linguistic, literate and cultural practices of our communities meaningfully in educational spaces" (Paris & Alim, 2014, p. 88), and work toward developing pedagogical frameworks that can be sustained in practice.

Researchers, such as Sleeter (2012), have further reasoned a major critique of CRP in practice. She stated CRP is often used in simplistic and limited ways, such as cultural celebration, trivialization, and essentializing culture. Too often when CRP is used in schools, SoC and immigrant student home cultures are celebrated, but not sufficiently used as resources for their own learning (Nykiel-Herbert, 2010). CRP is regularly reduced to several steps to follow for cultural inclusion and characterized by fixed and homogenous conceptualizations of all members of an ethnic group culture "rather than understanding it as a paradigm for teaching and learning" (Sleeter, 2012, p. 569).

Place-Based Science

Place-based education (PBE) has been used as an alternative science teaching method that researchers believe can be sustained in practice to move away from isolated standardized science instruction (Semken & Freeman, 2008). By using the local community and environment as a starting point to teach concepts, PBE stresses hands-on, real-world learning experiences that emphasize an understanding of natural phenomenon and science related social issues that are relevant to student's everyday life (Brkich, 2014).

The success of PBE for urban SoC has been documented in several studies (Adams et al., 2014; Brkich, 2014; Buxton, 2010; Davis & Schaeffer, 2019). In a study of earth science teaching in a fifth-grade classroom, Brkich (2014) used auto-driven photo elicitation to probe students' ideas of, "Where do you find earth science in your life" (p. 147)? Their study found PBE provided direct connections to students' lives through observable examples in the community and indirect connections, such as the use of analogies for phenomena that cannot be directly observed. Davis and Schaeffer (2019) conducted a study on the effects of place-based science education on Black student meaning making of water and water justice in Michigan.

Using a PBE unit called *Water is Life*, they leveraged conventional science content to help students understand the properties of water, and PBE strategies to help students develop a deeper understanding of their lived experiences with issues of water injustice, and the need for greater change. Through classroom observations and interviews, they found PBE strategies allowed students to use their experiences as a basis for socioscientific meaning making.

PBE research has also largely focused on out-of-school settings, as well as on teacher education. In a study conducted at a nature-center program for low-income youth of color, Buxton (2010) found statistically significant increases in students' science content knowledge of risk factors related to water in both the local and global context through critical PBE instruction. He argued critical place-based pedagogy in science can help learners to increase their awareness of social, political, economic, and environmental injustices, and work to "diminish inequities by raising youth consciousness" (Buxton, 2010, p. 130). Adams et al. (2014) conducted a study on preservice STEM teachers of Native American students and found teachers believed engaging in PBE helped their students develop deeper knowledge, provided opportunities to connect experiences, lead to greater retainment of content, and increased motivation in learning. Overall, these studies (Adams et al., 2014; Buxton, 2010) offered strong evidence that PBE can be a beneficial strategy to engaging students in real-world learning experiences that can enhance their understanding of social issues.

Researchers such as Aikenhead (2006) have argued PBE in science teaching can be problematic, as PBE focuses on preparing the teacher to be a "local expert" and "cultural translator" rather than the student. Although being the "local expert" is beneficial for educators who have local knowledge or come from the community, many teachers in urban communities of color are not from and do not live in the community they teach. Therefore, they cannot act as these “cultural translators,” as they do not have familiarities that allow them to connect science content to the lives of their students (Brkich, 2014). Although they may be able to empathize with student experiences, they are not able to holistically understand how to use these experiences to bridge science content and community life. As a result, the “disadvantaged” label given to SoC, especially those of lower socioeconomic status, more accurately reflects the “fundamental lack of alignment between their own funds of knowledge and those of the teacher” (Hogg, 2011, p. 667) rather than an actual lack of understanding.

Community-Based Education

Community-based design (CBD) emerged, in large part, in the late 1980s from the work of researchers at the Cheche Konnen Center. Their work has been dedicated to transforming learning and teaching for students from nondominant communities, focusing on engaging in deep and meaningful science leaning that can be used to navigate everyday life TERC, 2014). Although some research has focused on the use of CBD is urban spaces (Bouillion & Gomez, 2001), research using this framework has primarily been used in Indigenous communities (Aikenhead, 2011; Bang & Medin, 2010; Warren et al., 2001) to situate students as cultural experts, and first extend community-based ways of knowing to then understand Western conceptualizations (Bang & Medin, 2010). CBD works from in the ontologies of the community (Bang et al., 2016), and rests on the participation of all community members in education to address locally relevant scientific phenomena (Bang et al., 2010). In these community-based practices, studies have alluded to the benefits of including youth participatory action research tenets to create room for youth to exercise shared power in school spaces (Kirshner et al., 2011; Kornblush et al., 2015).

Bang et al. (2010) used CBD practices in their research on a forest ecology unit with students of the Menominee people in Wisconsin. Through these practices, they saw a shift in students from seeing science as a “body of knowledge,” to seeing science as a “set of practices for learning about the world” (Bang et al., 2010, p. 16). In these shifts, conceptualizations of culture in science transformed from being seen as an “add-on” in lesson plans, to a foundational base from which science knowledge is built. Similarly, Bang and Marin (2015) studied how science learning occurs in everyday nature–culture relations relative to waterways, with Indigenous middle school children in a Chicago science summer program. They argued that due to canonical science’s settled expectations of nature–culture relations, science learning far too often restricts identity and agency for Indigenous students. Thus, they called for the need for science education curriculum and practice to “empower and build from the ontological heterogeneity reflective of peoples’ lived lives, particularly those historically dispossessed and dominated” (Bang & Marin, 2015, p. 542).

Although the benefits of CBD in science have clearly been detailed in the literature, and much research has illustrated the advantages of connecting science to students’ everyday lives, much of this research has focused on connecting the “lived experiences of Indigenous populations, and not the lived experiences of urban students of color” (Brkich, 2014, p. 143). Therefore, there is a need to conceptualize these community-based frameworks and practices in other settings and among other populations. In the smaller amount of research that has focused on the use of community-based science curricula practices in urban environments with SoC, it has been argued that the inclusion of EJ-focused CBS can be used to engage students in real-world scientific investigations and problem solving as a means to anchor classroom instruction in their everyday lived experiences (Bellino & Adams, 2017), and engage SoC in a collective, holistic, community-rich frame of thinking and learning

Community-Based Environmental Science as a Curricular Framework

> Challeng[ing] epistemological hierarchies and mak[ing] space for critical, diverse and lived accounts of scientific phenomena. (Davis & Schaeffer, 2019, p. 369)

Due to the impacts of structural racism, environmental injustice, and urban disinvestment, urban school communities have seen massive restructuring and the development of significant EJ and SJ issues (Green, 2018). People of color, those of lower socioeconomic status, Indigenous, and immigrant populations are consistently disproportionately affected by environmental issues in their communities (Pellow, 2016). Subsequently, researchers have sought for greater place-based and community-based education strategies that address these SJ issues in science education to link schools and the local community (Bang et al., 2010). When instruction is contextualized in the local environment, in-and-out of school learning trajectories can be bought together to provide students with a means to use their everyday experiences as tools to inquire about curricular concepts (Silseth & Erstad, 2018).

Science Education as and for Participation in the Community

Despite the standards of “Science for All,” school science continues to remain largely unchanged, focusing on everyday practice and ways of knowing in white, middle-class, and hegemonic perspectives (Roth & Lee, 2004). All communities, no matter their location, have specific issues that affect the daily lives of its members. When learning contextualizes around these community-relevant issues, students are provided with more significant opportunities to participate as active citizens by “contributing to the knowledge and representations available in, and to, the community” (Roth & Lee, 2004, p. 272). In viewing science education as participation in the community, educators encourage students to investigate issues on their own terms and in their own ways, using representational tools that best fit their needs.

From this perspective, the concept of community has an expansive and transformative view guided by an SJ-focused science practice. This understanding of science as participation in the community challenges deficit perspectives by incorporating diverse ways of knowing (Tolbert et al., 2017) through a definition of *community* that includes not only the geographical boundaries of the local area, but also the cultural epistemologies and historical ontologies of students' social and cultural environments. In doing this, educators challenge what is defined as privileged forms of knowing and learning, leading to increased participation in science from traditionally alienated students (Roth & Lee, 2004).

Further, when science is taught from community perspectives, students can discuss issues in their own relevant frameworks and epistemologies, while engaging themselves in everyday cultural practices, without the feeling of being "unscientific" (Aikenhead, 2011). When students are involved in real-world community problem solving in school science, we transcend past traditional approaches of preparing students for future science classes, to nuanced approaches of *engaging* students in everyday, relevant science activities (Roth & Lee, 2004). We must consider that science is not a matter of fact and fiction, but a collection of social experiences. There is a need to reclassify science and scientific knowledge more broadly, as aspects of collective social activity, and participation in community and cultural life.

Science Education as and for Social Justice

Studies have agreed to the undertheorizing of social justice in science education (Dimick, 2012; Morales-Doyle, 2017; Upadhyay, 2010), specifically for youth living in areas affected by social, political, and environmental change (Tzou et al., 2010). With inequalities in science across gender, class, and race, educators have advised the importance of social transformation to challenge inequality through science teaching and learning (Morales-Doyle, 2017). To do this, studies have pointed toward the need to acknowledge and value the lived experiences and narratives of urban youth as the first step toward science education for SJ (Tzou et al., 2010; Upadhyay, 2010). For SoC specifically, SJ-focused pedagogies are important because: (a) learning takes place in context, (b) students need to be able to see the connection between school science and social contexts, and (c) community knowledge should be shared and respected as assets in science classrooms (Upadhyay, 2010).

Although there is no single conceptual definition of SJ science education, researchers have characterized pedagogical practices using this method of teaching in different ways. Morales-Doyle (2017) conceptualized a justice-centered science pedagogy on a macro-scale as a framework to address inequities in science education by challenging larger structures such as white supremacy and neoliberal capitalism. His pedagogy draws from Ladson-Billings' (1995) CRP and addresses issues of race, racism, genderism, sexism, and economic exploitation by focusing on the development of critical consciousness, and the praxis of social transformation to decrease reproductive forms of assimilation.

On a more micro-scale, Dimick (2012) argued SJ science education fights against social inequalities by creating more equitable access and opportunity for marginalized students to participate in science and pursue science careers. In her conceptualization of SJ science education, Dimick believed pedagogical practices should support active learning by drawing upon students' prior knowledge as resources in learning to critically assess curricula and transform their public and personal environments. Her lens used three tenets of the student empowerment framework: (a) social empowerment, (b) political empowerment, and (c) academic empowerment, to take an antideficit stance by providing students with opportunities to negotiate participation roles, and share classroom authority (Verdin et al., 2016).

Finally, Davis and Schaeffer (2019) theorized a justice-oriented science pedagogy as a response to the need for pedagogical models that "problematize privileged forms of science and situate learning in the context of larger justice movements" (p. 369). By leveraging students' FoK, and welcoming multiple epistemological ways of thinking in the classroom, this model creates space for diverse and critical interpretations of scientific phenomena. In this framework, students are positioned as "transformative intellectuals" (Davis & Schaeffer, 2019, p. 369) who examine socioscientific issues that are of communal and personal importance and serve as actors of change. This framework is especially relevant to SoC as it addresses historical oppression by highlighting the interconnectedness of various domains of everyday life and scientific enterprise and stresses the significance of merging science across contexts.

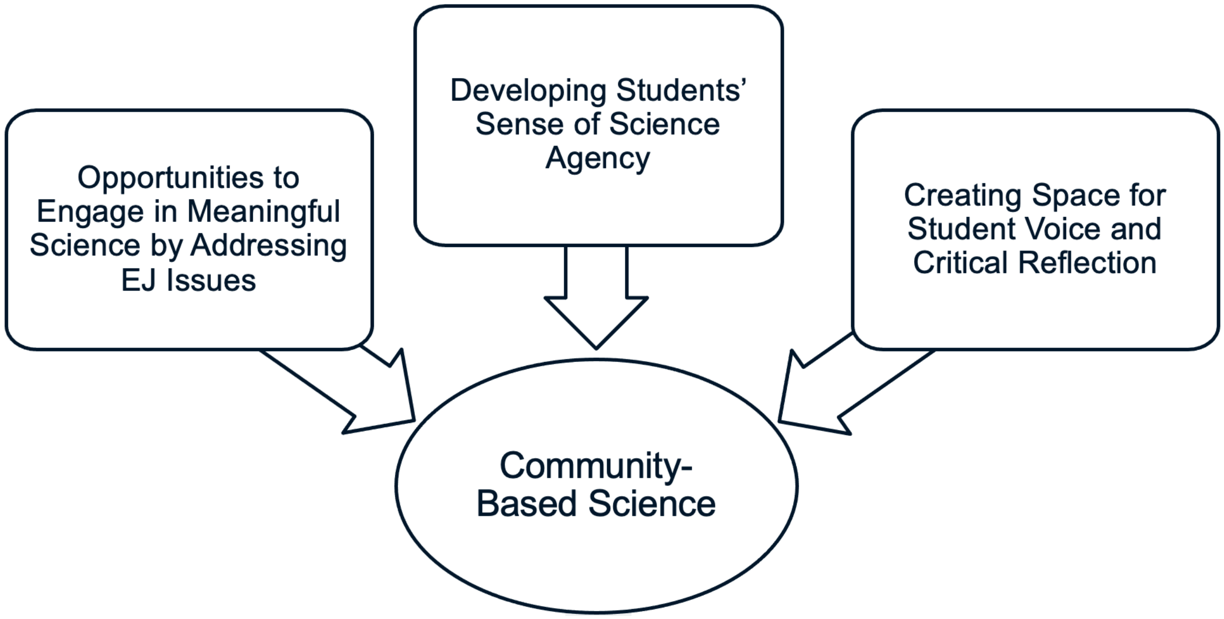
In my CBS framework, I drew from the more micro, socially focused justice-oriented pedagogy of Davis and Schaeffer (2019) and student empowerment framework of Dimick (2012). These frameworks take an active stance toward the inclusion of social justice in science education, with a focus on local issues that are relevant to student's daily lives. Although my frame of CBS conceptualization draws from some of the central tenets of these frameworks, it differs in its approach by focusing on both EJ and SJ issues. In aligning with the values of SJ science education, my view of CBS negotiates what counts as knowledge in science classrooms by drawing upon students' FoK as resources for understanding how EJ and SJ issues are present in their everyday lives. Extending ideas of place-based pedagogy, community-based education and Dewey's idea that learning most frequently and naturally occurs at the intersection of people, purpose, and their local community (Harms & DePencier, 1996), I argue CBS orients community, and learning, to people, place, purpose, space, and reality (Buxton, 2010; Clark & Gyles, in press; Emdin, 2016). Thus, my goals in CBS are to provide students with opportunities to connect school science concepts to their lived experiences in relation to issues of EJ to foster genuine purpose in science learning.

Goals of the Community-Based Science

CBS, which anchors science in locally and socially relevant phenomena to provide students with opportunities to contribute and use their funds of knowledge in learning to conceptualize canonical science content and address community injustices, is grounded in three major goals (see Figure 1). Vetted in the literature, these goals support the ways I believe students can and should be supported in engaging in more authentic science learning by developing connections between school science and community through investigations of local EJ and SJ issues.

Figure 1

Goals of Community-Based Science



Goal 1: Opportunities to Engage in Meaningful Science

The first goal of a CBS instruction is to provide students with opportunities to engage in authentic science, specifically by addressing relevant EJ and SJ issues. Based on the work of Barton (2001) and Davis and Schaeffer (2019), CBS curriculum seeks to go beyond solely cognitive gains in learning. Built upon and informed by student prior knowledge and experiences, CBS practices contextualize school science around real-world, community relevant EJ and SJ investigations, presenting science as meaningful to students by addressing the context of their everyday experiences in the classroom learning (Mallya et al., 2012). Through engagement in CBS learning, students can construct their own understandings of EJ issues in their community through the application of school science concepts (Aikenhead, 2006), moving away from the traditional, predetermined set of scientific ways of understanding (Mallya et al., 2012), to engaging in a collective, socially, and culturally contextualized way of understanding.

In this sense, “there is a role reversal of sorts, that position the student as the expert in his or her own teaching and learning, and the teacher as a learner” (Emdin, 2016 p. 59).

Goal 2: Developing Students’ Sense of Science Agency

The second goal of a CBS framed curriculum is the development of students’ science agency. Specifically, this goal centers on how students use the content and concepts learned in science classrooms to conceptualize their everyday occurrences and experiences of EJ. Aikenhead (2006) coined the term *humanistic science* to conceptualize school science that is student-oriented, practical, promotes human values, and connected to modern events in society. Mallya et al. (2012) built on this idea to conceptualize *science agency* as students’ ability to realize how science can be used to understand, reflect, make decisions, and take action to transform community spaces. As such, I positioned CBS as building students’ science agency by providing students space to leverage scientific ideas to ask questions, think, and speak more critically about community happenings. These justice-oriented science practices in CBS aim to challenge epistemological hierarchies by designing curriculum that develops student agency and creates space for “critical, diverse, and lived accounts of scientific phenomena” (Davis & Schaeffer, 2019, p. 369). It is important to note agency is complicated and contextual, and students can sometimes have a hard time seeing themselves as having choices and being agents of change (Mallya et al., 2012); thus, agency in CBS is also viewed as improvements in understandings and articulations of EJ issues that students use to make sense of their lives.

Goal 3: Creating Space for Student Voice and Critical Reflection

Based on the tenets of empowerment as seen by Dimick’s (2012) research, the third feature of a CBS curricular framework is the construction of space for student voice and critical reflection in the classroom to help them better understand science in their everyday lives.

Curriculum design should serve to help contextualize science in students' outside lives by creating space for them to use their voices, express their opinions, and engage in collaboration and critical reflection around their views (Dimick, 2012; Emdin, 2016; Moore & Mallya, 2006), to empower them as social and political beings and as academic intellectuals. In giving students voice in their education and the space to use that voice, instruction can take steps toward reducing the alienation some students feel toward science education (Jenkins, 2006) and instead, provide them with opportunities to incorporate their words, thoughts, and ideas in instruction. When students are given voice related to the teaching and learning of science, it opens space for shared authority (Dimick, 2012) and provides opportunities to critically reflect and engage in discourse around science relevance (Logan & Skamp, 2008).

Connecting It All Together

In an increasingly diverse society, there is a need to reframe science education to consider the varied experiences of all students who are served. Sociocultural approaches to science education support the reconceptualization and redesign of curriculum and instruction to recognize the historical and cultural communities that influence student thinking and learning (Miller, 2011). However, social constructivism views learning as an active social process (Amineh & Asl, 2015) where knowledge is constructed based on students' existing FoK (Duit, 1996). These FoK not only serve as important cognitive and cultural resources that support students in understanding academic concepts (Silseth & Erstad, 2018), but also bridge everyday life experiences with classroom practice to counter hegemonic notions through empowering pedagogical practices (Barton & Tan, 2009; North, 2009). By including FoK in science education, educators can promote perspectives of learning that give students voice and power in the classroom and build connections between science and their social and cultural contexts (Upadhyay et al., 2017).

CRP, PBE, and CBD have all made strides to include sociocultural contexts in the frame of science learning. Each of these anti-deficit frameworks strive to include the community and cultural resources of diverse students. They each, however, fall short in their own ways in the contexts of urban SoC. CBS-framed curriculum seeks to use students' FoK, conceptually, through a sociocultural theoretical lens, to engage students in a social, collective, community-rich frame of thinking and learning by contextualizing science through their lived experiences.

Conclusion

In creating a space for students to collectively question the nature of science, and develop deeper understandings of their lived realities in practice and pedagogy, equitable changes in norms, practice, and participation in school science are created by moving away from a deficit view of student abilities (Bouillion & Gomez, 2000) and, instead valuing their roles as creators of knowledge. diSessa (1993) argued student experiences and the developed knowledge informed by those experiences should be thought of as "knowledge in pieces" that can be built upon by educators. Hammer and Elby (2013) furthered this idea by stating students have developed epistemologies based on their life experiences that are immediately relevant to science learning. These epistemologies can be employed in school science contexts to create a more inclusive set of relevant practices and orientations through problem-based and place-based science curriculum that is locally meaningful (Bang & Medin, 2010). These epistemologies should inform canonical content, creating space in science classrooms for the negotiation of what counts as scientific knowledge (Bang & Medin, 2010; Dimick, 2012).

A CBS framework in science curriculum helps to elicit these epistemologies and develop students' connections between classroom content and their lives by (a) providing students opportunities to engage in meaningful science; (b) developing their sense of science agency; and (c) creating space for student voice and critical reflection in class, reducing alienation through opportunities to engage in discourse around relevant EJ and SJ issues. Collectively, this framework engages students in learning by positioning them as experts of their own experiences, whose knowledge and understandings are valid pieces of scientific data (Vossoughi & Shea, 2019). Instead of neglecting broader discourses of global science issues, a CBS framework helps conceptualize these problems in the context of students' daily lives (Brickhouse & Kittleston, 2006) to support authentic and real science learning that incorporates "what scientists do *and* doing it in a way that fundamentally inform[es] [students'] lives" (Barton, 2003, p. 155).

CHAPTER 3: METHODOLOGY

This study explored the design and implementation of a year-long community-based science curriculum in an urban seventh- and eighth-grade Black and Latinx "Energy and the Environment" elective class. I sought to determine: (a) how to integrate and address students' of color (SoC) funds of knowledge (FoK) in science teaching and learning through investigations of local issues of environmental (EJ) and social (SJ) justice, and (b) how SoC conceptualize these community issues through science learning. To address this topic, I employed a qualitative methodological approach to explore the following research questions:

1. Design Question: What are the features of codesigned artifacts that support the engagement of students' funds of knowledge in science learning?
    a. How does a teacher structure dialogue to support the engagement of students' funds of knowledge?
2. Implementation Question: How are students of color conceptualizations of environmental and social justice issues in their everyday lives reflected during the enactment of a community-based codesigned curriculum?

This chapter presents an overview of this multimethod, codesign study research context, including the study site and participants, methodological approach, and data analysis approach.

Research Context

School Site

The motto at The Community School (TCS) is, "Challenging old assumptions. Removing barriers to learning. Reshaping the way we think about public education." TCS is a university-assisted neighborhood public school in South Los Angeles, where this study took place during the 2020–2021 school year. With a student population of Black (51%) and Latinx (48%)

students, 22% of whom are English language learners, the socioeconomically disadvantaged student population (82%) closely mirrors the district as a whole (81%). The racial demographics of TCS, however, serve as a stark contrast to the percentage of Black students in the district (8%) and the state (5%), with a significantly large percentage of the teachers being faculty of color (92%; Quartz, 2019).

Opened in 1926, TCS has been a staple in a community that has undergone many changes in the last 95 years. Until the 1970s, TCS served as an epicenter of educational excellence for the community when, fueled by changing sociopolitical and racial community contexts, student enrollment began to decline at the school as parents sought a better education for their children. In 2016, after plummeting to a total student population under 300, TCS partnered with the University of California, Los Angeles, to rebrand itself as a community-based, learner-centered school where students and educators come together to create a “rigorous and relevant instructional program in a personalized environment” (Quartz, 2019, p. 6). As a partnership school focused on connecting to the community, and a commitment to valuing students’ prior knowledge and experiences and community and cultural knowledge and practices as assets to the learning environment, TCS provided a place for me to engage in the codesign of community-based science (CBS) curriculum. TCS’s commitment to support—not only the well-being of the “whole” student, but also the well-being of the community—served as an essential and compelling place to enact this CBS-framed curriculum that was tightly guided by the knowledge and experiences of students living in the community.

Historical Contexts of the Community

Widely known for its high crime rates, gang culture, low college enrollment, and vast urban sprawl, South Los Angeles is home to approximately 278,000 residents, of whom 28% are

Black and 61% are Latinx. The median household income is $34,000 (City of Los Angeles, 2019). Despite the strides TCS has made to support the community, the neighborhood reflects many of the characteristics of South Los Angeles (Quartz, 2019) and faces serious environmental injustices. Nestled between the 405, 10, 110 and 105 freeways, a steady stream of planes flying to and from Los Angeles International Airport, numerous industrial facilities, car repair stores, and other sources of air pollution, hazardous waste facilities, a lack of trash service, and reliable public transportation, this South Los Angeles neighborhood is a hotspot of environmental pollutants. A 2005 study by the Associated Press found Black people in Los Angeles were 79% more likely to live in a neighborhood that posed a significant danger to their health because of industrial pollution (Bullard et al., 2008). Working-class Latino communities are highly correlated with industrial land, uncontrolled hazardous-waste sites, and high pollution concentrations (Pulido, 2000).

Each day, the students at TCS face numerous environmental and social injustices that impact their lives, their family, their community, and their futures. These individuals and spaces serve as rich sources of knowledge that are underused in science education spaces. As the National Research Council spoke to the need to engage students in science learning designed around everyday applicability and connect school science with their experiences, interests, and knowledge (Prewitt, 2012), TCS served as a space to put this objective into action.

Teacher Participant and Codesigner

Ms. V, the focal teacher of this study, is a 5th-year middle and high school science teacher at TCS. Ms. V and I have engaged in a research–practice partnership (RPP) over the last 3.5 years, beginning in the second year of my doctoral program. RPPs are defined as “long term collaborations between practitioners and researchers that are organized for investigating problems of practice and for developing solutions for improved school practice" (Coburn & Penuel, 2016, p. 48). Together, Ms. V and I designed multiple iterations of community-based science curricular units (4–6 weeks) over our first 2 years, which culminated into the design of a year-long community-based science elective class in our 3rd year.

Ms. V is passionate about teaching. In an interview in late 2018, she reminisced about the days she used to line up her stuffed animals to play school each afternoon as an example to show she has always been interested in education. This passion for teaching led her to pursue her teaching credential through the UCLA Teacher Education program. After graduation, she began her science teaching career at TCS. Ms. V centers her pedagogical practices around the belief that science should develop students' "toolbox" of skills they can use in all areas of their lives. Specifically, she speaks to the importance of science developing students' critical thinking skills to understand and analyze the world around them. Ms. V describes her SJ teaching pedagogy as "honor[ing] [student] knowledge as developing scientists and affirm[ing] that their anecdotal or observational knowledge qualifies as valid scientific data." She believes students have "stories [that] add valuable information and perspectives to our scientific understanding of the processes at work in the community," and believes these stories and experiences can make science more proximally relevant by connecting school science and students' lives. Ms. V's passion for her students and commitment to environmental and social justice learning provided a particularly interesting space for enacting our designed curriculum. During dissertation data collection, Ms. V also served as a coresearcher alongside me, engaging in theory building in our weekly codesign meetings to reflect on and create new understandings of CBS based on our classroom experiences, and putting theory into practice.

Student Participants

The designed curriculum for this study was enacted in two of Ms. V's "Energy and the Environment" seventh and eighth grade elective science classes. Our seventh grade class (sixth period) had a roster of 27 students, with only about 15 students coming to class on a regular basis. Our eighth grade class (seventh period) had a total of 28 students with roughly16 students coming to class on a regular basis. The demographics of both classes closely mirrored that of the school. Due to the transition to online learning as the result of the COVID-19 global pandemic and the multitude of intersecting factors that came with living and learning at home during a worldwide health crisis, students' participation in classroom learning both directly (in terms of verbal engagement in class) and indirectly (in terms of completion of their work), was severely affected. Of the students who came to class regularly, there were even fewer students who habitually completed their work. As such, analyzed curricular artifact data for this study were collected from completed assignments from students in *both* classes to have enough data to support analysis. Data sources for this study are further discussed later in this chapter.

My Role

In both of Ms. V's classes, I served as a curricular codesigner, coplanner, and coteacher over the 2020–2021 school year. This model served to increase sustainability for Ms. V by bolstering her bandwidth to fully engage in the design and reflection processes. I was also supported by the model. A multifaceted role fostered richer data collection and analysis, as I was actively engaged in each step of the process from curriculum design to implementation to iterative refinement. This role further supported a more robust and meaningful learning experience for our students ,as it allowed us to engage in more community building and more frequent one-on-one academic guidance.

In the codesigner role, I worked alongside Ms. V to collaboratively plan our community-based curriculum through weekly codesign meetings. In this space, we developed the overall arc of the curriculum, the specific phenomena and purpose of each unit, and the activities the students would engage with in the unit. As a coplanner, I helped Ms. V develop weekly lesson plans, created content lectures, and gathered supportive materials such as articles and videos. Finally, as a coteacher, I worked to implement the curriculum in real time, along with Ms. V, by serving as the secondary teacher in the classroom. In this role I taught lessons, supported individualized student learning, provided student feedback, and graded assignments just as the head classroom teacher. In this role, I was deeply involved in the day-to-day teaching and learning in the Zoom classroom.

The COVID-19 Global Pandemic, Sheltering in Place, and a Transition to Online Learning

With the unexpected onset of the COVID-19 global pandemic and the subsequent decision by the Los Angeles Unified School District officials announced on March 13, 2020 to transition all K–12 classes to online learning, the designed curriculum in this study was enacted in an online format over Zoom and using Google Classroom. The pandemic exasperated disparities in education for SoC, especially those who are socioeconomically disadvantaged, as seen through a lack of technological resources such as internet access, individualized educational support, and communication from their schools (Dibner et al., 2020). Despite these disparities, Ms. V and I choose to see online instruction as an opportunity to blur the lines between school science and students' lives, enabling our students to see themselves, their family, community, and culture as assets to the learning environment (Agarwal & Sengupta-Irving, 2019).

In physical classroom spaces, the structured nature of K–12 science education can make it extremely difficult to engage students in science learning. This is even more challenging when attempting to find ways to make scientific phenomena both rigorous and locally relevant (Dillon, 2009). These effects are compounded in online learning spaces, where physical and geographical space between students and instructors present key engagement and pedagogical issues (Hull & Saxon, 2009). As pedagogical and instructional practices for in-person learning spaces are not easily .or neatly transferable to online learning (Salmon, 2005), especially considering locally relevant science practices, Ms. V and I were forced to reconsider our ways of engaging students in science education in online learning. To this end, we decided to engage students in a project-based learning (PBL) curriculum design to provide meaningful investigations that reflected local problems and the creation of authentic artifacts that make science learning relevant, engaging, and accessible (Miller et al., 2021). Although we found PBL to be valuable for some students, due to a lack of attendance, there were still issues of consistent engagement across all students due to a lack of attendance. This matter is further discussed in the next section.

The pandemic further surfaced other concerns that were not considered prior to the transition to online learning. First, students were not always willing to turn on their cameras or microphones, as they felt uncomfortable with others seeing or hearing their home environments. As such, many students chose to participate via the Zoom chat feature, often directing their comments directly to Ms. V or myself. Second, some students were at home with multiple siblings or relatives, creating difficulty with concentrating during online learning. Relatedly, some students were expected to support the learning and care of their younger siblings, leaving them bouncing between their own classrooms and that of others. Finally, some of our newcomer students felt uncomfortable participating in classroom dialogue due to disconnects in language. Together, these sets of factors affected data collection, as I was not always able to gather student comments that were not directed toward me in the chat, and the back-and-forth nature of traditional classroom dialogue was also greatly reduced, potentially limiting moments of connection and student learning. This limitation is further addressed in Chapter 6.

Design Contexts

In this section, I provide an overview of the design contexts of this work, including an argument for the use of PBL and a summary of the curricular units.

An Argument for Project-Based Learning as Situational Engagement

Ms. V and I decided early on in curricular development that we would use a PBL design model to engage students more deeply into EJ and SJ science learning through investigations of their own communities. Cited in Appendix D of the Next Generation Science Standards (NGSS, 2013), PBL guides students through a collaborative exploration of a complex real-world problem relevant to students' lives and interests. By situating learning in the investigation of a driving question, this model connects the investigation of community issues to curricular learning goals that emphasize and support students' active involvement in the learning process (Juuti et al., 2021). PBL structures in curriculum, it has been argued, permit students to "experience a wide range of scientific phenomenon . . . with varied phenomena and representations . . . [which] provide various ways for students to interpret and make sense of science ideas" (Rivet et al., 2003, p. 7).

PBL differs from curricular approaches such a problem-based learning (Helle et al., 2006) as the investigation of the driving question in PBL units must end with students developing an artifact that can be publicly shared to demonstrate student learning (Helle et al., 2006; Juuti et al., 2021; Kokotsaki et al., 2016). Like traditional models of PBL in science, our curriculum was guided by three essential attributes in design:

1. An open-ended *driving question* that addresses disciplinary objectives and is relevant and meaningful to students (Krajcik & Blumenfeld, 2006) by addressing *a need in their local community* (Miller & Krajcik, 2019).
2. Opportunities for *extended learning* where students participate in multiple activities and experiences and create physical artifacts that demonstrate their learning over time (Blumenfeld, 1991).
3. The development of a public product through student collaboration (Bell, 2010) addresses a need in the students' local community (Miller & Krajcik, 2019).

Building upon these traditional PBL models, the design of our curriculum specifically focused on the development of PBL structures that support students drawing upon their FoK and cultural and community contexts in learning. Moje et al. (2001), who investigated language and literacy in PBL, noted studies in science PBL must acknowledge the differing ways of knowing that are valued by learners, science discipline, and the leaning context. Our PBL curriculum sought to integrate these ways of knowing in design, specifically drawing upon students' FoK to support disciplinary science learning. Mutually, these ideas provide our motivation for choosing a PBL design structure approach to our online, community-based science curriculum.

PBL and Online Instruction

The COVID-19 global pandemic perpetuated inequities in education due to a lack of access to technology and the internet, preventing many students from participating in synchronous online instruction (Miller et al., 2021). Studies have noted potential challenges in engaging students in PBL instruction in the virtual space, including struggles to engage in meaningful discussion because of technical barriers (e.g., Garrison, 2009) and the development of artifacts in the virtual environment (Swart, 2016). Despite these challenges, Ms. V and I speculated PBL could be a supportive structure for our students, whether they were or were not synchronously participating, as they could engage in discipline and domain-specific learning tasks through data collection on their own time. For example, as addressed in Chapter 4, our PBL structure asked students to interview family and friends as community experts, to position their families, cultures, and communities as resources in science learning (Agarwal & Sengupta-Irving, 2019). As such, students interviewed these individuals to gather data for their individual projects. This project dimension was able to be completed asynchronously for students who were not able to access the online classroom space. Collectively, the PBL structure allowed students to be able to complete their projects without having to be directly in front of a computer or have internet access.

Further, as online instruction perpetuates physical, geographical, and sometimes emotional separation characterized by a lack of interaction between students (Hull & Saxon, 2009), PBL can support social connection as students must collaborate in groups during different dimensions of PBL instruction. Finally, PBL also helps students find resonance in science content and learning, as students investigate issues that are relevant to their own lives and communities. Overall, the decision to use a PBL curricular design served as an approach to science learning that "broaden[ed] student engagement, provid[ed] a rigorous approach to science instruction, and support[ed] a community-based approach to learning" (Miller et al., 2021, p. 643). As the situative perspective of sociocultural theory guided our understanding that knowing and learning are situated in social and material contexts (Lave, 1993), Ms. V and I used PBL as an approach to instruction that situated the observations, experiences, and lives of our students as sources of data to understand and interpret science concepts.

Overview of Curriculum Design

Our CBS curriculum was based on 2 years of knowledge acquired from our students and our own research while developing smaller, EJ and SJ focused units in Ms. V's classes during the 2018–2019 and 2019–2020 school years. Our curriculum was divided into five units that were scaffolded to build students' skills toward designing and completing a self-run project. Table 1 presents an overview of the five units, including the unit topic, driving question and the developed artifact, followed by a description of each unit. As further discussed in the design approaches section, only Units 1 and 3 were analyzed and discussed in this dissertation.

Table 1

Overview of Designed Curricular Units

Unit number	Unit topic	Driving question	Developed artifact
0	Engineering design	How can I build a boat that floats using materials from my home?	Video of floating boat and descriptions of the engineering design
1	Nutrition and food justice	How can I make my favorite recipe healthier?	Redesign of favorite cultural recipe
2	Making my home work better	How can I make my home work better during the COVID-19 global pandemic?	Infomercial on the redesign of a home space
3	Problem solving in our community	Student-Generated	Advocacy letter
4	Student choice	Student Choice	Student choice

Unit 0

Unit 0 was designed to be an introductory unit into PBL. In this unit, students used materials that were already present in their home to engineer the design and development of a "boat" that would float. Students decided on the building materials, created iterations of blueprints of their design, and built multiple iterations of their boat. At the end, students were required to submit each of their blueprints, an explanation of the materials used for their boat, and a picture or video of the final product floating. In this unit, Ms V and I discussed engineering practices and the science and purpose of recycling materials in our homes.

Unit 1

Unit 1, the first unit analyzed in this study, was our nutrition and food justice unit. In this unit, students engaged in learning around the building blocks of nutrition, specifically macro and micronutrients and their purposes in our body, as well as food justice and food access in South Los Angeles. Students were required to interview friends and family to develop an understanding of what they knew and where they learned about nutrition, as well as their beliefs, observations and understanding of food access in their community. For their final projects, students redesigned a healthier version of their favorite family or cultural recipe based on their new knowledge of nutrition and food access. As a class, they voted on their two favorite recipes, and Ms. V and I cooked them and presented are thoughts in class.

Unit 2

The design of Unit 2 was specifically structured to address student's home circumstances during the COVID-19 global pandemic. In this unit, students were required to develop a new system that could be used in their home to make it more comfortable and/or efficient. Students chose to engage in projects that investigated how to better structure their living space when there was a COVID case in their household, or how to redesign their learning space to make it more conducive to online schooling when multiple people were present at home. For this project, students used cause-and-effect analysis to determine what spaces to redesign and created multiple blueprint iterations. For their artifact, students were required to create a short infomercial on their new system they would present to the families as an argument for switching up their homes spaces.

Unit 3

Our place-based unit, problem-solving in our community, served as the Unit 3 project and the second unit of analysis for this dissertation. In this unit, Ms. V and I presented students with introductory resources for nine different EJ and SJ issues in their community (e.g., environmental contaminants and pollutions, gentrification/rent equity, health disparities, food deserts/food swamps, over-policing, mutual aid networks, school funding, public versus charter schools, water waste and greenspace equity), derived from topics students were interested in investigating. In this unit, students developed a driving question based on their topic of choice and went through each step of the science investigation process, including conducting background research, collecting data, analyzing data, and developing a solution to address the issue. Students recorded their findings in their digital interactive notebook (DIN), which housed worksheets and other materials that Ms. V and I developed to scaffold student projects. For the final unit artifact, students wrote an advocacy letter to a local government official or organization they deemed appropriate to discuss the issue and their proposed solution.

Unit 4

The final unit, Unit 4, was our student-choice unit. In this unit, students led each part of their project, from the topic they wanted to investigate to the developed artifact they wanted to create. The only requirement for their project was the topic had to be related to a local issue affecting their community. Students chose a range of topics—from the effects of light pollution in Los Angeles, to the lack of public trashcans and how that contributed to littering in the community. Like Unit 3, students engaged in each step of scientific investigation, and recorded their findings in their DIN. To ease student stress with artifact design, specifically considering grading, Ms. V and I created rubrics for six different artifacts students could choose from, including an advocacy letter, PowerPoint presentation, social media profile, engineered prototype, art installation, or a proposal or action plan. These approaches for students to demonstrate their findings was based on the belief that learning can be expressed through a variety of mediums, and students should be able to attend to their strengths to demonstrate learning. If a student did not like these options, they were able to discuss another idea with us.

In this next section of this chapter, I present an overview of the design approaches used in this study. Specifically, I present an overview and justification for the use of design-based research and codesign approaches in developing curriculum, and then provide an overview of data collection methods and sources, and a detailed explanations of the process of data analysis.

Design Approaches

This study took both a theoretical and pragmatic approach to curricular design by using theory to develop the overall framing and foundation of the curriculum itself, practical community-based issues of environmental and social justice to contextualize content, and learning in the local community to scientize students' daily lives (Ahn et al., 2016). In this study, I sought to determine the features of curricular design that support the engagement of students' FoK in science learning, as well as how students conceptualize EJ and SJ issues in their everyday lives using their FoK. I employed an overarching approach of design-based research through codesign methods to develop an understanding of design features that can be used in science curriculum to support the engagement of students' FoK in learning.

Design-Based Research

Learning scientists have a long history of designing instructional and curricular resources to support classroom-based inquiry learning (Gomez et al., 2018). In recent years, research has alluded to the significance of including teachers in the design process—not only to make the developed resources more operational and sustainable, but also to facilitate ownership of the final product (Gomez et al., 2018; Gomez & Mancevice, 2021). By designing with rather than for teachers, researchers hope to promote the greater likelihood of intervention success.

In this study, I drew on these participatory methods through design-based research (DBR; Brown, 1992; Gravemeijer & Cobb, 2006; Sandoval, 2013; Sandoval & Bell, 2004) as an umbrella approach for the development of our CBS curricular intervention. DBR is a methodology that seeks to create, analyze, and refine interventions that improve the translation of educational research into practice (Anderson & Shattuck, 2012) by grounding the creation of the intervention in participant (i.e., teacher and learner) expertise (McKenney & Reeves, 2013). Maintaining a commitment to designing locally relevant learning (Brown, 1992), DBR interventions are developed through collaborative efforts between researchers and educators to design materials that improve a certain practice that is significant to the contexts of which the design will be implemented (Anderson & Shattuck, 2012).

In this study, Ms. V and I worked to improve science practice by designing curricula that more succinctly integrated and engaged students' FoK in learning, to enhance connections between school science and students' everyday experiences, by investigating local issues of EJ and SJ in South Los Angeles. As DBR is participant oriented, it was necessary for Ms. V and I to address our own underlying theoretical constructs and negotiate authority, value, and power in design (Kyza et al., 2017) to make sure that the developed product was useable and useful to her, myself, and our students (Gomez & Mancevice, 2021).

A commonly discussed limitation in DBR research is the intimate involvement of the researcher in all steps of the research process. It has been argued that this can lead to issues of validity—specifically the credibility and trustworthiness of assertions —as the design process may epistemologically represent the researcher, rather than the combined expertise, knowledge, and skills of all participants involved in design (Barab & Squire, 2004). Design-based researchers have argued the iterative nature of the DBR process addresses this problem (Anderson & Shattuck, 2012) as multiple cycles of design, enactment, analysis, and redesign can address ineffective elements, and adjust for unexpected outcomes (diSessa & Cobb, 2004). To further address the possible threat of intimate researcher involvement, I specifically used a codesign methodology to expand upon the original conceptions of DBR by including the teacher as a curriculum codesigner, versus a receiver, of a designed curriculum.

Codesign

In DBR, participatory design—or methods of research that create new relations between researchers and the researched—are employed in different fundamental approaches in education research. Collectively, these approaches serve to include stakeholders at the table to engage in collaborative interventions to address education issues. Participatory design methods can be seen in a variety of research efforts, including participatory action research (Fine et al., 2003; Whyte, 1991), youth participatory action research (Cammorata & Fine, 2018; Kirshner, 2010; Mirra et al., 2015), or codesign (Gomez et al., 2018; Kwon et al., 2014; Kyza & Nicolaidou, 2017; Penuel et al., 2007) to name a few.

This study used a codesign approach toward generating a CBS curricular intervention to ensure buy-in from Ms. V through collaborations to develop locally useful instructional tools (Gomez et al., 2018; Penuel et al., 2007) that ensured utility and feasibility (Kwon et al., 2014; Penuel et al., 2007; Peters & Slotta, 2008) and supported student learning (Samuelson Wardrip et al., 2015). Codesign methods are structured to give teachers a participatory voice, ensure the effectiveness and long-term sustainability of reform efforts (Kyza & Nicolaidou, 2017; Roschelle et al., 2006), and mediate difficulties in practice by involving teachers as active members in design who have ownership, voice, and stake in the process of intervention development (Gomez et al., 2018). In total, codesign seeks to improve educational practice by combining educational research, teacher professional learning, and pedagogical design (Juuti et al., 2021).

The codesigned curriculum that Ms. V and I developed was organized around the belief that science education should be situated to provide students with opportunities to use their knowledge about their environment to engage in science learning that extends in and beyond the classroom. Through weekly curricular refinements, as further discussed in the next section, Ms. V and I aimed to ensure the designed materials supported the engagement of our students' FoK in learning, actively engage our students in investigations of their lived experiences, and sanctioned students' knowledge, descriptions, and self-understandings of scientific phenomena as contributions to the learning environment. Collectively, the codesign process supported us in "bridg[ing] between core practices of a democratic education – such as inquiry, critical thinking, voice, and social relevance—and the demands of new academic standards" (Kornblush et al., 2015, p. 869).

Data Collection Methods and Sources

Four data sources informed this study: (a) researcher–practitioner codesign meeting artifacts, including lesson plans, PowerPoints, designed activities, DIN template, and meeting notes and transcripts; (b) field notes from classroom observations, including memos and transcripts; (c) classroom artifacts, including student work; and (d) teacher interviews. These data sources allowed me to document features of design that best supported the inclusion of students' FoK and what type of FoK it supported, and document how SoC conceptualize EJ and SJ issues in their everyday lives by connecting canonical science content to their lived experiences. The primary data source to address each research question, description of that data source, and the method of analysis can be seen in Table 2.

Table 2

Summary of Data Sources

Data source	Description	RQ	Method of analysis
Researcher-Practitioner Codesign Meeting Artifacts	Weekly lesson plans; Lesson/lecture PowerPoints; Designed unit activity templates (e.g., worksheets, unit reflection activities, community circle note catchers); Digital Interactive Notebook (DIN) template; meeting notes and transcripts	RQ1	Round 1: Deductive coding Round 2: Open coding Round 3: Axial coding Looked for common features across all codesigned artifacts using constant comparative analysis (Strauss & Corbin, 1998)
Field Notes/ Classroom Observations	Unit memos from researcher; transcripts of teacher and student talk during class sessions	RQ1 and RQ2	Round 1: Deductive coding Round 2: Open coding Round 3: Axial coding Looked for common features across all artifacts using constant comparative analysis (Strauss & Corbin, 1998)

Data source	Description	RQ	Method of analysis
Curriculum Artifacts	Student work samples; student final projects; student reflections; student DINs	RQ2	Round 1: Deductive coding Round 2: Open coding Round 3: Axial coding Looked for common features across all artifacts using constant comparative analysis (Strauss & Corbin, 1998)
Semistructured Teacher Interviews	4 interviews (2 during the 2020–2021 SY, and 1 from the 2019–2020 SY, and 1 from the 2018–2019 SY)	RQ1	Round 1: Deductive coding Round 2: Open coding Round 3: Axial coding Using constant comparative analysis (Strauss & Corbin, 1998)

Researcher–Practitioner Curriculum Design Meetings

To engage in an inquiry into RQ1, determining the features of the codesigned artifacts that supported the engagement of students' FOK in learning, Ms. V and I met four times over the course of the summer to develop the overall arc of our designed curriculum. Ms. V and I met weekly during the school year to complete lesson planning and design refinements. Frequent meetings were essential to ensure we could iteratively refine the curriculum as we continued to determine essential structures and components of design. During our summer design meetings, which lasted between 1.5–3 hours each, Ms. V and I developed the curriculum map, which included: (a) the overall arch of each unit including the timeline, (b) topic of focus, (c) driving question, (d) initial guiding event, (e) skills of focus, (f) potential community experts, and (g) the final product style. During this time, we also developed our "must haves," or the essential elements each unit should include, our PBL lesson sequence, or the order of events for each unit, and our considerations for distance learning, or factors to note that online learning could affect.

During the 2020–2021 school year, Ms. V and I met once a week (a total of 39 meetings), anywhere from 20 minutes to 1.5 hours to reflect of the current week's teaching, create any necessary curricular refinements, and lesson plan for the following week. The first part of these audio-recorded meetings was spent reflecting on the past week of teaching. Juuti et al. (2021) highlighted the importance of reflection in RPPs for teachers to share their experiences in unit implementation, and collectively analyze student engagement in learning. During the reflection section of our design meetings, Ms. V and I would discuss student learning and determine areas of success and areas of improvement in the unit and material design for the current week. We then made recommendations to support the next iteration of design. We separated our recommendations into three categories: (a) immediate refinements, (b) intermediate refinements, and (c) long-term refinements (Gomez et al., 2015). By separating our recommendations in these categories, we were able to determine pertinent refinements needed for urgent changes in the design of our lessons and materials, and suggestions that could be saved for later lesson iterations. We then made changes to the curriculum map and redesigned artifacts as needed.

The second part of our meeting was the lesson planning section. During the lesson planning portion, Ms. V and I developed our weekly lesson plan by documenting and developing activities and the order of activities we would have students engage in. Further, we put together our lecture slides for the week, and created any worksheets, reflection activities, or community circle note catchers or questions. Due to time constraints, not all activities were completed during our meeting. If there was work still to be done, Ms. V and I would assign each other homework, which we would then email to the other person when completed for feedback and revisions.

Over the course of the year during our design meetings, Ms. V and I designed and developed multiple iterations of a DIN. The DIN was a space for students to document and keep track of their thinking, research, findings, and solutions at each point of investigation in the PBL process. At the start of each unit, Ms. V and I spent one to two meetings redesigning the DIN based on our own observations and feedback from students as to which sections and questions were useful, as well as what should be added to make it a more supportive and engaging space.

After design meetings, I memoed our ideas for activities, the development of lesson materials, our intended takeaway concepts for students, how we believed these activities would support students' FoK, and our individual roles in supporting material design outside of meeting times. Through these records, I was able to account for what Ms. V and I believed the design feature would accomplish and cross analyze that objective with student data to determine how it was used by students in practice. As further described in Chapter 4, only two out of the five units were analyzed for this dissertation due to design quality and the quality of data. Therefore, only design meeting transcripts from Unit 1 (six transcripts) and Unit 3 (six transcripts) were analyzed, as well as the four summer design meeting transcripts, for a total of 16 transcripts. Although Unit 3 ran for a total of 11 weeks, transcripts for short meetings that did not cover any significant material were not included in this analysis. After our meetings, I transcribed all recordings, cleaned the data, and deleted the original audio.

Field Notes and Classroom Observations

Participant observations were conducted five times a week during the 9 months of the 2020–2021 school year. During class, I served as a participant observer and a coteacher, both memoing and noting moments of connection and FoK elicitation by Ms. V and FoK use by students, leading lessons, and supporting individual student learning through teacher support. My observational efforts were guided by an inquiry into RQ1a, understanding the communicative signals that Ms. V and I used, which often mirrored the designed artifacts, as "responsive teaching practices" (Gotwals & Birmingham, 2016) to invite in students' community and cultural FoK into classroom dialogue, and RQ2, to understand how students conceptualized EJ and SJ issues in their community using their FoK.

To inform RQ1a, I looked for evidence of recurrent communication signals, including verbatim speech and paraphrased talk, that served as a guiding tool for Ms. V and I to (a) invite students to use their FoK to draw connections between classroom content and out-of-school contexts, (b) affirm student connections as significant pieces of scientific understanding and, (c) reflect upon these FoK in response. As further discussed in Chapter 4, a *communicative signal* is an instructional move in discourse that a teacher uses to actively engage students' ideas about, and orientation to, a concept to facilitate learning (Harris et al., 2012). An example of Ms. V's use of a communicative signal in classroom discourse is posing open-ended questions to invite in student wondering, experiences, and understandings to make connections across different contexts. To inform RQ2, I looked for patterns in student talk, specifically in how they articulated their understandings of EJ and SJ as problems in their community and their perceived effects of these issues.

During these audio-recorded lessons, I noted times in the recording where Ms. V or a student made a particular comment in reference to the research questions; after the lessons, I pulled the noted comments from the transcript. The original audio file was then immediately deleted. Evidence from these participant observations were cataloged weekly into a field notebook. All observational field notes for Units 1 and 3 were analyzed, and all findings were recorded and examined through analytic memos to track conclusions, and consider, analytically, what communicative signals were used by Ms. V and myself, and how students conceptualized their understandings of EJ and SJ issues.

Curriculum Artifacts

A content analysis of completed designed artifacts including student work samples (i.e., designed activities), student final projects (i.e., student recipes for Unit 1 and student advocacy letters for Unit 3), student reflections (i.e., unit reflection activities) and student DINs (i.e., their investigative process) were analyzed to determined themes around students' conceptualizations of community EJ and SJ issues. These artifacts allowed me to investigate RQ2 to illustrate if or how students used their FoK, in both dialogue and writing, to understand and articulate EJ and SJ issues, and characterize their connections across place and space.

As a reminder, our artifact design was guided by theoretical constructs of sociocultural theory to (a) promote diversity and inclusion in understandings and interpretations of scientific phenomenon, (b) restructure norms and practice in science to not privilege normative and hegemonic discourse and knowledge, and (c) promote equitable and just participation in learning by viewing science a reciprocal learning process between the teacher and students. Thus, the study sought to position students' FoK as important to their understandings and conceptualizations of science concepts and understand how students capitalize on FoK to explain scientific phenomenon in the community. An example of students using their FoK would be discussing health concerns to conceptualize collective community struggles. When talking about connections between food type and health issues in the community, for example, students made statements such as, "when people live in a food desert, they are at risk of obesity which can cause a lot of health issues like diabetes and high blood pressure."

Quite simply, these artifacts helped me to see how students perceive environmental justice, social justice, and their communities through the design of our activities. Through an analysis of curricular artifacts, I sought to spotlight student voice, experiences, knowledge, and epistemologies as valid sources of scientific data and scientific understanding (see Appendix A).

Semistructured Interviews

Finally, I also conducted two semistructured, audio-recorded, one-on-one interviews with Ms. V at the beginning of the school year (preimplementation) and at the end of the year (postimplementation) to support engaged inquiry in RQ1 (see Appendices B and C). The preimplementation interview served to elicit her interpretations of her teaching philosophy, current teaching practices, beliefs about using students' FoK in science, and beliefs about why using a CBS approach could benefit SoC in science learning. The postimplementation interview served to clarify analysis from the first interview, address the implications of engaging in codesign efforts, discuss specific observations I made during curricular implementation in reference to her elicitation and use of students' FoK to drive classroom instruction and dialogue, and compare her beliefs about the relevance of FoK in science practices pre and post curricular intervention. Collectively, the teacher pre and postinterviews allowed me to document changes in Ms. V's beliefs, practices, and implications of those practices over time, informing my understanding of the benefits and disadvantages of teacher participation in the codesign of a CBS curriculum.

It should also be noted that although I did attempt to conduct student interviews, only two students volunteered to participate. I completed an initial, beginning-of-the-year interview with both students to develop a baseline understanding of their past experiences in science class, their beliefs around teachers' use of their everyday experiences in science, and how they saw current classroom content connecting to their out-of-school lives. I was unable to complete an end-of-the-year interview. as both students stopped coming to class during the 3rd quarter. All transcripts, both student and teacher, were anonymized, transcribed, and stored in a secure online folder.

Data Analysis

FoK, as a framework, theorizes ways to make science relevant to students' everyday lives by capitalizing on the knowledge and skills students have erected from participation in their households and communities (Moje et al., 2004). I argue students use these FoK as tools to inquire and intellectualize EJ and SJ issues in their community. Thus, in research design, data collection, and analytic treatment, this study centered students as knowledge holders whose experiences and voices pay tribute to the effects of scientific enterprise on urban communities of color. These voices served as the basis of data analysis.

Data analysis is defined as an iterative process of looking at data to determine new connections, additional questions, and understandings of phenomena in contexts (Berkowitz, 1997). For this study, data analysis involved an iterative and emergent process of memoing, describing, classifying, and interpreting information to generate insights into understandings of the benefits of CBS curriculum in science classrooms. To validate my qualitative data, I examined the consistency of my findings in and across data sources, including field notes, meeting design artifacts, classroom artifacts and teacher interviews. Analytically, I engaged in an overall reading, and used constant comparative analysis (Strauss & Corbin, 1998) in three rounds of coding for this study: (a) deductive coding, (b) open coding, and (c) inductive/axial coding.

Overall Reading

I first engaged in an overall reading of all my data to generate an umbrella understanding of the different approaches that were used by Ms. V and I in design (RQ1) and how students conceptualized EJ and SJ issues in that design (RQ2).

Deductive Coding

My deductive coding was guided by several different concepts in the literature that were relevant to the theoretical and conceptual framing of this study. For RQ1, I used deductive codes such as "relevance and applicability" (Barton & Tan, 2009), "including cultural artifacts and materials" (Barton & Tan, 2009), and "repositioning" (Brown & Crippin, 2017). For RQ1a, I applied several deductive codes including "posing open-ended questions" (Harris et al., 2012; Irish & Kang, 2018), "countering ideas" (Harris et al., 2012), and "examples and analogies" (Irish & Kang, 2018). For RQ2, deductive codes were primarily guided by Moje et al.'s (2004) characterization of students' diverse FoK in science, including family and community funds. Family FoK included codes such as "environmental/health issues," "family and ethnic traditions," and "materials from home." Community FoK consisted of codes including "ethnic identity," "social and community activism," and "educational or economic struggle."

Open Coding

Once deductive coding was completed, these deductive codes were compiled in larger themes through open coding. For RQ1, some of these open codes included "grounding concepts and questioning," "humanizing science," "incorporating present people and materials," and "science as a larger purpose." For RQ1a, deductive codes were compiled into open codes to group communicative signals into larger themes including "eliciting FoK," "Recognizing FoK," and, "Responding to FoK." Open codes for RQ2 included, "characteristics of the community," "connections to family and culture," "personal experiences," "choices and change," and "recognizing patterns," most notably. For example, for RQ1**,** deductive codes "mirroring out-of-school activities" (Barton & Tan, 2009) and "relevance and applicability" (Barton & Tan, 2009) were open coded into the theme, "grounding concepts and questioning in relevant and applicable contexts."

Inductive and Axial Coding

Finally, the open codes were inductively coded, using axial coding. My aim was to inductively determine emerged subcodes in the open codes that were specific features of design and identify specific conceptualizations of students' understandings in relation to EJ and SJ issues in the local community. For example, for RQ2**,** the open code of "comparisons across and in contexts," was inductively coded into two subcodes including "comparing across race and ethnicity" and "comparing across socioeconomic status." Axial coding was then used to group the individual themes for RQ1 and RQ2 into overall categories. For RQ1, themes were grouped into two overall categories including "developing concrete connections" and "redistributing value." For RQ2, these overall categories were coded as "assessing 'environmental' contexts and conditions," and "subjective wealth." An in-depth analysis of these categories can be found in Chapters 4 and 5, respectively.

Through all rounds of data analysis, I used Bazeley's (2009) "Describe – Compare – Relate" formula for qualitative analysis to work through the data and record my results. In the first step, I described and recorded the specific characteristics and boundaries of each code, asking myself questions such as: What type of answers did we try to elicit in design? How did students talk about this category? What was and was not included in their answers? Next, I compared differences in the characteristics and boundaries for a category across contexts. I asked myself questions such as: Did this theme occur more or less frequently at certain times? Was the theme expressed differently by different students? This comparison step, specifically, allowed me to investigate questions of who, what, when and why. At this step I recorded all meaningful associations, as well as the absence of certain associations that I thought might have been significant or shown variation. Next, I related the category to others that are already written about. In this step, I asked myself questions such as: Under what conditions does this theme occur? What strategies/actions were involved? Finally, I added a step of "interpretation" to Bazeley's (2009) coding scheme, to support rigor and reliability. At this step, I provided an explanation of my finding and connected it back to the literature.

Ethical Considerations That Guided the Analysis

As a central goal of my CBS learning was to create space for student voice in science, I sought to uphold and preserve students' words and perspectives by developing inductive subcategories through their own voice, to "enhance and deepen [my] understanding of their cultures and worldviews" (Saldaña, 2013, p. 9). I wanted the students to be seen as knowledgeable and experts of their own experiences. Constant memoing throughout data analysis helped me to track their voices, my own ways of thinking, emerging and questioning themes, and acknowledge my own positionality in theme development. Memoing is ethically important in analysis as it serves to provide researchers with an exercise to iteratively access their analytic process and findings and reflect on our own thinking and positionality which could affect interpretations of the data. To further support my analysis and findings, I also provided Ms. V with an overview of my analysis for review to strengthen credibility and verify the accuracy of all narrative interpretations from my data sources.

Conclusion

My inquiry into the literature has suggested although many research efforts have shown the importance of the inclusion of student FoK in local contexts in science learning (Bell et al 2016; Silseth & Erstad, 2018), there is still a need to investigate the creation and implementation of designed curriculum, pedagogies, and practices that address and promote social justice in science teaching and learning (Davis & Schaeffer, 2019), and investigate the use of CBPs that connect science content to the lived experiences of urban SoC (Brkich, 2014). The design of this qualitative study, at the nexus of FoK, CBS, EJ and SJ, and the associated data artifacts and analytic approach, aimed to contribute to this scholarship.

By emphasizing how collectively utilizing FoK, CBS, and EJ and SJ can serve to help SoC better connect science content to their everyday lived experiences, I aimed to provide evidence of features of design that support these connections, and describe how students conceptualize EJ and SJ issues they view as proximally relevant to their communities. Through codesign meeting artifacts and teacher interviews, I hope to provide insight into researcher and practitioner understandings of how a codesigned curriculum, organized and guided by a CBS framework, can create a space for a teacher to recognize, use, and affirm student FoK in classroom contexts. Through observations and classroom artifacts, I hope to understand how students used their FoK to support their conceptualizations of EJ and SJ issues in their community and connect school science learning to their everyday lives. In Chapters 4 and 5, respectively, I provide an empirical example of one approach to codesigning features of science curriculum to make school science more meaningful, engaging, and relevant for urban SoC, and describe how students conceptualized EJ and SJ through that design.

CHAPTER 4: DESIGNING TO AND FOR COMMUNITY IN SCIENCE LEARNING

This chapter provides a detailed examination of specific features of design the curriculum Ms. V and I developed that served to engage community and culture by attributing to students' funds of knowledge (FoK), opinions, and experiences in our elective science class. In redefining curriculum as a praxis that has "embodied values, thinking abilities and intended actions" (Bell et al., 2016, p. 4), Ms. V and I engaged students in community-based science (CBS) learning to scientize their lives (Clegg & Kolodner, 2014) and help them recognize the relevance of science in everyday life participation. Like the work of Stromholt and Bell (2018), this chapter examines features of curricular design that support environmental justice (EJ) and social justice (SJ) focused science education to promote human dignity for all (Booker et al., 2014) by considering how curriculum can be structured to disrupt dominate hegemonic discourses and power structures that promote and perpetuate systemic inequities in science learning and beyond. I, then, provide evidence as to how these design features were reflected through emerged teacher communicative signals, or elements of teacher talk, that served as signposts for students that their community and cultural FoK, ideas, and opinions invited into classroom dialogue. The communicative signals, I argue, served as "responsive teaching practices" (Gotwals & Birmingham, 2016) to further engage and understand students' FoK through questioning and probes in dialogue.

Collectively, this chapter examines features of design and dialogue that could be engaged across multiple science education contexts, not just in elective science classes, to engage the rich histories and knowledge of students, their families, their communities, and their cultures in learning spaces, with the intention demonstrating to students that "all contexts can potentially . . . be leveraged by educators as a resource in other settings to support learning" (Stromholt & Bell, 2018, p. 1021). The design and dialogue features of this curriculum, I argue, provide structural processes that demonstrate, sustain, and support how students' FoK, ideas and opinions can be employed in formal science learning spaces to promote authentic practice and expansive learning experiences for students by positioning themselves and their communities as capable experts in science practice (Stromholt & Bell, 2018).

In this chapter, I present evidence from Units 1 and 3 of our codesigned curriculum to provide an argument for specific design features, across all units, that were developed to integrate students' community and cultural FoK into science learning, as well as the communicative signals that emerged to support these design features in dialogue. Findings for the design features are presented as two overall design themes: Developing Concrete Connections in Science Learning and Redistributing Value to Nonhegemonic Foundations in Science Learning. These overall themes are then further divided into subthemes. Each subtheme presents an analysis of the specific design features that encompass and support that subtheme. The purpose of this work is to provide educators with concrete strategies in which they can integrate into their own practices to make community curricular.

Theme 1: Developing Concrete Connections in Science Learning

In the design of the curriculum artifacts, there was an overall feature theme of Developing Connections across multiple contexts. Our curricular artifacts were designed to engage students' FoK in learning by probing them to connect their knowledge and experiences across space, place, and time. Tran (2011) noted although connections can be beneficial to student learning experiences, students' ability connect classroom science and their out-of-school experiences is "heavily influenced by the learning activities structured in the classroom" (p. 1628). Therefore, in our work, Ms V and I attempted to structure our curriculum design to support these connections by helping students to see science as something that is constantly occurring in their lives and not only present in school contexts As seen in Table 3, the development of connections was designed through three subthemes, (a) grounding concepts and questioning in relevant and applicable contexts, (b) humanizing science through personal connections in learning, and (c) incorporating and viewing people and material already present in students' lives as valuable assets to learning, which are then broken into specific design features.

Table 3

Overview of Developing Concrete Connections in Science Learning Theme

Subtheme	Design feature
Grounding concepts and questioning in relevant and applicable contexts	Writing project goals to display how science can be leveraged to create community change
	Contextualizing driving questions in the community comparison and contrast
	Posing open-ended questions to generate concrete connections
Humanizing science through personal connections in learning	Sharing personal narratives through storytelling
	Emotionality and engagement
Including and viewing people and material already present in students' lives as valuable assets to learning	Analyzing community data
	Utilizing community experts

Subtheme A: Grounding Concepts and Questioning in Relevant and Applicable Contexts

As previously stated, traditionally and too often, science is taught through abstract concepts that are unrelated to students' lives, especially students of color, as concepts are articulated through white and western ways of knowing and doing with a single audience in mind (Aikenhead, 2011; Brown, 2019). This articulation can, in some cases, cause teachers to ignore pedagogical possibilities that come with connecting science to diverse audiences and understandings. To account for this, one of the most pervasive features of design for developing connections in our curriculum was grounding concepts and questioning in relevant and applicable contexts. The design features of this theme served as guideposts to welcome in students' FoK by contextualizing activities and questioning in students' communities and cultures and, as Ms. V stated, "make science more linked to students' real lives and . . . adjust curriculum to reflect what students are interested in and experiencing."

In this case, relevance and applicability were determined through engagement in conversations with students about their interests and experiences, talking with families and community members, and researching the local news about current and prevalent issues in the community. In interviews and planning meetings, Ms. V consistently stated science should be "linked" to students' lives. She said these connections serve as "engagement points" and "hooks" for students to enter in the learning space as it starts with them and their communities and shows that these aspects of their lives are important sources of understanding. She described these connections as developing a more "holistic picture" and "holistic view" of science learning, as utilizing CBS "brings an element of empathy to the scientific process because we are always asking, no matter what the research question is, how is this going to come back and help people." Science, especially in school, is often focused on fact memorization versus learning/utilizing science to make a difference in family, community, or cultural life. By grounding science in relevant contexts, we sought to contextualize instruction to use students' everyday knowledge as resources in learning (Silseth & Erstad, 2018) so students could begin to see that science has a purpose outside of classroom contexts. This context was incorporated into our curriculum through four design features, as outlined by the following sections.

Feature I: Writing Project Goals to Display How Science Can Be Leveraged to Create Community Change

Hodson (2014) defined *science education* as having four distinct learning goals: (a) learning science, or acquiring theoretical and conceptual knowledge; (b) learning about science, or striving to understanding the characteristics of science inquiry and the knowledge it generates; (c) doing science, or participating in scientific inquiry and problem-solving; and (d) addressing socioscientific issues, or developing the necessary critical skills to address the personal, economic, environmental, social and moral–ethnical aspects of socioscientific issues. He urged science educators that their learning goals should be reflected in the teaching and learning methods they use. In our designed curriculum, project goals, as well as overall teaching and learning methods, were written to account for the learning goals of "doing science" and "addressing socioscientific issues."

In developing our curricular units, Ms. V and I first noted that to position community and science in conversation with each other, it was important for us to design goals for each project supportive of ideas that science can be used to understand and create community change. As such, the first design feature of each unit was writing projects goals to position science as a mechanism for community change. The purpose of these goals were twofold: (a) to encourage students to learn more about their community through an open-inquiry process of "doing science," where students lead and engage in each part of the research process; and (b) driving and creating community change by "addressing socio-scientific issues" through science practice. In introducing these project goals to students at the onset of each project, Ms. V and I conjectured that these goals served to create multiple engagement points for students. Ms. V stated, "at the beginning of the unit . . . I'm looking for hooks . . . it starts like funneling that conversation down from a very wide engagement point where kids have like lots of different places to kind of attach to their interest, and then from there, we can start guiding them."

For Project 3, for example, project goals were written as: (a) understand a problem in your community ("doing science"), (b) Create a change idea for how to address that problem ("addressing socioscientific issue") and (c) Write a letter presenting your research and change idea to someone who can act on it now ("addressing socioscientific issue"). By grounding their goals in the community, we asked students to draw upon their knowledge and experiences to understand the problem, how it affected their community, and design a solution to the scientific phenomena in a context that specifically would benefit their community. In writing goals in this manner, students were required to bring forth their knowledge about the problem in context of their community through the learning goals of "doing science" to "address a socio-scientific issue" (Hodson, 2014), thereby using their everyday experiences as tools to inquire about the curricular concept (Silseth & Erstad, 2018). By grounding community in design, Ms. V and I broke down barriers between school and out-of-school to show that school science can be connected and valuable to science learned outside of school (Brown, 2019).

Feature II: Contextualizing Driving Questions in the Community

As stated, one key feature of PBL is grounding learning in a relevant driving question. Our curriculum extended this idea of "relevant" beyond general applicability (Krajcik & Blumenfeld, 2006) to the inclusion of a specific design feature that contextualized the driving question as "community relevant." In this sense, the driving question was situated to address a specific issue that is present in the local community to encourage students to "do" science and "engage" in scientific activity and learning by exploring an issue that was relevant to them and their community.

For Project 1, we explored the scientific phenomenon of food and nutrition, and the social phenomenon of food access and food justice in Los Angeles. To explore these concepts, students were asked to answer the driving question "How can we make our favorite recipe more nutritious?" This driving question was written for students to connect and demonstrate their learning about macronutrients, food energy, etc., by creating new and healthier recipes for their favorite cultural food. Students were able to use their FoK by investigating a food that was of significance to them.

In discussing the importance of grounding the driving question in the community, Ms. V stated, "I want them to genuinely learn more about a problem in their community that they care about, and I want them to start thinking about how to solve it." From this comment, Ms. V viewed the focus of the of the driving question, and CBS in general, as a means for learning through a community lens. As developing a driving question is the first step of the PBL process, grounding this question in the community signals to students that out-of-school contexts are important to understanding science concepts and engaging in science learning. Ms. V further supported this notion by noting that writing driving questions in this manner "makes sure that science concepts are put in contexts that are relevant to students' lives . . . [by] tak[ing] things that seem very abstract and distant and make them actually helpful for kids." She went on to note, "I feel like sometimes we assume that everything is relevant to kid's lives, but it's not until you put it into context." These quotes demonstrate the driving question can serve as a mechanism to contextualize abstract science concepts into contexts that are meaningful and relevant to students, versus a science concept that is contextualized based on something that we, as educators, may prescribe as relevant simply because we see them as important to learning. In this manner, we move past traditional approaches of preparing students to do science, to nuanced approaches to engaging students in relevant science activities (Roth & Lee, 2004).

Feature III: Compare and Contrast

A third prominent design feature for grounding concepts and questioning was using a compare and contrast model for activity structure. In our designed curriculum, many of the activities had an element—most frequently in the form of questioning—that asked students to bring in their knowledge and understandings of a general science issue by drawing comparisons across place (worldly versus the immediate and surrounding community) to support learning. For example, students completed a "food around the world" activity where they investigated the major food groups by analyzing food pyramids and plates from across the world to determine how health is valued across contexts. Discussions of their findings led to conversations of the arbitrary and contextualized nature of nutrition based on place and cultural contexts. Students were asked to compare what they saw in these pyramids and place to the U.S. food pyramid, and further, their own eating. Students were asked questions such as "Compare the pictures – What is similar about the pictures? What is different?" What does it make you think about the food that we eat in the United States compared to food that is eaten around the world?" In answering, students frequently presented foods and dishes that were important to them for points of comparison. For example, Juan, an eighth grader, compared how rice was on their food pyramid in China and in Mexico (where he is from); even though it was not on the pyramid, rice is an important aspect of many dishes.

From this example, we saw by asking students to compare and contrast scientific phenomena—in this case, aspects of food and nutrition—students found it necessary to draw on their personal lives and understandings to back their answers. In supporting this finding, Ms. V noted in a planning meeting that “it’s just so abstract to them when you’re trying to do that kind of comparison and contrast, unless there’s something *personal* about it.” The aspect of “personal” is essential to this design feature—comparisons and contrasts cannot be without context and must be related to aspects of students’ lives or identities that they can draw upon. In positioning these aspects as significant to science, we transformed the view of FoK in relation to learning by noting there is no singular nor normative scientific viewpoint, as there are multiple ways of knowledge in diverse communities (Boutte et al., 2010).

Feature IV: Posing Open-Ended Questions to Generate Connections

Lastly, the use of open-ended questioning was a consistent design feature Ms. V and I incorporated in multiple aspects of the curriculum, including reflection activities, discussion posts, lectures, the digital interactive notebook (DIN), and as discussed later, in dialogue. The use of open-ended questioning (free answer), rather than closed questioning (yes or no), was used to create an exemplary inquiry learning environment (Smart & Marshall, 2013) where we could elicit student thought and ask them to elaborate on their ideas to engage students in higher order thinking (Chin, 2007). In using a higher level of questioning, we engaged students in more than just a regurgitation of facts, but specifically ask them to consider and articulate the how and why they know and understood a concept.

In the case of our designed curriculum, open-ended questions specifically asked students to draw connections between scientific phenomena and their outside lives to support their understandings. These open-ended questions most frequently followed a question around a specific science or social science concept. In formulating these open-ended questions, explicit references were made to students’ selves, communities, and culture. For example, in a Unit 1 reflection activity, students were asked, “How do you define food justice? How do you believe food access is as an issue in South L.A.?" In this example, we asked students to define the social scientific phenomena of food justice, and then elaborated on this definition by considering *how* they know and understand this definition based on their experiences of living in South Los Angeles.

In general, the open-ended question stems that were used throughout our curriculum were presented through phrases such as, "What do you notice?", "How does this relate to you?", and "How do you think your community is affected?" In crafting questions as open ended, students had the freedom to answer through contexts they deemed relevant, often bringing their experiences and knowledge into the learning environment as we purposefully asked them to draw on the "you" aspect of the phenomenon to support learning. Through this form of questioning, we, as teachers, were able learn how students conceptualized science based on the connections they made.

Smart and Marshall (2013) noted when middle school science teachers ask higher order questions, as done through open-ended questioning, students are presented with greater opportunities to "explain, justify, and rationalized in the social context . . . and engaged more deeply with science concepts, formulating hypotheses, and using evidence to draw conclusions about phenomenon" (pp. 264–265). Our design feature of open-ended questioning supported this conclusion, as it allowed us to engage students in these deeper forms of thinking by asking them to explain and justify through reflections of investigations and in activities. This design alsp supported our own redesigning of questioning future design iterations, as we were able to account for the FoK that students evoked as a result of this form of questioning in practice.

Subtheme B: Humanizing Science Through Personal Connections in Learning

Extending on Subtheme A, connections were also developed by humanizing science through the development of students' individual personal connections in learning. Whereas grounding concepts and questioning in relevant and applicable contexts focused on general connections students may have because of being members of their immediate and surrounding community, humanizing science through personal connections asked students to draw on connections from understandings they have as a result of a direct encounter or experience that has impacted their individual or personal lives.

Our designed curriculum created opportunities for students to develop and express their personal connections to the concepts they were learning, allowing students to emotionally connect to the work as it was connected the contexts of their everyday lives in very distinct and specific ways. Brown (2019) noted students are often able to describe scientific concepts and phenomena without the use of complex scientific language; he stated the challenge is not necessarily students understanding the concepts, but the teacher being able to recognize those understandings. When a teacher's epistemological and curricular practices mirror this idea, science concepts can be represented through multiple discourses. Our design features were structured to mirror these understandings and humanize science by drawing on a multitude of ways for students to express their understandings and demonstrate connections to their FoK.

Feature I: Sharing Personal Narratives Through Storytelling

Sociocultural theory postulates that science learning cannot be separated from the social circumstances in which students come to understand science (Lave & Wenger, 1991). In previous unit development iterations, Ms. V and I discovered that to display their learning, students would often tell stories. During the 2019–2020 school year, I sat in Ms. V's class one

Tuesday afternoon working with students on a recycling activity that investigated practices at the community recycling center. Ms. V asked the students, “When things go to the recycling center, do you think they are separated, or all packaged together?” Andrew, a student typically disengaged in this work, shot his hand up to answer. In what followed, Andy detailed a story of how he goes to work with his cousin at a recycling center in a neighboring community. In his story, he noted he learned that different materials are recycled into different piles based on what they are worth. From this story, Ms. V engaged the whole class in a discussion of home recycling practices and why we see people in the community collecting cans and bottles out of recycling bins. This short story presented a clear picture as to the significance of storytelling as a mechanism to connect science learning and social practice.

From this story, along with many others, Ms. V and I incorporated the design feature of sharing personal narratives through storytelling to bring forth students’ experiences and understandings into the learning environment. Witherell and Nodding (1991) noted stories can serve as powerful research tools, as they provide teachers and students with a picture of “real people, in real situations, struggling with real problems” (p. 280). These stories do not necessarily represent long, drawn-out, and exhaustive descriptions; rather, they provide short snippets of relevant pieces of data that support students’ engagement in science learning and understanding of a concept. In asking students to provide a short story, share out, or explain how this is relevant to them, storytelling became a mechanism for students to extend their learning and using their FoK to support their thinking.

For example, in Project 1, students completed a “my food story activity” in which they were asked to name a food or dish that was important to them, give a general description of that food, and provide a short story describing a personal connection, memory, or significance of that food in their life. For Project 3, students were asked in their advocacy letter to explain why this research was important for them and what personal connections they had with it. Incorporating storytelling as a design feature humanized science to show students that it had purpose and relevance past, as Ms. V stated, “delivering facts to their brains,” and that research and science learning are connected across contexts both in and out of school. This “holistic picture” and “holistic view” of science showed students that “their experiences are important . . . [and] count as knowledge,” (Ms. V). Overall, this design feature supports Barton (2003)’s notion that by sharing stories:

> We begin to see that we cannot just label as scientific only things we see as scientific. We have to allow our understanding of what they were doing to be transformed. We also have to allow our understanding of the purpose of doing or learning science at that particulate junction to be transformed. (p. 9)

In sharing stories, we recognize that students might not always have the scientific vocabulary, but they have understandings, and it’s a matter of using those understandings and that comprehension to help them learn the science because, according to Ms. V, “stories are important data points whether or not they can be generalized.”

Feature II: Emotionality and Engagement

Emotions, as defined by the socioconstructivist perspective, encompass a person’s beliefs, judgements and desires as determined by the cultural beliefs, morals, and values of their communities (Zembylas, 2005). In considering this definition, emotion is often excluded in science classrooms, as they are seen as “subjective judgements that pose a threat to rationality and morality” (Sunderland, 2014, p. 183). Over our initial 2 years of codesigning, Ms. V and I found, for our students, simply believing they will be engaged in the lesson because it was “cool” or “interesting” to us, was not possible. We had many discussions about the importance of “emotions,” as demonstrated through connecting student beliefs, morals, and values, to support connection and applicability of science concepts to real life. Engaging emotions in learning, therefore, became a significant design feature in our curriculum to promote engagement.

In our second 2020–2021 summer planning session, Ms. V and I were discussed the importance of incorporating different perspectives throughout our units. Ms. V stated, “we can introduce different perspectives . . . but I feel like we need that *emotional* piece for them [students] to connect.” Her warning stemmed from our ideas of creating emotional chords throughout the units. For example, in learning about the socioscientific phenomena of food justice and food access in their community in Unit 1, during our community circle time—or space where we engaged students in discussions or readings about the direct effects of the science concept in their lives—students read narratives (a method discussed in Sunderland, 2014) about a Black family’s experience of living in a food desert during COVID-19, and their struggle to get the food they needed to survive. After reading, students expressed emotions of sadness and anger, which was the reality of people who lived in their community. Students began to talk about ways they or people they know have gone through similar circumstances or tried to support people who had. The classroom became, as Ms. V described in a planning session, an “authentic learning space” where students could draw on their emotions (Zembylas, 2005) and experiences to contextualize the concept, and use their FoK to support their articulation and interpretation. Although Sunderland’s (2014) study was conducted in the context of engineering, this design feature supports their idea that the critical engagement of emotions in STEM, especially when considering ethical issues, are necessary as they influence how we make sense of the world, and lay the foundation of lifelong ethical learning.

Subtheme C: Incorporating and Viewing People and Material Already Present in Students' Lives as Valuable Assets to Learning

Finally, the artifacts also contained design features to support the development of connections by incorporating and viewing material and people already present in students' lives as valuable assets to learning. Much research centered around science education among Indigenous communities focuses on the importance of including family and community members in learning spaces (Bang et al., 2010). Despite its success in these populations, this strategy is very rarely used in urban school settings.

Upadhyay (2010) noted community knowledge should be shared and respected as assets to science classroom. Bellino and Adams (2017), however, stated school science does not habitually recognize or draw upon this knowledge as valuable sources in learning. As such, our curriculum design had an intended action of privileging students' proximal circumstances (i.e., people and materials) as sources to support science learning. In designing the curriculum from this vantage point, we showed students that science emanates from them, versus something that is imposed on them, and invited their FoK into the space to support learning. In this design, we determined the boundary of "already present" to incorporate people that students could directly view and/or access, and materials that students could assess in their homes, neighborhood, community, or Los Angeles in general. For some students, such as newcomer students, their understanding of "already present" surpassed those that were directly viewable to incorporate aspects of their lives in their home countries. Therefore, they would sometimes present from this perspective. In contextualizing and bringing these contexts into the learning environment, students were able to draw on nontraditional mediums of information to contextualize and make understanding of the science concepts.

Feature I: Analyzing Community Data

In the context of "doing science" (Hodson, 2014), gathering, analyzing, and interpreting information and data to draw conclusions is a critical aspect to engaging in project-based learning (Kokotsaki et al., 2016). In our curriculum, Ms. V and I believed data analysis should not be a random set of numbers or data points, but instead should be contextualized in proximal contexts. One of the most common design features we incorporated in our curriculum was analyzing community data. Community data were used to specifically integrate the idea of science as/for the community in learning, and create a democratic space that supported students in choosing the data and representational tools that best fit their research interest and needs (Roth & Lee, 2004).

In our curriculum, students were asked to engage in several activities where they used community data to investigate an aspect of the science concept. For example, the food access mapping activity asked students to use Google maps to look at the number of food access points in 2 miles, between 2–5 miles, and between 5–7 miles of The Community School (TCS). Although students picked different food access points, they were able to draw similar conclusions about the overall trends in issues of food access in Los Angeles and use this notion as a proxy to discuss and theorize the larger concept of food access inequities in the world. In discussing their findings, students made connections to what types of food they saw around their neighborhoods, making statements like, "We have to go to multiple grocery stores to get what we need", or that "The grocery stores don't have a lot of healthy food options." From these statements, we were able to see that by grounding the data directly in the community, students were able to connect their own experiences to support the trends they saw.

For Project 3, a student further analyzed hazardous waste sites, using community maps and models to investigate hazardous clean-up sites in South Los Angeles. Through their investigation, the student elicited their community FoK to present suggestions as to why such large discrepancies in the number of clean-up sites across West Los Angeles (white, affluent neighborhood), and South Los Angeles (lower income, predominately area of color) based on their experiences of living and being from a certain "figured world" (Moje et al., 2004). In this case the students' socioeconomic identity, which they described as "living in a more poorer neighborhood," play a significant role as to why their community was more affected by this phenomenon. This conceptualization is further discussed in Chapter 5.

In this design feature, community data were not only defined as previously collected data that could be accessed via the web, but also data that students collected themselves. In Project 1, students surveyed their families and friends about their understandings of food and nutrition and analyzed that data to draw conclusions around how people in the community understood nutrition and how they viewed the access to healthy food. For Project 3, students had the option to survey, interview, or conduct observations to gather data and answer their student-led driving question. Overall, these multiple forms of community data served to engage students in the scientific process and show students that science learning can be derived from the individuals and spaces present around them (Aikenhead, 2011).

Feature II: Utilizing Community Experts

Early on in our work, Ms. V and I observed that students almost exclusively viewed a science expert as someone who was a scientist. Collectively, we both voiced our disagreement with this notion, indicating our view of an "expert" as any individual who has knowledge of a topic—not only based on their education, but also their experiences. To redefine expert in learning and show students the value of experiences in supporting knowledge of the intricacies of science phenomenon, Ms. V and I determined an important feature of curricular design was utilizing community experts in learning. Specifically, we wanted to take the position that "anyone can be an expert" if they have experiences and positionalities that allow them to speak to the concepts at hand and articulate the narrative that individuals already in students' lives can serve as experts in their own right (Stromholt & Bell, 2018).

As such, we had students draw on their families, peers, and other community members as sources of knowledge in data collection by viewing them as experts in learning who were able to provide them with understandings of the questions they were trying to investigate. For both Project 1 and Project 3, students interviewed their family and friends to help them gather information about their project. In having students interview family and friends, the designed artifacts positioned these individuals as sources of knowledge and expertise because they had actual experiences that were relevant and applicable. In dialogue, Ms. V further positioned those already present in students' lives as experts stating to students:

> Maybe someone's mom is a nurse, and they know a lot about health care and how we can make sure people get the care they need. Maybe someone's dad works at a grocery store and knows about whether there's extra groceries at the end of the day that we can do something with. Maybe someone's uncle or someone's brother knows about like pollution in the community and they're already doing something about cleanup efforts. So really think about who you know what kind of knowledge you already have.

In this statement, Ms. V suggests to students that those around them can serve as sources of knowledge and expertise for their projects because their jobs and experiences may have provided them with a specific set of information. Further, we also invited students' family and community members as expert speakers in the classroom space to teach students about the science topic at hand. Ms. V described this as engaging students in conversation and work that is "authentic and real . . . and not something where we have to pull in a NASA scientist who is so separated from students' experiences."

Although we acknowledged this conceptualization of expert was not unproblematic nor one-directional (Gutiérrez & Arzubiaga, 2012; Philip et al., 2013), we highlighted the possibility of conflicting discourses and tensions between primary sources (i.e., sanctified science resources versus community experts) are productive rather than problematic, as they generate differing perspectives and challenge students to address thought-provoking questions. Overall, using community experts contributes to creating science classrooms that reflect the identities of students in a more culturally congruent manner by contributing to border crossing for students across social and educational contexts (Stromholt & Bell, 2018). As such, we contributed to students understanding that they themselves are developing experts who can enact change and transform their communities.

Theme 1 Conclusion

A student's ability to connect science learning in the classroom with their out-of-school lives and experiences is not a natural occurrence. The structure of learning activities in the classroom have a significant influence on how students develop these connections and how they may be beneficial to student learning (Tran, 2011). The design features I presented served to engage students' FoK in learning by positioning them as important elements to understanding and addressing scientific phenomenon. By grounding concepts and questioning in relevant and applicable contexts, humanizing science through personal connections in learning, and incorporating and viewing people and material already present in students' lives as valuable assets to learning, our designed curriculum features collectively supported the development of connections across space, place, and time to engage students in learning that extended beyond the traditional confines of school science.

Theme 2: Redistributing Value to Nonhegemonic Foundations in Science Learning

In traditional science contexts, value is often attributed to what is deemed a fact across all contexts and for all people, as it can be proven. In our curriculum design, value was redistributed to other features that are historically considered irrelevant or not of worth to scientific practice and scientific enterprise. As such, the second overall theme of our codesigned curriculum was Redistributing Value in science learning. This overall design feature addresses Bouillion and Gomez's (2001) following critique:

> Disconnect occurs when students do not see how the science in schools had value in or related to their lived experiences and when schools do not see how the lived experiences of children have value in learning and doing science. (pp. 894–895)

By redistributing value, the designed curriculum prompted students to engage their FoK by associating nonhegemonic, or nonwestern, and noncolonial aspects or elements of their lived experiences as having merit and utility in the learning environment, therefore creating a space where students could draw upon these aspects to support their understanding and interpretations of science concepts. Further, these findings alluded to Vossoughi and Shea's (2019) idea of critical science agency (CSA), or "opportunities to merge scientific and other forms of knowledge and practice that address instances of injustice" (p. 328). Through investigations of injustices in the context of their own communities, value is redistributed to show students that the contexts of their lives have significance in the classroom. Cooperatively, the design features of this theme support the three main aspects of CSA: (a) develop student expertise in science and their community contexts, (b) students use their expertise to identify and take action to address community problems, and (c) students take action that is justice oriented. As seen in Table 4, the redistribution of value was represented through two subthemes, centering science as having a larger purpose and repositioning students as having agency in learning, each of which were further coded into specific design features.

Table 4

Overview of Redistributing Value to Nonhegemonic Foundations in Science Learning Theme

Subtheme	Design feature
Centering science as having a larger purpose	Developing a toolkit for the future Cultivating space for advocacy Generating critical hope for the future
Repositioning students as having agency in learning	Affording students authority to lead their learning Students as scientists and agents of change Associating student knowledge and experiences as assets

Subtheme A: Centering Science as Having a Larger Purpose

One of the most salient feature themes, as seen throughout the design of the curriculum, was redistributing value by centering science as having a larger purpose in students' lives. In planning meeting notes, there was evidence of recurring talk between Ms. V and I of demonstrating to students that science extends beyond the walls of the classroom, to instill an understanding that the work they do in science class can be employed to help them understand the world around them, while also preparing them to engage in that world.

The purpose of this design feature was to position science as beneficial to students' present lives, proximal future, and distant future by providing a learning environment that gives them tools to navigate their present and future lives and selves through informed decision making. Ms. V described this as “build[ing] citizens” by “giv[ing] them the *tools* to be able to look at society around them and [recognize] that’s a problem and someone should fix it.” The idea of creating a toolbox and skillset was continuously repeated in curriculum design and lesson planning, as further discussed, to connect to the idea of building informed and critical citizens that are able question and criticize everything around them (Mallya et al., 2012).

Connecting to this idea, the intent of this design theme was to inform students about larger systemic inequalities that perpetuate because of scientific enterprise. Our features attempted to show students the issues that they see, recognize, and are affected by are not just present in their neighborhood, but in others that like theirs as well, to reframe “personal challenges as systemic issues” (Davis & Schaeffer, 2019 p. 385). Continuously in planning, Ms. V and I discussed the idea of guiding students to, as Ms. V noted, to “recognize oppression and recognize untruth . . . and be able to do something about it . . . and navigate systems that are not built for them.” As such, contextualizing science in a larger purpose served to speak to the learning goal of “address socio-scientific issues” (Hodson, 2014) to help students increase their social, political, economic, and environmental awareness of injustices (Buxton, 2010) through three design features:

Feature I: Developing a Toolkit for the Future

Consistently throughout our planning meetings, Ms. V and I reflected on science teaching as having capacity to do more than just teach concepts. We sought to provide students with the tools to engage in critical thinking, social and economic mobility, participate in society and make decisions, and prepare them as they go out into the world. To build these tools, one of the most common and consistent design features in out curriculum was supporting students developing a toolkit for the future.

When we first brainstormed the overall structure of this class during our summer planning sessions, we decided to do a youth participatory action research-like (Anyon et al., 2018) project-based learning class for students. Studies utilizing community-based design practices have suggested the benefits of youth participatory action research tents in learning to provide youth with room to exercise shared power (Kornblush et al., 2015; Kirshner et al., 2011). We also believed in using this process, we could develop students' skills to support their classroom learning, their learning in other classes, and in other facets of their lives. A common thread throughout our design conversations consisted of Ms. V and I expressively discussing developing students' "critical thinking," "critique," "revision," "analytic," "inquiry," "engineering," and "presentation" skills. To account for this in design, Ms. V and I grounded each project in a set of skills we were trying to help the students build upon. For example, Project 1 focused on research and reflection skills to build students' toolkit to conduct research projects and be able to reflect on their FoK to guide their work and understandings. Research skills were developed through students' first attempts to collect and analyze community data, although reflection skills were developed through storytelling and community circle activities, as well as reflection prompts. For Project 3, the skills of focus were inquiry and presentation skills to build students' toolkit to ask questions, use their research skills, interpret information, and make decisions based on that information. Inquiry skills were developed through students engaging in a guided, but student-led project, that encouraged them to critically observe, describe, and investigate a community issue by relating science context to their lives outside of school (Marx et al., 2004). Presentation skills were developed to build students' toolkits to communicate the findings from their research.

The most salient way these skills were brought together to engage students' FoK was through the DIN, which was designed as a scaffolding tool for students to build upon their knowledge to engage in each step of the research process. Questions were designed to engage students' knowledge, push their critical thinking, and reflectively analyze to support the development of evidence-based solutions to community-oriented issues (Kyza & Nicolaudou, 2017). Ms. V described this as "hon[ing] in on those skills rather than telling students the most important thing to memorize is the concept," to encourage their process toward context understanding. Collectively, Ms. V noted the development of this toolkit supported students to "move themselves, help their communities, recognize oppression, recognize untruth, and be able to do something about it to navigate systems that are not built for them," supporting larger change in their lives, and CSA Component 2: students identifying and taking action against a community problem (Vossoughi & Shea, 2019).

Feature II: Cultivating Spaces for Advocacy

As environmental challenge is positioned to be investigated from universal perspectives, the Next Generation Science Standards (NGSS) do not address the social and political facets of environmental issues and their effects on communities of color (Feinstein & Kirchgasler, 2015). As such, another significant design feature of our curriculum was engaging students in conversations and understandings that science can be a medium to discuss the political, social, and environmental implications of issues of EJ and SJ, particularly in marginalized communities. In participating in these conversations, we sought to cultivate a space where students could recognize, and engage in, forms of advocacy to address these implications. By engaging in advocacy, students employed their science agency to understand, reflect, make decisions, and act in their everyday lives to transform community spaces (Mallya et al., 2012). Students also addressed systemic inequities, in this case, through investigating local EJ and SJ issues as a proxy. Ms. V described this as guiding students toward knowing, stating, "this is what inequality looks like . . . this is what inequity looks like when it's on this macro scale . . . to really make that clear."

This idea of "naming it" was seen throughout the curriculum design, specifically when considering dialogue and points of questioning. The curriculum was specifically structured to "name" the larger systemic problems that are present in students' lives and generate space for students to advocate for change by addressing these larger issues at the local level through the development of community-driven solutions. The advocacy aspect was most saliently designed in students' final products for each of the projects. The final products were designed to have students take a stance on an issue, develop a change idea to address the issue, and present that idea to individuals who could influence change. For Project 3, students wrote advocacy letter designed to have them identify an individual who is of significance to the problem they were investigating and write a letter to them explaining their research project, how it affects Los Angeles or their community (engaging their FoK), what they learned, and understanding their change idea. The purpose of this activity was to position students as change agents in their communities, as further described in the next subtheme, who are tasked with advocating for the needs of their community (Vossoughi & Shea, 2019). We recognized that advocacy, especially for students, is complicated and contextual as they may not see themselves as being capable of creating change (Mallya et al., 2012). By designing for the cultivation of advocacy in science learning, our hope was to help students see that they are positioned to enact social change in their communities (Tzou et al., 2010) and can use their science learning to enact those changes. Although we believe this positionality was taken up by some students, it was beyond the scope of this dissertation to investigate student beliefs around this identity, the success of this feature in perpetuating students to take action.

Feature III: Generating Critical Hope for the Future

When discussing EJ and SJ issues, the implications this can have on students must be considered, specifically considering how conversations of negative community harm may affect their mental well-being. Ms. V described this as students asking themselves questions such as "Am I going to live to see 40?" "How do I deal with health insurance if I get sick?" "How do I take care of my parents? They have to work." As we designed artifacts for background research and data collection, Ms. V and I discussed that it may be hard for students to, as Ms. V noted, "focus so much of their energy on these topics when maybe they're used to school being a break from real life." To account for this, we focused curriculum design in the feature of generating critical hope for the future.

Generating critical hope was accomplished in two ways in Project 1 and Project 3. For Project 1, focused reflection questions such as, "How can you use what you have learned about food/nutrition in your life from now on? How do you think you can help your family and your community?" asked students to consider how and what they learned in class can be useful to their lives outside of school. For Project 3, generating critical hope was accomplished through the focus on students developing a "change Idea" to address their project driving question. As Davis and Schaeffer (2019) advised, "caution against conceptions of justice-oriented science education that focus exclusively on the identification of the problems" (p. 386). The purpose of this change idea was to reframe science as a space where students can use their FoK and experiences and scientific knowledge of the phenomena to change the identified problem in their community. Bang et al. (2013) noted fostering transformative experiences in science for marginalized youth is required to address SJ science issues. We believe by engaging aspects of critical hope, in both pedagogy and practice, we moved away from solely focusing on the negative aspects of EJ and SJ, and instead, positioned students as "transformative intellectuals" who are capable of imagining and creating mechanisms for social change (Morales-Doyle, 2019).

Subtheme B: Repositioning Students as Having Agency in Learning

Value was also redistributed by positioning students as having agency in learning. Traditional classroom power dynamics position students as sponges who soak up the knowledge the teacher provides. We disputed this form of power to view the classroom as a reciprocal learning space (Higgins et al., 2019) where students have agency. Hempel-Jorgensen (2015) argued students' ability to exercise their learner agency can be influenced and constrained by pedagogical practices and curriculum. They noted in sociocultural contexts, learner agency is crucial to supporting meaning-making and knowledge construction for students. In their work, they reasoned that in socially just contexts, curriculum, and pedagogy should support five key aims, three of which we sought to address in our work: (a) validating students' local knowledge and identities, (b) high-level intellectual engagement in learning, and (c) a critical analysis of power relations in learning. In our design, Ms. V and I sought to provide students with the space to use their learner agency to leverage scientific ideas to ask questions, think, and speak more critically about community happenings. Specifically, we designed learner agency in our curriculum to mirror Davis and Schaeffer's (2019) idea of creating space for "critical, diverse and lived accounts of scientific phenomena" (p. 369) to support the engagement of student FoK by repositioning power in the classroom to the teacher as the facilitator of knowledge versus the holder of knowledge. As the facilitator of knowledge, space was created for students to bring their FoK into the learning environment to contextualize and support their understandings. As North (2015) postulated, when educators include students' prior knowledge and community resources support active learning, they sanction students to negotiate power dynamics in the classroom through the countering of hegemonic views of knowledge holding and acquisition. This was accomplished in our curriculum design through three features:

Feature I: Affording Student Authority to Lead Their Learning

To provide students with agency in learning, Ms. V and I structured our classroom and curriculum through the design feature of affording student authority in learning. Ms. V described this as "let[ting] the kids lead." In this feature, the idea of "adjusting as we go" served as a critical element in curriculum development. Although the overall classroom structures, goals of the project, and project flow were preplanned, specific activities, resources, worksheets, etc. were planned weekly. Based on student need, and the knowledge and understandings students bought forth, we iteratively adjusted artifact design to account for new learning, and develop questions based on these experiences.

For example, throughout the first half of the year (Projects 0–2) students engaged in activities to develop their understanding of EJ and determine what EJ issues were important to them. We then used these understandings to support the development of project topic options and their associated resource packets for the scaffolded independent Project 3. The topics derived from our learning about student interests and needs, again demonstrating the idea of letting the students "lead us." Ms. V and I spent many meetings asking ourselves questions such as "What can we do with what they already have . . . [instead of] dictating what they are doing?" (Ms. V). In asking these questions, we started from the design perspective and assumption that students are scientists and already know something about their topic, thus, we are not starting at "level zero."

Overall, learner agency was supported by obliging us, as teachers, to address power relations in the classroom. Specifically, we attend to leaner agency by problematizing the design of our curriculum (Lingard et al., 2003) to promote student participation in knowledge construction and meaning making, while prioritizing their nondominant identities in learning. Through the deconstruction of power in the realm of dominant social discourses we made in our design attempts to transform unjust curricular and pedagogical practices in learning (Hempel-Jorgensen (2015).

Feature II: Students as Scientists and Agents of Change

Positioning students as problem solvers and changemakers supported the design feature of cultivating a space for science advocacy - an important feature across the design of all our projects. Morales-Doyle (2017) argued justice-centered science pedagogies, in this case through the design of curricular practices, can position students as transformative intellectuals who can engage in thinking and doing around complex science and social justice issues through a cultivated commitment to their communities and cultures of origin. In our work, we oriented students as transformative intellectuals through the engagement of community-grounded research projects designed to position students as able to, according to Ms. V, "do science, because research is doing science and understanding systems is understanding from the perspective of a scientist."

To accomplish this in practice in their original, student-led research projects (Units 3 and 4), we focused a significant amount of time and energy on students developing a "change idea" based on their research findings. Student development of this change idea was scaffolded to ask them to consider their experiences in their community. Understanding their community culture and community needs supported students' development of an idea that would answer their driving question while also supporting greater change in their lives and surroundings. As such, we promoted students' critical science agency by asking them to use their expertise to take on justice-oriented community action (Vossoughi & Shea, 2019). This design feature served to reframe traditional notions of the purpose of school science toward community engagement in learning, as well as prepare students to use their toolkits to engage in EJ- and SJ-oriented community change. In merging students' credibility as knowledgeable experts and their credibility of understanding the needs of their marginalized community, we positioned students as beyond solely academic achievers, but as transformative intellectuals who could serve as change agents in their community (Morales-Doyle, 2017).

Feature III: Associating Student Knowledge and Experiences as Assets

The most prominent feature of our community-based curriculum was repositioning student knowledge and experiences as assets to learning by incorporating them in curriculum design. diSessa (1993) argued student experiences and associated knowledge, should be thought of as "knowledge in pieces" that can be built upon by educators. We sought to build upon our students' knowledge through multiple measures in curricular artifacts. First and foremost, each activity, lecture, DIN page, etc., was structured to start with the idea of "What do you [student] already know?" or "What do you think about this?" This type of questioning was a common design feature and allowed students to connect to the science content and bring forth their knowledge as the start to learning. This element supported Vossoughi and Shea's (2019) critical science agency element of "developing student expertise," as we positioned students as already having significant knowledge that contributes to the learning environment. This questioning demonstrated to students their prior knowledge serves as expertise to address community issues. As noted by Ms. V, our pedagogical approach in design took the positionality “if [the] science textbook and curriculum says one thing, but students are experiencing another thing, [we] shouldn’t try to explain that away or disregard that. [We] should take that into account and incorporate that into the way students are learning.” Our codesign meetings served as a space to account for and incorporate these ways of knowing into the iterative refinement of curricular materials, aligning with Warren et al. (2000) perception that students’ accounts of their everyday experiences can uncover previously unnoted aspect of phenomenon which are useful in classroom learning.

As an emerging design feature in our curriculum, that we did not originally incorporate, in moments of tension where students disagreed or saw things differently, we created space to have discussions with the students to think through what we learned. In design meetings, we then discussed how we could account for this knowledge in the learning space. These conversations served a crucial role in the iterative design of lesson planning on a week-to-week basis. Further, these conversations also supported understandings that when engaging in CBS work, and trying to account for students FoK in learning, educators will have to adjust “on-the-go” in design to generate space to see and interpret phenomenon differently (Warren et al., 2000) and account for new information, new ways of thinking, and new knowledge. In keeping this practice, students are positioned as having learner agency in the classroom as their identities and knowledge are validated and used in the classroom space (Hempel-Jorgensen, 2015).

Theme 2 Conclusion

Disconnect in science learning occurs when students are not taught the value of science in their lives or the value of their lives in science (Bouillion & Gomez, 2001). Our designed curricular features addressed this disconnect by redistributing value to features of students' lives that are historically not considered as relevant or useful in science practice to support their critical science agency (Vossoughi & Shea, 2019). These curricular features and positioned science education as a space to address issues of injustice in the context of their lives. By centering science as having a larger purpose and repositioning students as having agency in learning, our design features supported the realignment and engagement of students' FoK as essential elements to science learning. By connecting community and culture in learning, we created a learning atmosphere that contested traditional boundaries of how we value different beliefs, realities, and histories in science learning (Boutte e al. 2010). Although, across both themes, design features were presented as distinct elements for purposes of analysis, it was important to note they were not solitary entities where one feature supports a single theme. Instead, the elements were interrelated and collectively supported the design of curriculum to concretely engage students' FoK. These methods of engagement of students' FoK in dialogue, are examined in the next section.

Teacher Communicative Signals in Episodes of Classroom Dialogue

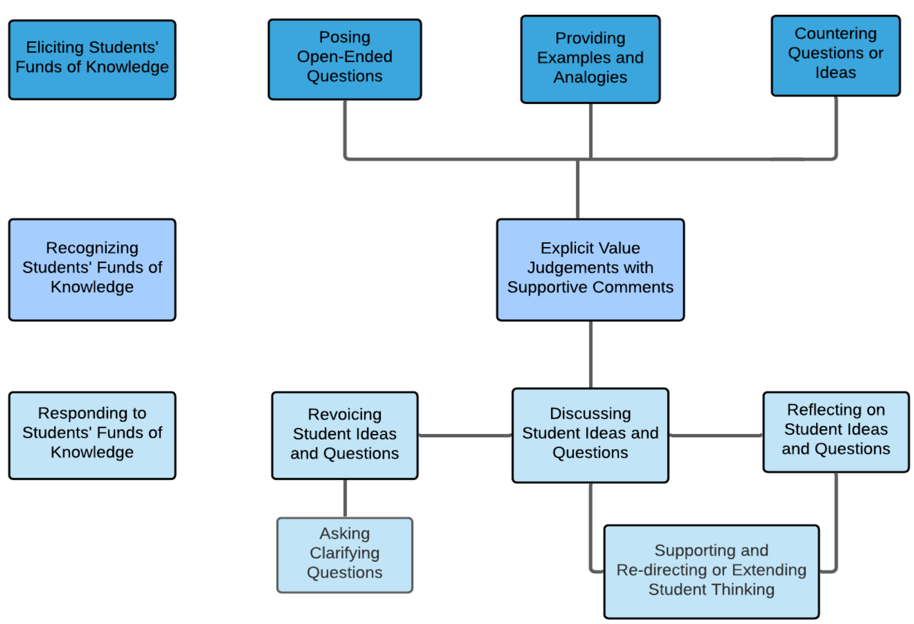
Dialogue in science classrooms often follows the initiation-response-evaluation (IRE) model where the initial question usually does not require a sophisticated response, and evaluation of the response does not encourage students to think beyond the initial comment (Cazden, 1988; Lemke 1990). Research that has sought to provide teachers with mechanisms to go beyond this model (e.g., Gotwals & Birmingham, 2016; Harris et al. 2012; Irish & Kang, 2018), specifically to capitalize on students' life knowledge and experiences, have traditionally and primarily been investigated in the context of curricular design, such as examined in the first part of this chapter. Little research, however, has focused on how this knowledge and experience can be capitalized during classroom discourse. Teachers often find efforts to include student knowledge and experiences in dialogue difficult, as it necessitates them to be flexible in their routines (Carpenter et al., 2004). In our curriculum, structures of dialogue were not explicitly designed. Although Ms. V and I would note specific points of discussion around certain topics or concepts we wanted to engage in during codesign meetings, the structure and mechanisms of these topic discussions were not considered in any specific way. Despite not structuring dialogue, when moments of dialogue in the online classroom were analyzed, there were clear patterns and strategies in the instructional moves (Harris et al., 2012) Ms. V and I used to request students to use their knowledge and understandings in dialogue. In the following sections, I provide a detailed description and analysis of these instructional moves, which I designate as communicative signals that were used to indicate to students their knowledge, experiences, and/or opinions were being welcomed into classroom dialogue.

An Overview of Flow

Communicative signals, as I classified them, comprised elements of teacher talk, that served as signposts for students who Ms. V or I invited to bring their community and cultural FoK and experience into classroom dialogue. Although these communicative signals were emergent and not designed in the curriculum, the methods of signaling reflected our designed curricular artifacts in their purpose, and served as "responsive teaching practices" (Gotwals & Birmingham, 2016, p. 2) to engage students' community and culture in the learning environment. Responsive teaching practices are defined as practices that characterize a teacher's attempt to understand what students are thinking through questioning and probing and use this understanding in future instructional moves (Pierson, 2008). In this study, we attempted to understand and included students' FoK, experiences, and opinions, in learning and use what we learned in future design iterations. Similar to the work of Gotwals and Birmingham (2016), which investigated teacher candidates use of responsive teaching practices, the communicative signals I present here were present as steps. Unlike their study, I present these communicative signals as a linked process (see Figure 2) of engaging students' FoK in inquiry-based science dialogue and learning, versus siloed steps that are disconnected and used individually. Although this study does not examine the quality of the communicative signals Ms. V and I used or their effects on students, as this is beyond the scope of this dissertation, I do provide a description of each signal, and an analysis of its purpose in classroom dialogue.

Figure 2

Communicative Signals in Inquiry-Based Dialogue Process



In dialogue, I identified three distinct, but connected, steps in process: (a) eliciting students' FoK, (b) recognizing students' FoK, and (c) responding to students' FoK. Each step of the process is composed of a set of communicative signals that served to support that phase of dialogue. These steps flow together to create a multistep longitudinal process of engaging students FoK in classroom dialogue. Each step of the process was demonstrated through individual indications to students that the teacher was inviting in their community and cultural knowledge, experiences, or opinions into the classroom space.

The specific communicative signals I addressed in each step of the process echoed and supported instructional strategies presented in the literature. I extend this work by presenting these strategies as a linked process that work together, rather than as separate or detached entities. In all cases, the aim of the communicative signal served to support the engagement of students FoK in the learning environment. Although there were instances in data analysis when only one step of the process was apparent, such as the teacher only elicited the funds of knowledge but did not recognize or respond when students provided examples, Ms. V and myself almost always engaged in each part of the three-step process when attuning to the students' lives in classroom dialogue. An examination of each step and the associated communicative signals is presented.

Eliciting Student Funds of Knowledge

The first step of the process, eliciting students' FoK, served to frame teacher questioning and comments as more than "fact checking" students. To ensure students understood science concepts in contexts beyond simple declarative statements or the regurgitation of fact, Ms. V and I used communicative signals to prompt students to draw on their ideas, experiences, and understandings to support classroom learning. By eliciting student FoK, we provided opportunities for students to demonstrate their understandings of the content and to share their ideas. Across discourse observations, Ms. V and I sought to elicit students' FoK using the communicative signals in three different ways: (a) posing open-ended questions, (b) countering questions or ideas, and (c) providing examples and analogies.

Communicative Signal I: Posing Open-Ended Questions

As examined earlier, open-ended questioning was a design feature in the written curriculum. This design feature was further translated in moments of classroom dialogue. Analysis indicated this strategy was one of the most common ways we asked students to use their FoK in classroom dialogue, specifically to make connections across context based on their own ideas, wonderings, experiences, understandings, and conceptualizations, similar to findings in studies by Harris et al. (2012) and Irish and Kang (2018). Question stems often included general talk patterns through statements such as, “What do you notice about . . . ?,” “What do you think we should add to . . . ?,” and “How do you think . . . ?” According to Ms. V, the purpose of this questioning was to demonstrate to students that they already have valuable resources that contribute, and can be incorporated, into science learning.

For example, when talking about food access and inequities in Project 1, Ms. V said to the students in a community circle discussion:

> So, what I’m interested in is your suggestions. What can we do as a community to try and fix this problem? We know that there’s an inequality between neighborhoods where wealthier neighborhoods have healthy food, not as wealthy neighborhoods have less healthy food, so what should we do about it?

In this quote, Ms. V started her questioning with the stem, “So what I’m interested in is your suggestions,” indicating to students she wants them to bring forth their own ideas and recommendations for possible strategies to solve this issue. She then follows up with her open-ended question, “What can we do as a community to try and fix this problem?” and “What should we do about it?" to indicate to students that she was attempting to elicit and explore their ideas around solutions to the problem. These open-ended questions created a space where teacher and students were seen as equal contributors to the learning environment, whose ideas and solutions were equivalently valued and supported.

Communicative Signal II: Countering Ideas or Questions

Countering ideas or questions (Harris et al., 2012) was another communicative signal Ms. V and I used. Although not as frequent, this strategy asked students to draw on their FoK by providing differing ideas, experiences, understandings, or opinions when another student had already presented a concept conceptualization. Using this strategy, we strove to elicit FoK from other students to see if there were similarities across their conceptualizations. Question stems were framed as "Do you all agree?" "Do you think it is something different?" "Does anyone else see the same thing?" "Anyone have the same or different opinions?" All these sentence stems asked students to draw upon their own experiences and FoK to compare or contrast their conceptualization to that of another student.

In some instances, we as the teachers made our own attempts to support students in engaging in this type of dialogue by providing our own countering ideas or questioning to ask students to see things from another perspective. For example, Ms. V used this communicative signal when we engaged students in a conversation around food insecurity. In this conversation, multiple students discussed the homeless as the only individuals to face food insecurity. Ms. V countered this statement by saying:

> But something *we can also consider* it's not just people who are homeless who are food insecure. Like Ms. Vincent, the person in the article, she has a place to live . . . but if she doesn't have the money to buy groceries or to buy food, that's where food insecurity can

come from.

In this statement we see that Ms. V provided a counter to the students' idea, using the stem "we can also consider" to explain that many others, including people that may not be homeless, can suffer from food insecurity.

Communicative Signal III: Providing Examples and Analogies

Providing examples and analogies (Irish & Kang, 2018) was the third communicative signal Ms. V and I used to elicit students' FoK. Although this strategy had the same overall goal as stated in the previous two strategies, it differed slightly. Instead of being student-generated, analogies and examples were teacher generated based on ideas that Ms. V or myself *assumed* students could connect to and would find relevant, not necessarily connections that students previously indicated as relevant. In speech, these communicative signals often were phrased with statements such as "Think about . . ." or "That is similar to . . ." to show students that the teacher was attempting to draw comparisons or contrasts to generate student knowledge.

For example, when talking about cultural foods, Ms. V used an analogy to compare salmon, as significant to Native cultural celebrations, to tamales, as important in Mexican cultural celebrations. She stated:

> So the same way that salmon is a special food in the culture of native communities, there are some foods which are also special in our cultures. I know when a lot of people think of tamales, they think of making them at Christmas time with their family.

By using the words "so the same way," Ms. V signaled to students she was providing an analogy between concepts. She assumed this analogy would be relevant as many of her students were Mexican, and the making of tamales was a previous example brought up by students.

Similarly, Ms. V also provided examples to make a "clear attempt to make the material more relevant and meaningful by connecting the concepts with what [she] thought the students might be familiar with or interested in" (Irish & Kang, 2018, p. 1235). In her lesson on food justice, Ms. V provided the examples of two local restaurants near the school that the students frequently visit to demonstrate what can be considered healthy versus unhealthy. She stated, "I know Tommy's Pizza is delicious, [but] healthy . . . probably not. Or like Pupita's is a little healthier because they're making everything by hand. It's not like big fast-food places like Jack in the Box or McDonald's or even Burger Palace." In this example, Ms. V used Pupita's and Tommy's to help students understand the concept of healthy and nonhealthy, respectively, by providing community-based examples through places that students frequented.

Recognizing Student Funds of Knowledge

The next step in the process, after eliciting students' FoK, was the communicative signal of explicitly recognizing moments in which students engaged their FoK. At this step, Ms. V's goal was to show students she valued moments in classroom dialogue where they brought forth their experiences, knowledge, and understandings, and viewed them as valuable in learning. Similar to a Harris et al.'s (2012) idea of making "value judgements" of student talk, in this communicative signal step, Ms. V provided clear, in-the-moment evaluations of students' comments to encourage their use of FoK. These evaluations, which affirmed students' FoK, included communicative signal statements such as "That's a really good point!" "Thank you for sharing!" "That's a super great point to think about." or "You've hit on something very important." Comments such as these served as communicative reminder to students that their experiences, understandings, and ideas were supported, respected, and positioned as legitimate resources and sources of knowledge in the classroom space. In providing these evaluations, Ms. V hoped students would continue to bring forth these resources in learning.

Responding to Student Funds of Knowledge

The last step of the process, responding to students' FoK, encompassed Ms. V and I replied to students presenting their FoK with explicit feedback that either supported and asked students to build upon their comments, or redirected their current understanding. These responses demonstrated we were synthesizing their presented knowledge and integrating it into larger classroom discussions to leverage the ways students make sense of science (Gotwals & Birmingham, 2016). Responding to students' FoK was presented in three main ways in dialogue:

1. revoicing student ideas and questions (Gotwals & Birmingham, 2015; Harris et al., 2012),
2. discussing student ideas and questions (Harris et al., 2012), and
3. reflecting on students' ideas and questions (Harris et al., 2012).

Communicative Signal I: Revoicing Student Ideas and Questions

The first communicative signal Ms. V and I used to respond to students' FoK was to revoice their ideas and questions. Revoicing was demonstrated in two ways. First, we used revoicing to communicate interpretations of a students' comments when they brought forward their FoK in dialogue. When using revoicing in this manner, we would repeat a student's comment back in our own words, signifying our interpretation of their comment, and allow them to either confirm or contradict our construction of their idea. This was simply in the form of repeating the comment, and then asking a question such as, "Is that what you meant?"

Second, revoicing was used to recall past FoK that a student had presented earlier in the lesson or in a previous lesson. This often took the form of comments such as "Someone mentioned that . . ." or "You said earlier . . ." These signposts indicated to students that we remembered and recalled when they presented their FoK and were using it to "explicitly align different student contributions and ideas with content" (Harris et al., 2012, p. 773). For example, in discussing their food and culture reflection activity, Ms. V stated, "Alex mentioned earlier that paletas were really important to him and his culture," showing she recalled Alex's earlier comment and revoiced it at that moment because it was significant to conceptualize the concept being discussed.

Once a students' comment was revoiced, it was almost always followed up by asking them a clarifying question to elicit their reasoning around their presented idea. Communicative signals for clarifying questions were often in the form of paraphrased follow-up questions such as "What do you mean by that?" or "How do you see that as relevant?" The purpose of these clarifying questions were to provide students a space to further share their ideas by prompting student reasoning to support their knowledge construction or present further information and understanding to support their point.

Communicative Signal II: Discussing Student Ideas and Questions

Next, responding to student FoK was also shown by discussing student ideas and questions. Discussion was signaled through remarks that indicated support of the students' comments in conversation, and then engaging in an extended dialogue around that topic. The signal of discussion was distinct, as comments and conversation were contained in the students' original idea and did not extend into other contexts. The discussion of student ideas, as illustrated, was almost always followed by the support and redirection of the comment, if the information presented was not necessarily correct, or an extension of the comment, if student thinking presented a thought that should be further explained. For example, in a conversation about transportation access points to healthy food options, Ms. V discussed a student's comment by stating:

So, Leo says that there were more bus stops closer to The Community School . . . So the further you get from The Community School, the further the food is from the bus line, which make sense to me because in some other neighborhoods everyone has a car, right? Or everyone could Lyft and Uber everywhere. So, it's easier for them to get to places that aren't next to bus stops. In our neighborhood if we have elderly folks or people who don't have cars then places need to be close to bus stops for them to get there.

In this example, Ms. V supported Leo's comment by stating his observation made "sense" to her and extended his observation through an explanation of her proposed reasoning as to why bus stops might be more present in South Los Angeles, close to the school, versus farther away.

Communicative Signal III: Reflecting on Student Ideas and Questions

Finally, responding was also demonstrated by reflecting on students' ideas and questions. As a communicative signpost for reflection, Ms. V and I would often present the student's thought process in the idea of "so what does this mean?" Differing from discussion, reflection was used to contextualize the student's idea in a context *outside of their original comment*, asking students to consider other contexts in which their idea may be relevant. For example, in Unit 3, Allison brought up the COVID-19 global pandemic as an example of an environmental justice issue that had compounded on communities of color. I, Symone, discussed Allison's idea through a support and extension of her comment:

Allison just said COVID. That's a really important point because we think about how these effects kind of compound, or like build up on each other. So, people that live in communities of color already have higher rates and risk of illnesses and diseases, partly because of, like Jordan mentioned, the lack of access to healthy food, and what's put in our bodies and the environments we live in. We can think about how that makes people more susceptible to COVID-19 and being able to get over it and fight the virus.

In this example, I reflected on and supported Allison's idea that COVID is connected to food insecurity by stating how the "effects compound" and then extended her idea by connecting it to issues of illness and disease that another student, Jordan, had presented earlier in the lesson.

Demonstrating the Flow

As stated earlier, the communicative signals I presented are not novice, but instead, support previous findings in the literature as strategies for teachers to engage students' ideas in dialogue (Gotwals & Birmingham, 2016; Harris et al., 2012; Irish & Kang, 2018). I do, however, extend on this work by bringing these strategies into conversation with each other, and present them as a process of linked tactics that work together in classroom dialogue to support the engagement of students FoK, and general ideas, in science learning spaces. Using Silseth and Erstad's (2018) turn-by-turn analysis of dialogue, I provide a detailed examination of two short fragments of classroom dialogue to demonstrate an example of this process, from eliciting to responding to FoK, that occurred in our CBS class. I selected these examples because they are representative of moments of back-and-forth discussions between the teacher and student and present this process in clear and concise fragments of dialogue. As stated earlier, back-and-forth moments were not always present in the online learning space, instead, occurring mostly in the Zoom chat feature. Therefore, these examples serve to show what this process can look like in a classroom setting on or offline.

Example A: Providing Examples and Analogies Process Flow

In the example, Ms. V and I were engaging students in a whole class discussion around LA city policies and procedures for building a new eating establishment. The following is an excerpt from a conversation between Ms. V and a student, Josh, during this larger discussion:

1. Shriya: **We can think about it this way**, even if I love, **In-n-Out**. I absolutely adore
2. **In-n-Out** and I want to have an **In-n-Out** build right next to my house. Can I just, do
3. that? Can I just be like okay cool, I want to build **In-n-Out**, and then like get it
4. built next to my house? Who would need to make that decision?
5. Josh: The city of LA.
6. Shriya: Okay, so maybe the city of LA gets to make some decisions, **that's totally true**.
7. Josh: Yes
8. Shriya: **The city does have some codes** about a restaurant can get built in this spot or
9. another one. **Who else decides to put a restaurant somewhere?** It is a business,
10. so, **who would it matter to?**

In this excerpt, Ms. V attempts to help students to understand the science of policies and practices that contribute to systemic inequalities around food access. She does this using the communicative signal of *providing examples and analogies* (Lines 1–4), stating, "Well we can think about it this way," and then using In-n-Out (i.e., a popular Los Angeles burger fast food spot) as her example. Ms. V uses this establishment, as believes it is relevant to the students and a place they eat because there are multiple locations in the community. She follows this example with a question for the students to answer. Once Josh provides his answer, Ms. V then moves on to the next step of the process and recognizes Josh's comment by providing an evaluation (Line 6), stating, "that's totally true." Finally, Ms. V engages in the last step of the process and reflects *on* Josh's idea (Line 8) by stating, "the city does have some codes . . . " and attempts to support *and extend his thinking* by asking follow-up questions as to who he think makes the decision about the coding (Lines 9–10).

Example B: Countering Ideas and Questions Process Flow

In the example, I (Symone) was in a Zoom breakout room with a group of students discussing our food mapping activity in which we had students use google maps to determine the presence of different food access points (e.g., fast food, grocery stores, farmers markets) in extending miles away from the school. The following is an excerpt from a conversation between me and two students:

1. Symone: Fast Food, yeah so there was definitely a lot, a lot of fast food in two
2. miles of The Community School. **What else? What else do did people notice? Anyone have any different opinions on that?**
3. Andrew: There was a market
4. Symone: **Yes!** So, there was a market that might have provided some access to fresh
5. food
6. Juan: What about a jack in the box or a burger?
7. Symone: Jack in the box, **there's definitely a lot of those**. What type of food are
8. those? Are they restaurants, fast food?
9. Juan: Fast food
10. Symone: Fast foods, right? So we see that there's a whole lot of fast food in and
11. around the school community. Why do you guys think there's so much fast
12. food?
13. Juan: Because a lot of them…a lot of Latins like fast food
14. Symone: **You said a lot of Latin people like fast food? Right?**
15. Juan: Yes.
16. Symone: **Why, why do you think that? What makes you say that?**
17. Juan: Cause there's a lot of McDonald's near us.
18. Symone: Mmm Hmm, **so do you think it's what people like, or what gets placed**
19. **there?**
20. Juan: *confidently* What some people like
21. Symone: Okay, **so who do you think is deciding to build these fast-food places**
22. **there?**

In this excerpt, I was attempting to help students articulate the patterns in food access points between South Los Angeles (a predominately low-income area of color) and West Los Angeles (a predominately white wealthy area). As the students were discussing their ideas around what options of food were found near the school, they continued to note that it was mainly fast food. I then provided a countering question, to see if other students had noticed anything different (Lines 1–3). When Andrew answered with a counter example, I responded to it by providing a value judgement with the word "Yes" (Line 5) to show that his answer was valid. When Juan continued to bring up other fast-food places, as that was his observation, I also recognized it by providing a value judgement by stating “there’s definitely a lot of those.” I respond to Juan’s statement with a follow-up question based on his answer (Lines 12–13) in which he answers with an opinion (Line 14). I, then, engage in the last step of the process and respond to his opinion by revoicing his idea (Line 15) to make sure that I was interpreting his answer correctly, and follow up by asking him *clarifying questions* (Lines 17, 19 and 22–23) to support his claim, allowing me to more clearing understand the reasoning behind his comment.

Conclusion

In this section I have demonstrated how the emerged communicative signals, and the pattern of dialogue in which they occur, served as “responsive teaching practices” (Gotwals & Birmingham, 2016) for Ms. V and I to invite in students’ community and cultural funds of knowledge, as well as their general ideas and wonderings. Through a process of eliciting, recognizing, and responding, I presented a case for how the communicative signals associated with these steps work in conjunction to demonstrate our attempts to understand student knowledge and opinions and use it in instruction (Pierson, 2008). In describing and analyzing the individual signals, as well as their collective process, I exhibited how students’ everyday knowledge can be mobilized to support reasoning in science learning (Silseth, 2018). Our hopes, collectively, are that these signals acknowledge the FoK, opinions, and ideas of students, and position them as significant to the social construction of science concepts. We present this as a process that teachers can draw and build upon to more purposefully engage in dialogue that contextualizes students’ lives in school science learning.

Pieces of a Puzzle

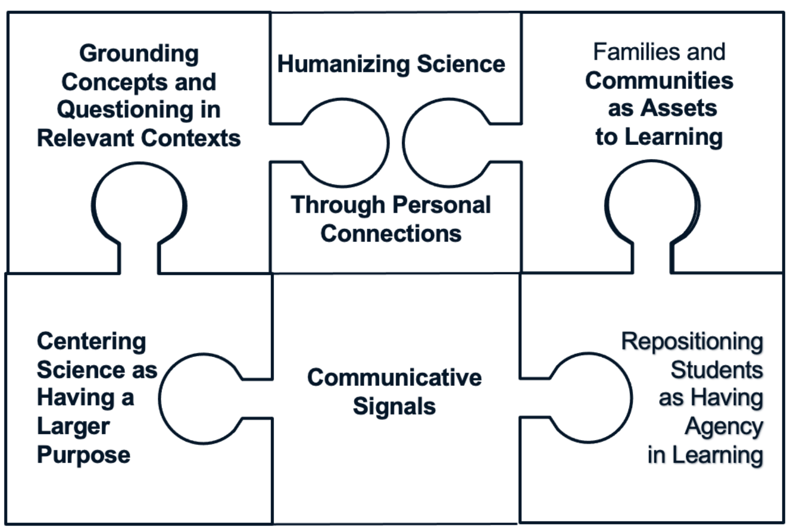
As qualitative researchers, we understand our identities play significant roles in how we come to understand, interpret, and value data. Students, however, are often not taught science in this manner, and view science as "objective" and "uninfluenced" by who they are and the social contexts that contribute to their understandings. By valuing student identity across our curriculum, our design features served to modify this understanding by attributing value to the people and elements of students' lives as unique sources of science learning. Our communicative signals, further, support the idea of student identity, experiences, and opinions as steppingstones of understanding for teachers to build upon (diSessa, 1993). In doing this, we support "boundary crossing," to create generative learning spaces that reposition youth as capable to investigating and engaging in complex socioscientific issues (Stromholt & Bell, 2018). Although the inclusion of identity in learning was not necessarily a designed element of the overall curriculum or communicative signals, it was an embedded aspect of both structures.

Supporting Lave and Wenger (1991) sociocultural theoretical construct that science learning cannot be separated from the cultural and social contexts in which students participate and learn, in this chapter I presented these design features as concrete strategies for educators to engage students in a reflection of significant elements of their lives and cultures, thus their cultural and social contexts, while also surfacing aspects of their identity to support the engagement of their FoK in science learning. Further, I presented the communicative signals as a process of dialogue maneuvers for educators to elicit and expand upon students FoK, opinions and ideas in learning to indicate to students that life experiences can be used to explain and understand socioscientific phenomenon.

Although design features are presented as separate entities that individually meet one goal or are individually found in a single artifact, in practice, they serve as collective pieces of a puzzle (see Figure 3) that are retrofitted and intertwined together, along with the communicative signals, to support the engagement of students' FoK in CBS learning. As a collective, these features enlist students' FoK as a mechanism to critically analyze the complex, political nature of contemporary science and challenge neoliberal narratives and power structures in science education (Roseberry et al., 2010) to reimagine science as a space for equity and transformation, and support notions that student knowledge and experiences are critical elements of engagement in science learning. The mechanisms students use to conceptualize the nature of science, specifically considering how issues of EJ and SJ are reflected in their lives, to challenge hegemonic narratives in science education in these design features, are explored in the next chapter.

Figure 3

Curricular Design Features and Communicative Signals as Connected Pieces



CHAPTER 5: STUDENT CONCEPTUALIZATIONS OF SOCIAL SCIENCE ISSUES IN THEIR COMMUNITY

In the previous chapter, I provided an examination of design features Ms. V and I used in our community-based science (CBS) curriculum to account for students' funds of knowledge (FoK) in science learning. In this chapter, I expand on those findings to address how students' conceptualizations of environmental justice (EJ) and social justice (SJ) issues in their lives and community, both in writing and dialogue, were reflected in the classroom through our designed curriculum. Specifically, I present a comprehensive analysis of the mechanisms that students use to facilitate and explain their understandings of the relationship between science and community while learning through a CBS framework.

Brown (2019) and Gomez (2007) noted students of color (SoC) have understandings of science concepts that are not historically recognized as scientific because the conceptual framing or vocabulary used to explain the concept are not "correct." Inequities in science learning are often perpetuated when the language and conceptualization of science are juxtaposed to, and sustained over, that of SoC, further positioning their lives, experiences, and cultures as not holding scientific value (Boutte et al., 2010). Thus, science classrooms, as situated in their own subculture, include "particular ways of knowing, talking, and doing that do not always clearly align with the social worlds that youth bring to science" (Barton et al., 2008, p. 72), positioning students' worldviews at odds with science instruction.

In this chapter, I seek to support ideas of how students create a third space (Barton & Tan, 2009; Gutiérrez et al., 1999)—or the place between the first space of school science and the second place of home—to create a hybrid zone that encompasses elements of both of school and home to align their articulation of socioscientific phenomenon with both their social worlds and science concepts. Extending on the work of Barton and Tan (2009), which investigated the different FoK and discourses students used in an urban middle school science class to author new hybrid spaces, this chapter provides evidence of the ways urban SoC use their FoK to create a third space in learning around EJ and SJ. Specifically, I analyzed the mechanisms students used in a CBS class to leverage their everyday lives and experiences to connect out of school and in school science learning to support their articulation and conceptualizations of the effects of EJ and SJ issues on their community.

These findings, I argue, provide educators with indicators of student conceptual understandings to be mindful of, and account for, when engaging in CBS learning to emphasize the integration of "everyday resources with disciplinary learning to construct new . . . practices that merge the different aspects of knowledge and ways of knowing offered in a variety of spaces" (Moje et al., 2004, p. 44). In this chapter, I present evidence from Units 1 and 3 to provide a case for the methods urban SoC use to conceptualized EJ and SJ issues in their community, through their FoK, during the enactment of our codesigned curriculum to create a "third space" in learning. Findings are presented as two overall themes, "Assessing 'Environmental' Contexts and Conditions" and "Subjective Wealth," that are further divided into subthemes. Each subtheme is described, and further divided into an analysis of the specific mechanisms of conceptualization students used to support their FoK in the classroom space.

Theme 1: Assessing "Environmental" Contexts and Conditions

The most prominent way students conceptualized their understanding of EJ and SJ issues in their lives was through the overall feature theme of Assessing Environmental Context and Conditions. In this theme, I characterized the term *environmental* as not only representing the physical environment, such as what students can see and what is around them, but also the social environment that students live and interact in. These unseen or overlooked features of the environment played a significant role in how EJ and SJ issues were present and perceived in their lives. Framed in this way, students drew upon their observations, reflections, and understandings to present environmental contexts and conditions that they believe play significant roles to perpetuating EJ and SJ issues in their community and other, similar, communities of color.

This overall theme addresses and supports Barton and Tan (2009) commitment to the importance of incorporating "students' nontraditional funds and discourses to enrich and broaden the boundaries of official school science," (p. 17). Through students' contextualization of EJ and SJ issues in broader contexts, not just those traditionally esteemed as relevant in science, students were able to meet our curricular learning goal of humanizing science to help students see themselves as:

1. "legitimate participant(s) in the science learning community" (Barton et al., 2008, p. 72),
2. their experiences and knowledge as sources of knowing and understanding that help to conceptualize science concepts, and
3. positioning students in a space to "renegotiate the boundaries of their participation in class" (Barton & Tan, 2009, p. 4) to nurture greater opportunities to engage in science subject matter, as well as inclusion, in the learning environment.

In this section, I describe the three ways (see Table 5) that students characterized the EJ and SJ issues in their community and in similarly demographically and socioeconomically constituted communities.

Table 5

Overview of Assessing "Environmental" Contexts and Conditions Theme

Subtheme	Design feature
Collective community struggle	Health concerns
	Environmental conditions
Drawing comparisons across contexts	Comparing across race and ethnicity
	Comparing across socioeconomic status
Choices and change	Community harm and community change through individual action
	Community change through community action
	Community change through world-wide action

Subtheme A: Collective Community Struggles

In our CBS class, Ms. V and I viewed the practice of science not as a matter of fact or fiction, rather, a collection of social experiences that contribute to our conceptualizations and understandings of the connections between science, scientific enterprise, and our lived experiences. From the constructivist perspective, the learning of science is an "active, social process of making sense of experiences" (Seimears et al., 2012, p. 269). As an overall curricular goal, Ms. V and I sought to help students make sense of their lived experiences by understanding the causes and effects of EJ and SJ issues in their community. Upon analysis, we discovered that in both writing and dialogue, students often reflected on and described the causes, effects, and perpetuations of EJ and SJ issues through descriptions of observed struggles of the collective community. In this context, students drew upon their experiences in, and observations of, community issues through two mechanisms: health concerns and environmental conditions.

Conceptualization I: Health Concerns

One of the most common collective community struggles students presented when discussing EJ and SJ issues were the causes and negative effects of prominent health concerns on members of their community. Like Barton and Tan (2009), students drew upon their community

FoK of “fast food” in Unit 1 through discussions of the presence of more fast-food restaurants compared to “healthy places” in their community. When discussing food access, students described patterns in the type of food most commonly available in their community (fast food) and the types of food that were available in the grocery store (unhealthy). For example, one student commented, “There’s a lot of fast-food places around The Community School. . . . Mostly I see a lot of junk food.” Another student supported this sentiment, stating:

> There are a lot of places that sell unhealthy food, like the markets that we usually go to. Those places have a lot of stuff that is unhealthy like chips, cookies, bread, and some of the meats are unhealthy too.

In these two comments, students noted patterns in the proximal geographic area around the availability of fast food versus healthy food, noting fast food was more common around their school. Markets that should have healthy food options were often littered with many unhealthy options as well. The use of “we” in their statements indicates their recognition of the relationship between where they live and the presence/absence of different food sources.

In our codesign curriculum, students extended on these ideas by correlating the presence of a high number of fast food restaurants to community health issues. Specifically, students often alluded to the contribution of these food sources to the struggle of Black and Brown communities with diseases such as obesity, diabetes, and high blood pressure. For example, in one students’ Unit 3 advocacy letter, they wrote, “when people live in a food desert, they are at risk of obesity which can cause a lot of health issues like diabetes and high blood pressure.” Another student supported this comment stating, “families [who] only eat fast food . . . can give you problems like obesity and diabetes.” Collectively, these statements demonstrate students’ awareness and understanding of high rates of disease in communities of color as a socioenvironmental issue resulting from a lack of access to healthy food. Further, the use of "people" indicated students recognized this not as an individual problem, but rather a collective issue faced by many who live in areas that lack healthy food options. Similarly, a third student stated, "young people can have obesity or diabetes, so it is dangerous for all people," indicating their recognition that even they themselves, as young men and women, are not exempt from suffering from the effects of this health crisis.

Studies have shown those who live near an abundance of fast-food restaurants compared to grocery stores have a "significantly higher prevalence of obesity and diabetes" (e.g, Babey et al., 2008, p. 1), with communities of color and low-income communities having the highest rates of these diseases. Student comments indicate they recognize the prominence of these health issues as serious concern, and attribute it to the lack of healthy food in their community. In this sense students articulated this FoK as a mechanism of conceptualization when discussing access to healthy food and its connection to the preservation of community health issues. Some students further extended these notions by connecting the perpetuation of these health issues to "not hav[ing] access to healthcare in the same way [as wealthier areas] and not having access to doctors." This mechanism of comparison across race when addressing EJ and SJ issues is further discussed in the next subtheme.

Conceptualization II: Environmental Conditions

Similarly, students also conceptualized collective community struggles through environmental conditions, specifically the presence and sources of air pollution in their community. As discussed earlier, the school community is home to multiple autobody shops and in the direct path of flights to and from LAX, both of which, according to the students, are significant sources of pollution in the community. Students' articulation of sources of air pollution were seen in comments such as, “la contaminación en el sur es aire producto principales de las emisiones de los tubos de escape de los automóviles. Tambien del diesel de camiones de los angeles [*Pollution in the South is air mainly produced by emissions from automobile exhaust pipes, [and] also from diesel from Los Angeles trucks*],” or “En el sur de Los Ángeles, la mayor parte de nuestra contaminación proviene de la empresas de gases toxicos . . . y de carros quemando gasoline [In *South Los Angeles, most of our pollution comes from toxic gas companies…and cars burning gasoline*].” From these comments, we see that students distinguish cars and automotive companies as contributing significant amounts of air pollution. As these sources are visible to students daily, these statements show that students engaged their observations of their community to present an understanding of sources of environmental harm.

Extending on these ideas, many students specifically reflected on the effects of sources of pollution as contributing to respiratory problems, and even death, among community members. For example, when discussing respiratory issues, one student noted in their Unit 3 advocacy letter that, “esta contaminación del aire puede causar efectos negativos para la salud comoproblemas respiratorios problemas oara respirar e y el aire se vuelbe muy daÑINO [*this air pollution can cause negative health effects such as respiratory problems, problems with breathing and the air becomes very HARMFUL*].” From this quote we see the student associated the air pollution as being unsafe for, and attributing to, respiratory issues among those living in the community. By writing “harmful” in all caps, the student emphasized their understanding that these pollution sources are contributing to community harm. In dialogue, another student supported this notion of the high numbers of respiratory issues in their community stating, “My big brother, he’s 14, my little sister, she’s 5 and my older sister, who is 23 all have asthma, but my little sister’s is the worst. It got worse since we moved to our new neighborhood [by the school] and she always goes to the hospital." This student drew on a personal experience to describe how he knew and understood the connection between air quality in the neighborhood and its effects on the respiratory system, specifically articulating the asthma of his family members becoming worse when they moved to their current neighborhood. This example illustrates that students associate their specific area are being significantly affected by negative environmental conditions.

Other students further extended the understandings of the negative effects associated with air pollution by linking it to increased death in their communities. In a Unit 3 project reflection, a student commented, "enpresas contribulen a liberar mucho dioxido de carbono que contribullen a que la gente muera [*the companies [automobile] contribute to release a lot of carbon dioxide that contribute to people dying*]," indicating the autobody shops served as a major source of pollution that contribute to the death of community members as a result of respiratory issues. Another student reflected this comment in their Unit 3 advocacy letter, stating, "pollution brings diseases, and some can be deadly, and we have to take care of it because if we contaminate more, you could make a person sick or die." Like Davis and Schaeffer's (2019) analysis of students' understanding of the Flint water crisis, our students present the EJ issue, in this case air pollution in their community, as a matter of life or death.

Overall, these statements indicated how students conceptualized EJ and SJ issues in association with negative effects on health and environment of community members. Students delineating specific examples of sources of pollution, bringing in personal examples, and drawing connections between these EJ and SJ issues and the larger effects it has on the community demonstrated that Ms. V and I were able to meet our curricular goal of students being able to recognize, discuss, and articulate causes and effects—in this case the negative impacts, of EJ and SJ issues on their communities.

Subtheme B: Drawing Comparisons Across Contexts

Data, both locally and nationwide, paint a clear picture of the unequal effects of the climate crisis on communities of color. In South Central Los Angeles where this study took place, working-class communities of color are up to 6.2 times more likely to live near industrial land, uncontrolled hazardous waste sites, and areas of higher pollution concentration than their white counterparts (Cushing et al., 2015). The ability to analyze and interpret data to recognize these patterns, was a scientific skill that Ms. V and I sought to teach our students in the context of our codesigned unit. Through our 3 years of working together, we recognized students demonstrated clear understandings, through descriptions of their direct observations, of the discrepancies between the impact of the climate crisis in their community versus more affluent communities. Thus, part of our design goal was to provide students with the ability to analyze community data and recognize patterns in data to support their articulations of community issues. While engaging in data analysis in the context of our codesigned curriculum, students' interpretations of data patterns around community EJ and SJ issues were articulated most frequently through narratives of comparisons across race and ethnicity and economic status. Students used these comparisons as a basis to conceptualize EJ and SJ issues across contexts and support their claims of community effects.

Conceptualization I: Comparing Across Race and Ethnicity

In discussing their interpretations of data analysis in the units, students often drew comparisons of EJ and SJ issues across race and ethnicity to explain why communities of color were more negatively impacted by EJ and SJ issues than predominately white communities in

Los Angeles. In these comparisons, students elicited their community FoK (Barton & Tan, 2009) through two overarching concepts—privilege and vulnerability—to present understandings as to differences in the effects of EJ and SJ issues across space.

The idea of certain people having "privilege" was an overall common concept discussed in students' interpretations of data analysis. In one students' Unit 3 analysis reflection, they stated, "privilege benefits some people over others simply because of how they look. . . . Everyone should have the same resources to succeed, even if they already have a lot of privilege." In this statement, the student connected the compounding effects of EJ and SJ issues on certain communities to the lack of "resources" available based on "how [people] look," insinuating that communities of color are more likely to have less resources to address EJ and SJ issues.

More specifically, in another Unit 3 project on hazardous waste sites, a student supported the idea of race privileging, stating:

> I think it [the greater number of hazardous waste sites in communities of color versus white communities in Los Angeles] is because of the fact that in our community there are a lot of colored people and they think it would be a waste of their time if they clean it because they think we are careless and will just mess it back up.

In this statement, the student attributed the perpetuation of numerous hazardous waste sites in her neighborhood to larger racial/social contexts of where she lives. Her use of the term "colored people" offered a sociopolitical analysis in speculating that race and racial identity plays a significant role in the social contexts of how these individuals are viewed (i.e., "careless and will just mess it back up") and why this issue has not been addressed.

This same sociopolitical analysis of the role of race contributing to the lack of willingness by the city and state to address EJ issues in certain communities was further supported by another students' data analysis refection, where they stated there are "no equal chances because they're people of color and if you live in a certain area there might not be changes because there's people of color." This statement indicated that the student conceptualized location and race as intersecting factors that determine where change and addressing EJ issues is more likely to occur. This reoccurring notion of privilege illustrates that students conceptualize the intersecting and compounding effects of race and ethnicity with the perpetuation of environmental harm from EJ and SJ issues in communities of color.

For our English language learners, a common conceptualization of the effects of EJ and SJ issues on communities of color was described through the concept of vulnerability. Students indicated that certain communities were more likely to be vulnerable to EJ and SJ issues simply because of the race of its occupants. In their data interpretation, students made comments such as "personas que reciben diferente trato por diferente raza u otras cosas, en si a los mas vulnerables [*people who receive different treatment for different races or other things, in itself are the most vulnerable*]" and "diferentes tratos en los hosptales o luages publicos, no poder estar libremente en algun lugar, No recibir la misma ayuda por ser de diferente raza [*different treatments in hospitals or public places, not being able to be freely somewhere, not receiving the same help because they are of a different race*]." In both of these quotes, the students described issues from the social justice perspective that certain people are more vulnerable in general, not just to EJ issues, because of being a certain race. Although the connection was not made explicitly, this interpretation could be a possible reflection of the student's own feelings vulnerability of being and living during a time of prominent racial unrest with attacks against marginalized individuals in the United States.

Conceptualization II: Comparing Across Socioeconomic Status

Across Units 1 and 3, students analyzed trends in data when investigating maps and models of EJ issues in the local community. In articulating their interpretations of the data, students also drew comparisons of the effects of EJ and SJ issues through discussions of differences between the "rich" and the "poor." In Unit 3, one student investigated the presence of hazardous waste sites across Los Angeles. In reflecting on their data analysis, the student presented suggestions as to why such large discrepancies were present across West Los Angeles (white, affluent neighborhood), and South Los Angeles (lower income, predominately area of color). The student stated said, "I think The Community School has so many cleanup sites because it is a more poorer neighborhood . . . no one pays attention to those places." In their conceptualization, the socioeconomic identity of the community (a "more poorer neighborhood") was presented as playing a significant role as to why their community was more affected by this EJ issue. By stating "no one pays attention to those areas," the student raises a larger issue by noting that low-income communities are rendered invisible in reference to the perpetuation of environmental harm. This comment indicates that the student recognizes the presence of larger systemic inequities, a goal of our codesigned curriculum, as perpetuating in lower socioeconomic area where individuals are more prone to the negative effects of EJ issues.

In another Unit 3 project, students investigated the SJ issue of inequities in school funding. In their data interpretation reflections, students drew comparisons between "rich" and "poor" schools to describe why these inequities existed. Students conceptualized this issue through comments such as "I feel like it's not fair that rich schools get more things instead of poor schools," and "This is unfair because schools in poor areas have leaks and don't have enough money to buy new books or laptops for students." From these statements, we saw students conceptualized school funding issues as a result of one set of schools (rich schools) having the funds to provide their students with adequate resources, while other schools (poor schools) as not able to provide those resources because they do not have the money. In their advocacy letter, another student extended on these ideas, stating:

> I looked at a map of school districts in LA County and I found out that richer communities don't want to share their money with other people in the county, so they created their own small districts. This means that poor neighborhoods only have their own tax money for funding their schools.

This statement demonstrated a sociopolitical analysis, indicating their recognition of systemic measures taken by people in wealthier areas to group themselves away from lower socioeconomic areas to keep money in their schools, creating boundaries in tax support for schools and inequitable barriers to school funding opportunities. Again, this student's analysis indicated they were able to meet our instructional goal of "naming" these larger systemic problems are present in their lives.

In Unit 1, comparisons were often conceptualized by students explaining differences in the availability of healthy food based on socioeconomic status. For example, in a reflection activity, one student stated, "Rich people get all the healthy food while us more poor people don't get any type of good produce." In this comment, the student presented the idea that access to healthy food is directly correlated with a person's socioeconomic status, indicating it is more difficult to access healthy when you don't have a lot of money, or in their distinction, when you are “poor.” The students use of “us” indicated that they associate themselves in this category and saw their community as affected by this issue.

Other students extended past the idea of the general availability of health food, to articulations around the cost of healthy food. In a students’ food access activity reflection they wrote, “rich people can afford healthy food but some people can’t,” indicating the cost of food as another social barrier to access healthy food for economically disadvantaged people. Supporting this idea, in a small group conversation around student data analysis on food access, the following the following interaction occurred:

> Symone: So are you went further away from The Community School, did the types of food that were available change?
> Josue: Yeah, they changed because of the millionaire people all the way in Santa Monica

This short bit of dialogue, the Josue’s statement of the “millionaire people” paints a picture that student views of food option availability is directly correlated with their conceptualization of healthy food primarily concentrated in areas where people are economically advantaged and can afford it. Collectively, students’ conceptualization through comparisons across socioeconomic status indicated that Ms. V and I were able to meet our goal of guiding students to learn how to analyze community data and recognize patterns in the data to support their articulations of the experiences and observation of community issues. In doing this, we support students’ alignment of socioscientific issues in their own lives through science concepts.

Subtheme C: Choices and Change

The harms of scientific enterprise are institutionalized and engrained in the foundation of our society, with patterns in issues of environmental injustices and inequalities disproportionately concentrated in low-income urban communities of color where non-white children live, play, and go to school (Clark et al., 2014; Kayumova et al., 2019). Neoliberal ideologies that plague traditional science learning often focus on ideas of individualism, creating science learning environments that position people as "individually responsible for their own well-being" (Bellino & Adams, 2017, p. 273). In this idea, the emphasis on discourses of individual choice and behaviors as causes and solutions is often prioritized over ideas of collective community action to support the revitalization of communities in the fight against EJ and SJ issues. In our codesigned CBS curriculum, data analysis indicated a theme of "choices and changes," indicating how students conceptualized who/what is responsible for environmental issues, and what can be done about it. The following section presents an analysis of students' conceptualization on who contributes to environmental issues, as well as proposed solutions that support positive community change.

Conceptualization I: Community Harm and Community Change Through Individual Action

Although students were able to recognize the larger systemic structures that perpetuate some EJ issues, in discussing ideas around who contributes to community harm, students' articulations were often in-line with neoliberal constructs that individual choices of community members (Bellino & Adams, 2017), specifically negative choices, were those that most commonly contributed to community environmental harm. In Unit 1, negative choices were described as individuals actively choosing not to eat healthy food, even if it was available. In reflections students wrote, "there are a lot of people eating unhealthy food because of the markets they go to . . . there are a lot of kids buying chips and stuff they like," and "in South Los Angeles people don't usually eat healthy food because they are not used to eating healthy food." These comments indicated students saw individuals making personal decisions that perpetuated unhealthy habits. It was interesting that although they recognized and articulated issues of food access as an EJ and SJ issue in their community, they still "blamed" unhealthy eating on people making a choice to not eat healthy. These comments indicated students believed the idea of "access" as a systemic issue was not the complete picture. Rather, access is also in conversation with the decision-making process of individuals. This idea was supported in a conversation I had with a student:

> Josh: Because a lot of them . . . a lot of Latins like fast food
> Symone: You said a lot of Latin people like fast food?
> Josh: Yes.
> Symone: Why, why do you think that? What makes you say that?
> Josh: Cause there's a lot of McDonald's near us.
> Symone: Mmm Hmm, so do you think it's what people like, or what gets placed there?
> Josh: *confidently* What some people like

From this dialogue, Josh equated the presence of many McDonald's restaurants because of a certain group of people "liking" the fast food. Again, he equated the idea of unhealthy eating with a choice people made because that is what they preferred, rather than what was available.

Further, students also conceptualized the negative choices of individuals as contributing to environmental harm. For example, students described how people made the choice to litter, with comments such as, "people feel like it's okay to litter," "people are throwing trash on the floor and the wind takes it on to the ocean," and "contamination of the plastic that we throw in the streets is the pollution that is killing the world." These statements indicated students conceptualized the individual action of people littering as collectively contributing to larger environmental harm on the community. Although students were not saying institutionalized environmental harm does not contribute to the perpetuation of environmental issues, they did indicate systemic issues were not fully responsible for environmental harm, and the individual actions that community members make significant contributions.

Keeping with these neoliberal constructions of individual responsibility, when discussing how to address change, students most frequently discussed engagement in individual action.

Individual action was defined as the actions people chose to make, in this sense positive, that can support community improvement. In Unit 1, these individual actions included, "making sure that everybody has food and make sure that nobody is dying," "help people who don't have food," and "don't waste food that could be given to someone who haven't had food in days." In Unit 3, when discussing environmental pollution, individual actions consisted of "no littering, respecting the world around you. Not throwing trash," "no tirando basura en la calle [*not throwing garbage on the street*]," and "go[ing] out into the streets and knock[ing] on the door and explain to people why it is important to take care of others . . . get people to help take care of the environment." These comments indicate students' belief that small choices that people make can support larger outcomes in their community to work against EJ issues. Again, their conceptualizations presented an interesting opposition, as students showed a recognition and understanding of larger system issues, but still presented ideas around change to address these issues most frequently through individual actions. These findings demonstrate that our curricular design fell short, in some ways, of breaking neoliberal conceptualization of environmental responsibility among students.

Conceptualization II: Community Change Through Community Action

Less common, but breaking away from neoliberal ideologies of individuality, students also conceptualized change when addressing EJ and SJ issues through engagement in community action. Community action was classified as acts that created community transformation on a broader basis. These were not actions by any one individual, rather they were actions that the collective community could attend to. In Unit 1, community change was conceptualized through ideas of addressing food access through supply and donation. Students made comments such as "people that own markets and grocery stores . . . should give out food for needing people and for the homeless," and "give healthy food to the people who don't have opportunities to buy the best food. I think we can make that with the help of the people who have stores of healthy food." In these comments, students indicated change as being accomplished by businesses in the community coming together and providing food to those in need. In this sense, students attributed responsibility to create change as a collective endeavor.

Further, students discussed community action through the equal distribution of goods. Specifically, for students who investigated SJ issues such as school funding, the concept of equal distribution was widely presented as a change idea among students. For example, in one students' Unit 3 digital interactive notebook (DIN), they described the solution as "properly distributing school funding more equally to all people. I feel like not all students get the same amount for school funding; for example, private schools . . . have way more stuff instead of public schools, so wouldn't it be fair if public schools get that?" In this case, the student conceptualized the city as needing to take action to provide equal resources for all students, no matter the school, to succeed academically. Another student echoed this sentiment stating, "It would be fair for the same amount of funding to all schools. Private schools have way more stuff instead of public schools." From this comment, we saw the student reasoned that school success can be supported through the community taking action to make sure that all school are provided with equal resources.

Collectively, students conceptualized the idea of community change through ideas of activism, as one student said, "everyone has to come together to fix a big problem, because no one can do it alone." In this statement, the student demonstrated the idea that EJ and SJ issues must be addressed through collective mobilization and community-relevant approaches that position not just individual citizens, but the larger community, as responsible for addressing community injustices (Bellino & Adams, 2017).

Conceptualization III: Community Change through World-Wide Action

Least frequently, students conceptualized change as larger, world-wide action. Here, students articulated addressing community EJ and SJ issues by first challenging and changing large social inequities. In this conceptualization, students presented ideas of a “trickle down” effect, indicating that if greater social and environmental inequities were addressed, then community inequities would be as well. In this conceptualization of change, students did not attribute responsibility on any person or entity; rather, students established change as actions that should be taken by all to contribute to a better environment. For example, one student stated “one idea is addressing social inequality including income gap, gender inequality, health care and social class. A second idea is health care—some individuals receive better and more professional care compared to others.” In this statement, the student conceptualizes change as everyone having equality in major social and economic realms. These are not changes that can be made through a single action, rather changes that must be accomplished across multiple spaces to snowball larger revolutions.

When specifically discussing EJ issues such as environmental pollution, students posited change through actions such as “stop releasing carbon into the atmosphere and someone will remove the plastic caps,” and “stop polluting our environment because also without the environment we do not live because the environment is what sustains us.” These comments indicated the students envision environmental action on a large scale, not just in their community. Although the worldly EJ issues students presented mirror those that have direct effects on their community, by presenting change as focused on a larger scale, students demonstrate a grappling with notions of the relevance of these topics in their communities, similar to those conceptualizations of students as seen in Davis and Shaeffer (2019).

The reduced frequency of conceptualizations around worldly change support perceptions that students met our goal of being able to see that change does not have to be external or the result of an outside influence, but can be as a result of members of the community taking action. Students' conceptualizations of change collectively, however, fall short in our goal of helping students to see themselves as those agents of change, as no students presented ideas that they could support addressing this issue except through small, individualized actions. This finding was consistent with Mallya et al.'s (2012) idea that students have a hard seeing themselves as having choice and being agents of change, as agency is complicated and contextual. Students' ideas of change do, however, present understandings that they can envision solutions to EJ and SJ issues in their community on multiple scales.

Conclusion

The nature of a community's "environment" consists of not only its physical characteristics or geographical boundaries, but also the social and political enterprises and entities that play substantial roles in the presence and perpetuation of EJ and SJ issues. In their written work and dialogue, we saw students recognized and adopted this broader idea of environment when conceptualizing how their community is affected by issues of environmental and social justice. In striving to meet our curricular goal of students recognizing and articulating the causes and effects of EJ and SJ issues in their communities, we saw students took a variety of approaches including discussing collective community struggles, drawing comparisons across contexts, and expressing choices and changes in multiple spaces to support community life. By welcoming in a multitude of conceptualizations by students to support their ideas and understandings around EJ and SJ issues, we created new spaces and ways for students to participate in science learning (Barton et al., 2008) by creating broader opportunities for students to engage in and described subject matter. This socially coconstructed third space that spans the boundaries of home and school allowed for everyday discourse to be mobilized in formal school discourse (Silseth & Erstad, 2018), and created new means of participation and engagement for students in science learning. Although these contextualization's did not necessarily meet other goals to the extent in which we would have liked (i.e., students seeing themselves as agents of change), these findings supported ideas that students do understand what community EJ and SJ issues are present and are able to draw connections across multiple "environments" to articulate how these issues perpetuate in South Los Angeles.

Theme 2: Subjective Wealth

Current contexts of science education have neglected the continuities between the everyday lives and scientific ways of knowing of students of color, and the pedagogical possibilities that come with recognizing these connections in practice (Warren et al., 2001). Despite research acknowledging that linking household and community practices and knowledge in curriculum has been shown to increase school science relevancy in local contexts (e.g., Bell et al., 2016), the possibilities that come with drawing connections to the lived experiences of historically marginalized students have been largely ignored (Davis & Schaeffer, 2019; Lim & Barton, 2006).

Yosso (2014) described communities of color as having an array of community cultural wealth, or knowledge, skills, abilities, and contacts they use to survive and resist macro and micro forms of oppression. In the codesign of our curriculum, I argued, the design features described in Chapter 4 served to both surface and further develop the multiple forms of wealth that our students already possessed as they began to recognize their experiences and knowledge (FoK) as valuable when conceptualizing EJ issues in the everyday world. Using these forms of wealth, I claim, positioned students to resist the hegemonic values and neoliberal ideologies of what is considered valuable and relevant in science learning spaces.

In this section, I provide a description and analysis of the different forms of wealth, or capital, students drew on in the context of our designed curriculum. Forms of wealth, in this case, refers to the knowledge and experiences students perceived as *actual and potential resources* to the learning environment. I designate these forms of wealth as "subjective," as subjectivity indicates that the students themselves, not the teachers, sanctioned these forms of wealth as relevant when contextualizing their understanding of EJ and SJ issues in the contexts of their communities. In our class, these forms of wealth were not those traditionally institutionalized in science education as valuable, such as a student's formal articulation of a science concept. Rather, value was embodied in the students' conviction of deeming these sources of wealth as relevant to the science concept and learning environment. An overview of these conceptualizations of wealth can be found Table 6.

Table 6

Overview of Subjective Wealth Theme

Subtheme	Design feature
Connections to family and culture	Traditions and items of importance
Engaging personal components	Expressing emotions
	Life experiences

Subtheme A: Connections to Family and Culture

Science curriculum tends to reproduce dominant culture by dismissing the social scientific practices that students learn through cultural and familial contexts (Verdin et al., 2016) and by excluding students' cultural identity (Hogg, 2011). As a form of their community cultural wealth, students have "familial capital" they drew on in the contexts of our codesigned curriculum to conceptualize science concepts. Familial capital refers to the cultural knowledges that students learn among their family (including immediate, extended, formal and informal) that they bring into the classroom (Yosso, 2014). In Barton and Tan's (2009) study of a fifth-grade food and nutrition unit, they found that students used family FoK, a form of familial capital (Yosso, 2014), and discourse in science classes to talk about family life in connection to food. Similarly, our codesigned unit encouraged students to bring in discussions about family life and experiences to support their understanding of science concepts. Analysis showed that students drew upon traditions and items of importance in their family and ethnic cultures to conceptualize and connect EJ issues in their everyday lives, reinforcing ideas that when provided space and opportunity, students can draw upon these experiences as sources of knowledge.

Conceptualization I: Traditions and Items of Importance

Like findings in Barton and Tan (2009), the familial funds students most consistently drew on revolved around aspects of their family life involving food, specifically considering celebrations and traditional food items. In Unit 1, students positioned food as important in traditional celebrations, religious or family practices, often representing food as a reflection of their history and culture. For example, in one students' reflection activity they stated, "La comida es importante porque cada comida lleva su propia historia o cultura, por ejemplo el ponche de frutas lo hacemos es Mexico cuando hay fiestas no lo comemos con buñuelos, y rompemos piñatas [*Food is important because each meal has its own history or culture, for example we make fruit punch in Mexico when there are parties we don't eat it with fritters, and we break piñatas*]." In this example, the student discussed how each food had its own connection to specific historical traditions, providing the example that fruit punch is a common drink that can be found at Mexican parties. In this sense, the student articulated the importance of food as significant because of the contexts in which it is present in their lives.

Although the talk of food itself does not contain much scientific talk or value, the subsequent conversations, and tasks that it was relevant to "w[ere] rich with content exploration" (Barton & Tan, 2009, p. 8). For example, a student noted in their DIN that "tamales are symbolic of Mexican street food and are a staple of many Mexican mother's kitchens, especially over the festive period and during national celebrations, such as Independence Day." In this case, the student presented two connections. First, the student discussed how tamales are something Mexican mothers make, connecting the concept of food to family practices. Second, the student connected tamales to being eaten at festivals or traditional celebrations such as Mexican Independence Day. Although these concepts may not be relevant to science as a practice itself, the tamales became the central food item that this student chose research and learn more about, specifically considering its nutritional value, and "re-make" for their Unit 1 final project recipe. By valuing these stories and experiences that students brought forward, we allowed "students to participate in school science as individuals who are situated with histories and cultural experiences" (Barton & Tan, 2009, p. 9).

In another example from Unit 1, where a student was trying to figure out what to include in their designed recipe, the following interaction occurred:

1. Ms. V: Well, think about how you can make an Oreo milkshake healthier
2. Chris: I don't know how to make it healthier

3. Ms. V: Well, think about what healthy food involves, right, it needs grains, protein, vegetables and fruits and dairy. So, you already have dairy covered. But okay, Michael, get this. So, think about what can you do to add protein to a shake? Have you heard of like protein shakes before? Right? Or you could do like protein powder or something like that. Or you could find a way to like sneak some fruit or something into an Oreo milkshake. Think of maybe a fruit that would go well.
4. Chris: Chocolate is a fruit. Chocolate technically is a fruit. Like normal chocolate, could put normal chocolate in it.
5. Ms. V: Umm I mean even the chocolate bars you get, unless its dark chocolate, are still going to have a lot of sugar and fat in them. So maybe think about what type of chocolate.
6. Chris: The cocoa ones, the normal ones. The ones that grow on trees.
7. Ms. V: Oh, like the cocoa bean?
8. Chris: Yeah
9. Ms. V: Can you do that? You have cocoa beans?
10. Chris: Yeah
11. Ms. V: Wow! I wish I could have cocoa beans. I mean yeah, okay cool! Put cocoa beans in your milkshake. That is for sure healthier than having actual Oreos.

In this example, Chris brought forth his conceptualization of chocolate as a fruit, as he associated chocolate with a cocoa bean, which was a significant item to him. Even when Ms. V described the chocolate as not being a healthy alternative for his milkshake, Chris brought forth his conceptualization of chocolate, in a cultural context, as healthy to indicate why it was a good alternative. Although these conceptualizations and uses of familial wealth may not be those that are traditionally esteemed as "educational," they do demonstrate that students have resources that can be engaged in the learning environment as valued assets.

Subtheme B: Engaging Personal Components

Upadhyay et al. (2017) stated urban science classrooms should employ students' cultural wealth and encourage students to draw on larger connections between science and their personal perspectives to support meaningful science learning and to use science as a source for broader sociopolitical awareness. The value of learning, they asserted, is not just in content learning, but in a students' ability to make "critical and conscious linkages between science and larger sociopolitical inequities" (Upadhyay et al., p. 2541). To demonstrate these linkages when conceptualizing EJ and SJ issues in their community, students drew on their subjective wealth through personal components to articulate how they perceived and understood these issues. These personal components often came in the form of students discussing how these issues made them feel and direct experiences they have encountered with these issues in their lives. In this case, personal components differed from connections to family and culture as these were instances where students discussed their individual experiences, rather than generalizable cultural experiences, to support their understanding and conceptualization of the EJ issue. Personal components were expressed through emotions and discussing life experiences.

Conceptualization II: Expressing Emotions

When students conceptualized EJ issues in reference to their community, it was often accompanied by an expression of emotion as to how they felt about effects of the issue on themselves or other community members. Davis and Schaeffer (2019) noted in their study of Black children's understanding of the EJ issue of water quality in Flint, Michigan, their articulations signaled "strong emotions" of disbelief, fear, anger, sadness, or empathy. In our students' conceptualizations, we saw similar expressions of emotion with students communicating strong positions in relation to an EJ or SJ issue.

Most often, students expressed feeling "sad" or "bad" in reference to the effects of EJ issues. Students comments consisted of statements such as, "I felt so sad when we were talking about the how people could not afford the healthy foods and that's sad because they can get sick off junk foods," or "I felt bad because it's sad to think and know that some people actually go hungry because they have no food or not enough food to fill them up it made me appreciate the little things even more." In these cases, students took an affective or moral stand (Davis &

Schaeffer, 2019) expressing sadness and sympathy that individuals were suffering because of a lack of food access. Students would often describe these EJ and SJ issues as being "unfair" or "disappointing" because "nobody cares," indicating that they recognize these issues as problematic and having larger social effects on individuals who are suffering from them. Students' frequent use of "people" or "they," instead of "we," indicated a distal framing of these EJ issues, showing that although it is a present issue in their community, students may not view it as proximally relevant to themselves.

Just as frequently, however, students expressed a lack of emotions in reference to these EJ and SJ issues. A lack of emotion was expressed through comments such as, "I feel nothing. What can I do for them? Nothing, I don´t feel sad or bad like the other do because I can't do anything." In these instances, a lack of emotions was connected to belief about their inability to engage in tangible actions that could support changing conditions for people who were suffering. Therefore, they did not feel any emotions as they saw it beyond their ability to take action. Studies have noted that critical engagement with community issues of environmental or social justice can be unsettling for young students (McKnight, 2010), with some studies even arguing against engaging children in learning around environmental problems as it can create spaces of ecophobia, or hopelessness and fear in reference to abstract environmental problems (Sobel, 1996). Conceptualizations of EJ issues with a lack of emotion indicate that students may feel this sense of hopelessness in addressing community problems. Although our curricular design strived to position students as transformative intellectuals, we see that although students were able to "think" around complex science issues, statements such as "I can't do anything," however, demonstrate that our curricular design fell short in positioning students as seeing themselves as capable of "doing*"* to address these EJ and SJ issues (Morales-Doyle, 2017).

Conceptualization II: Life Experiences

Most commonly, when students engaged personal connections to conceptualize EJ and SJ issues in their lives, they reflected upon life experiences faced by themselves, or family and friends who supported their understanding of how the EJ issues perpetuated, or its community effects. For example, in a discussion around healthy food choices in Unit 1, Jay—a student—stated, “my sister’s friend died from cancer, but she already had cancer, but the Taki’s and stuff she ate made it worse.” In this example, Jay related his friend’s worsening health conditions to the food choices she made. Ms. V used this life experience as a leverage in discussion to address how when people are sick, eating healthy is an essential practice; however, as it can be very expensive, availability may be limited to some individuals. This example demonstrated that the conceptualization Jay made in connecting eating habits to health, and the wealth he brought forward in engaging this life example, was a pivot point for Ms. V to address the larger SJ issue of the affordability of healthy food options. This example reinforced notions that student FoK about life, in relation to science, can be relevant and important to classroom learning when they are given the space and opportunity to discuss.

In another example, a student, Melinda, completed her Unit 3 project on food deserts. In her advocacy letter, she stated:

> Me and my mom always go to the market to buy what she needs, and I usually buy cookies and chips for myself. But we don’t go usually go there to buy groceries. My mom was really healthy when she was young because the food that she bought was at a market that sold a lot of healthy stuff. So that means that she doesn’t usually go to markets that sell unhealthy stuff.

In this quote, Melinda elicited her life experience of going shopping with her mom to explain how she knew that some markets sold "healthy" food options, while others sold "unhealthy" food options. Her explicit distinction between "a market that sold a lot of healthy stuff," and not going to "markets that sell unhealthy stuff," indicated that based on her experiences, Melinda was able to differentiate when and where healthy food is accessible in her community, specifically noting that the "unhealthy markets" are not where her family goes. She went on to describe how when going to the "healthy market" she and her mom had to drive far outside their neighborhood because the market options close were "unhealthy." This example Melinda demonstrates how her wealth, in the form of a life experience, served as a means of socioscientific meaning making (Davis & Schaeffer, 2019) for her to conceptualize the EJ issue of healthy food access and availability.

Conclusion

Cultivating an environment where students can bring their knowledge into the classroom created educational spaces of autonomy and agency. As stated by Bellino and Adams (2017), "Bringing youth's knowledge to the forefront as they investigate local neighborhoods and community identities, the production and transmission of cultural, popular and school knowledges are exposed and explored" (p. 279). In students' conceptualizations, as presented through their use of multiple forms of subjective wealth, we saw students were able to explore real life problems and develop am understanding of the effects of EJ and SJ issues on their communities, by bringing their knowledge to the forefront of learning. In doing this, we demonstrated a curricular accomplishment of creating space for diverse and lived accounts of scientific phenomena in support of student agency in learning (Davis & Schaeffer, 2019) and positioned student knowledge and experiences as sources of wealth in the learning environment (Yosso, 2014).

Creating a "Third Space" Through Community Curriculum

Daily, urban SoC across the country come face-to-face with numerous environmental and social justice issues in their lives, community, schools, and society. Findings from this chapter support ideas that although students' use of colloquial language and concepts conceptualizations of EJ and SJ issues and effects may not historically be considered "scientific" (Brown, 2019), their descriptive ways of reasoning and rationalization are logical and have meaning, despite the vocabulary or conceptual framing (Gomez, 2007). As the descriptions of these conceptualizations presented throughout this chapter clarified, students' assessment of the multiple environmental contexts and conditions of their lives, and their use of their subjective wealth, were two mechanisms to integrate their multiple forms of FoK (Moll et al., 1993). By incorporating community and family funds to merge their out-of-school lives, observations, knowledge, and understandings with scientific phenomenon, students demonstrated conceptualizations of science in ways that make sense to them. Furthermore, these findings supported understandings of how students created a "third space" (Barton & Tan, 2009) in our science classroom to align their articulations of socioscientific phenomenon in both their social worlds and science concepts.

Overall, students' presentation of multiple and varied interpretations of socioscientific phenomenon, through the utilization of their FoK, helped us to understand indicators in student talk and writing to account for when determining if or how students came to understand science concepts in a CBS curriculum. The means in which students connected in- and out-of-school contexts to conceptualize science concepts presented evidence in support of sociocultural perspectives that demonstrated learning as situated (Brown et al., 1989; Lave, 1993) with knowledge construction grounded in the multiple world's students are a part of (Barton & Tan, 2009). Further, findings demonstrated sociocultural perspectives in curriculum design can break traditional barriers in learning to reorganize student participation in science through the validation of their cultural and linguistic backgrounds and understandings (Nasir et al., 2006; Meyer & Crawford, 2011) and household and community funds of knowledge (Barton et al., 2004; Gonzalez et al., 2006; Roth & Lee, 2004; Moll, 1990) as sources of understanding in classroom instruction.

CHAPTER 6: DISCUSSION AND IMPLICATIONS

This dissertation explored how community-based science (CBS) curriculum can be designed to support the integration of students' funds of knowledge (FoK) in curriculum and practice, and how urban students of color, in a class that uses the designed curriculum, conceptualize community environmental justice (EJ) and social justice (SJ) issues during curricular enactment. Like many communities of color in Los Angeles, the neighborhood around The Community School (TCS), the site of this study, is negatively impacted by a variety of EJ and SJ issues. Suffering from high rates of crime, the constant spew of jet fuel from planes at Los Angeles International Airport, exhaust from the multiple cars and trucks driving in and out of the numerous auto repair shops, and several hazardous waste sites, the neighborhood is home to a mecca of injustices. As such, this neighborhood context provided an opportunity to examine how these injustices could be investigated in school science, and to understand how students conceptualized the effects of these EJ and SJ issues on their community (Zipin et al., 2012).

To provide an in-depth understanding of curricular design, development, implementation, and effects, I spent 5 days a week for 1 academic school year as a codesigner, coteacher, and coresearcher in Ms. V's Energy and the Environment elective science class. Together, we sought to determine structures of science curricular design that not only integrated students' everyday FoK in practice, but also legitimized their social and cultural capital as a source of scientific data and understanding that can support formal science learning. In reorganizing a formal learning space to bridge in-and-out of school knowledge (Barton & Tan, 2009; Bellino & Adams, 2017; Grant & Sleeter, 2011), we hoped to move away from traditional, predetermined scientific ways of understanding (Mallya et al., 2012) and engage students in a relevant science learning opportunity (Meyer & Crawford, 2011).

Grounded in the paradigm of social constructivism (Amineh & Asl, 2015), a codesign approach (Gomez et al., 2018; Penuel et al., 2007) was used to collaboratively develop a locally useful instructional tool (i.e., CBS curriculum) that embedded science learning in the context of students' everyday knowledge, experiences, and observations of their community. Using an innovative model of fully embedding the researcher in all aspects of the curricular process from design to teaching, and an analysis of student work, codesign meeting artifacts, participant observations, and interviews, this study offers a firsthand, in-depth analysis of features of design that support the integration of students' FoK (Moll et al., 1992) in CBS learning, and the mechanisms of students' conceptualizations of EJ and SJ issues through these features.

This qualitative study explored two separate but related research questions that sought to understand the development and effects of integrating community in curriculum by offering a design question and an implementation question:

1. Design Question: What are the features of codesigned artifacts that support the engagement of students' funds of knowledge in science learning?
    a. How does a teacher structure dialogue to support the engagement of students' funds of knowledge?
2. Implementation Question: How are students of color conceptualizations of environmental and social justice issues in their everyday lives reflected during the enactment of a community-based codesigned curriculum?

By operationalizing sociocultural theory (John-Steiner & Mahn, 1996; Polly et al., 2017; Vygotsky, 1978), this study contributes to literature calling for the development of critical learning opportunities that integrate and investigate aspects of culture, power, and justice in science learning. Specifically, this work answers Davis and Schaeffer's (2019) call for research that investigated the design and impact of curriculum and pedagogies that foster critical learning opportunities through SJ-focused science learning and agency in locally specific ways. Through an analysis of patterns in design features that integrate students' FoK in science learning, along with the ways students use their FoK to conceptualize community EJ and SJ issues, I provided evidence of how students, by growing and learning in complex urban environments, view and experience the world around them (Bellino & Adams, 2017).

Findings from this study aligned with empirical research that examined features of design supporting the integration of EJ- and SJ-focused science education (Stromholt & Bell, 2018) to create generative learning spaces that reposition youth as capable of investigating complex socioscientific issues (Bellino & Adams, 2017; Davis & Schaeffer, 2019). Through the implementation of these design features, findings from this study also extended literature that investigated how students conceptualize science through the creation of third spaces (Barton & Tan, 2009; Guiterrez et al., 1999) to align their articulation of socioscientific phenomenon in both their social worlds and science concepts. In providing evidence of these different, yet connected contexts, this study contributed to empirical and theoretical constructs of justice-centered science pedagogies (Davis & Schaeffer, 2019; Morales-Doyle, 2019) that structure curriculum and pedagogical practice in support of viewing students as transformative intellectuals. In viewing students as transformative intellectuals, this study adds to a representation of students who can, and do, use their FoK to exhibit their complex and critical thinking around socioscientific issues, a point I to which I return shortly. Through the repositioning of power, in multiple forms, in a science learning environment, findings from this study suggested community and science do not have to be viewed in silos, but rather, as connected sources that support learning.

In this chapter, I situate this study's findings in conversation with existing literature that investigated the integration of community and culture in science learning to elucidate empirical understandings of how curriculum design can integrate students' FoK into instruction to investigate the intersecting and multifaceted ecological and social factors that comprise urban spaces. I also provide implications and recommendations for education research and teacher practice to reimagine science classrooms as spaces of transformation and student agency, and a discussion of this study's limitations.

Summary of Findings

As with studies that investigated the integration of community into science curriculum design (Bell et al., 2016; Bellino & Adams, 2017; Davis & Schaeffer, 2019; Stromholt & Bell, 2018), and others that discussed strategies in dialogue to elicit and respond to students' connections to everyday life in science curriculum (Gotwals & Birmingham, 2016; Harris et al., 2012; Irish & Kang, 2018), design features in this designed curriculum conveyed purposeful strategies and structural processes that integrate, sustain, and support the inclusion of FoK as resources in curriculum. When designing to or for community, two major structures supported leveraging students' everyday knowledge as sources of science learning. The first of these structures (i.e., developing concrete connections in science learning) probed students to connect their out-of-school knowledge and experiences across space, place, and time-to-science concepts, and positioned these knowledge and experiences as relevant to the learning environment. Tran (2011) noted a students' ability to connect out-of-school experiences and classroom science is directly impacted by the structure of learning activities in the classroom. As such, design features in our curriculum were purposefully systematized to prompt students to draw associations across the contexts of their lives to support the inclusion of their FoK in learning.

The second structure—I would argue one of the most important design findings from this study—was the theme of Redistributing Value to Nonhegemonic Foundations in Science Learning. In traditional science learning, value is often attributed to what can be proven as "fact" across contexts. In this way, individualized experiences in association with scientific phenomenon and scientific enterprise, specifically those of people of color, are habitually ignored and disregarded (Aikenhead, 2011). As students have engendered in these traditional boundaries throughout their K–12 experiences, before educators can ask students to see their community and culture as relevant to learning, we must first, ourselves, attribute value to it in the contexts of design.

I designed the curricular structures to support the development of students' critical science agency (Vossoughi & Shea, 2019) to, as Ms. V said:

> Give [students] the tools to be able to look at society around them and [recognize] that's a problem, [and] move themselves, help their communities, recognize oppression, recognize untruth, and be able to do something about it to navigate a system that was not built for them.

To do this, each project in the year-long curriculum was designed to create space for critical and diverse accounts of scientific phenomenon (Davis & Schaeffer, 2019) by centering science as valuable to understanding and engaging in their proximal and distal worlds. Systemic measures in design to support students' use of their "toolkits" to enact community change was demonstrated through the creation of "change ideas." This design feature positioned students as capable of imaging social change, attributed their FoK as assets to developing social change ideas, and situated students as capable of creating social change.

Findings around teacher instructional moves (Harris et al., 2012) in dialogue further supported features of design that can be institutionalized in classroom practice to support the inclusion of student FoK in learning. The processes of eliciting, recognizing, and responding to students' FoK, through communicative signals in dialogue emerged as paradigms of responsive teaching practices (Gotwals & Birmingham, 2016). The practices demonstrated to students the teacher's attempt to understand their FoK in connection to science learning and use those FoK to support classroom instruction (Silseth, 2018).

Unlike traditional curriculum that arguably positions students' lives, experiences and cultures as having little, if any, immediate scientific value (Boutte et al., 2010), our curricular design supported these elements as having intellectual significance and depth, prompting the creation of third spaces (Barton & Tan, 2009; Gutiérrez et al., 1999). The third spaces encompassed elements of home and school to align students' articulations of socioscientific phenomenon with both their social worlds and science concepts. When creating this third space, findings from this study further noted patterns in students' conceptualizations of community EJ and SJ issues through two distinct mechanisms. As a reminder, conceptualization referred to students' mechanisms for articulating their understanding of a concept, in this case, a community EJ or SJ issue.

The first of these mechanisms, *subjective wealth*, referred to the actual and potential FoK students deemed as relevant to their understandings of EJ and SJ. Through the use of multiple forms of community cultural wealth (Yosso, 2014), including connections to familial and cultural elements and personal experiences, students explored EJ and SJ issues by drawing on a diversity of lived experiences to express their understandings of how, and why, their communities, and other communities of color, were subjected to certain injustices. Findings demonstrated when community and culture are established as legitimate features in curriculum, students are more likely to connect the world of community and culture to the world of science learning.

The second of these conceptualizations, *assessing environmental conditions*, further supported the creation of this third space as students uttered understandings around the collective struggles faced by community members, drew comparisons across contexts, and emphasized the importance of choice and opportunities for change to address EJ and SJ issues. The most notable of these conceptualizations, *collective community struggles*, provided a clear demonstration of students' use of their FoK in the designed curriculum as they described and reflected on the causes, effects, and perpetuations of EJ and SJ issues through personal stories of observed community health and environmental struggles. Students made connections between the lack of healthy neighborhood food options and high rates of disease in communities of color and multiple sources of air pollution as a significant cause of high respiratory issue rates and resulting death, which supported notions that nonhegemonic funds can serve to enrich formal school science (Barton & Tan, 2009).

Relation to Prior Research

Confirming the work of Stromholt and Bell (2018), this study's findings supported beliefs that curriculum design can be situated to create generative learning spaces that position youth as capable of engaging with, and investigating, complex socioscientific issues, specifically through the integration of their FoK in science learning. Although Stromholt and Bell's (2018) study used design-based research methods to investigate the development of curricular design principles to engage elementary school age children in local, problem-based learning, their design principles supported this study's findings to challenge dominant narratives and hierarchies of thinking and knowing embedded in science education systems (Rosebery et al., 2005). Structural practices must be specifically designed. These practices should support learning across settings and contexts, integrate students' FoK in learning, and position students and their communities as capable experts and sources of knowledge in science practice, as acknowledging and valuing the narratives of urban youth is the first step toward socially just science education (Tzou et al., 2010).

Further, as the work of Gotwals and Birmingham (2016), Harris et al. (2017), and Irish and Kang (2018) demonstrated, findings from this study verified clear patterns in instructional moves that teachers use to engage students' FoK in classroom dialogue. Gotwals and Birmingham (2016) presented an understanding of teacher candidates' use of practices in dialogue to respond to students' science ideas and support science learning; this study provides additional evidence of communicative signals teachers can use to specifically engage students' FoK in dialogue. Many signals presented reiterative and supportive findings to Harris et al. (2012), which investigated teachers' instructional moves to elicit and develop students' ideas and questions, and Irish and Kang (2018), which investigated how teachers request students to use out-of-school experiences to reason science concepts. This study's findings extend their work by aligning these signals as a linked process, rather than individual mechanisms. This process formulates and encourages a structure teachers can draw and build on to more purposefully engage in dialogue that connects in-and-out-of-school science learning.

Concurrently, student conceptualizations in this study supported the work of Brown (2019) and Gomez (2017), who noted students of color express understandings of science concepts in ways that are not historically recognized as scientific because of their conceptual framing or vocabulary. Findings in this study demonstrated students cultivate multiple ways of communicating their understanding of science concepts through connections to their varied FoK in the third space. As with findings from Barton and Tan (2009), Ms. V and I found the third space was used by students to display "competent and meaningful scientific literacy in applying scientific knowledge to their local communities and their daily living," (p. 22). Although their assessment of environmental conditions to connect multiple spaces and engagement of multiple forms of subjective wealth may not have used traditional scientific framing in science learning, their conceptualizations proved students have understandings of EJ and SJ issues and their community effects. We argued these conceptualizations can serve as building blocks that can be built upon by science learning educators (diSessa, 1993). As Roth and Lee (2004) noted, when learning is contextualized around community-relevant issues, students are provided with greater opportunities to "contribute to the knowledge and representations available in, and to, the community" (p. 272) as sources of learning.

On a broader scale, findings from this study further supported notions of justice-centered and justice-oriented science pedagogies investigated by Morales-Doyle (2017) and Davis and Schaeffer (2019), respectively. One notion reflected a justice-oriented science pedagogical reason that by leveraging students' FoK and multiple epistemologies to account for varied interpretations of phenomena when "bring[ing] the outside world into the classroom" (Davis & Schaeffer, 2019, p. 370), educators can position science education as a pathway to social change. In our design, Ms. V and I worked to accomplish this by positioning students' knowledge, experiences, and communities as resources in science learning to understand science concepts and imagine and create community change. Findings around student conceptualizations demonstrated that justice-focused practices, as a basis for socioscientific meaning making

(Bricker et al., 2014), can position students to think in complex ways about how science, social justice, and community interconnect.

Despite noting that findings supported our design features as positioning students as transformative intellectuals, as coined by Morales-Doyle (2017), Ms. V and I did not find evidence of students seeing themselves as capable of being these intellectuals. As such, findings aligned with Mallya et al.'s (2012) conclusion that students can find it difficult to see themselves as change agents in large scale transformation, as they "may have difficulties in terms of their own internal ability to see themselves as having choice and control" (p. 266). Nonetheless, findings in this study demonstrated that despite students' inabilities to see themselves as capable of change, they expressed ways of thinking that demonstrated an understanding of needed changes and possible methods for those changes to occur.

Despite the Next Generation Science Standards' (NGSS) call for educators to mobilize strategies in teaching that navigate connections between students' lives and communities to support traditionally alienated students seeing science as relevant to their lives (NGSS, 2013), little research has demonstrated how to structure pedagogy and curriculum to bridge these spaces. Although findings from current research on critical science learning align with the importance of integrating students' FoK in science practice (e.g., Bellino & Adams, 2017; Bricker et al. 2014) and how students conceptualize these ideas in classroom environments (e.g., Barton & Tan, 2009; Davis & Schaeffer, 2019), limited work has investigated the development and design of curriculum that breaks traditional boundaries in science learning to account for this knowledge. By operationalizing a situative sociocultural theoretical perspective that science learning cannot separate from the cultural and social contexts in which students participate and learn science (Lave & Wenger, 1991), this dissertation provides empirical evidence of the ways curriculum and practice can be designed to respond to students' social and cultural contexts. Specifically, this work exhibited how educators and researchers can problematize neoliberal narratives and power structures in contemporary science learning (Roseberry et al., 2010) by reimaging "who," "what," and "where" is privileged in science, and how we value different identities, realities, and histories (Boutte et al., 2010). In situating concepts not only in a scientific frame, but also in its ethical, social, and political dimension, we account for students' FoK by conceptualizing environment as an entity not separate from, but constructed by, the people who live and engage in it (Hufnagel et al., 2018).

Collectively, findings from this study illuminated deficit views around the relevance of students' of color FoK in science learning environments. Specifically when investigating issues of EJ and SJ, connections and sources of support that guide students toward commanding science concepts remain limited. By designing curriculum to engage students FoK in investigations of socioscientific phenomenon, we constructed hybrid spaces where science was no longer separate from the everyday worlds in which students lived, learned, and engaged (Barton & Tan, 2009), and deconstructed power in dominant social discourses and ways of knowing. For this reason, I argue educators and researchers alike must work to create purposeful conditions in curriculum and instruction that navigate this hybridity to disrupt dichotomies of "scientific" and "everyday life." Through a broader understanding of scientific phenomenon in principle and in practice, science learning can metamorphosize as a space of imagining and creating transformation and change. This argument serves as the basis of the implications and recommendations that follow.

Implications for Education Research

The nature of the codesign work in our research–practice partnership (RPP), as presented in this dissertation study, revealed new possibilities for reimagining traditional roles and structures when engaging in curricular design, along with new mechanisms to unpack and disrupt conditions in learning that perpetuate contradictions and separations between home and school. Penuel et al. (2013) described RPPs as "trading zones," or "social spaces where people can debate and exchange ideas, [and] material spaces where people engage in various forms of 'place-making'" (p. 238). They argued these trading zones are based on the idea that RPP participants occupy distinct cultures that form the basis of how they work together. Codesign contexts (Penuel et al., 2007b) with RPPs are often used in these trading zones to break distinctions of researchers "designing" and teachers "testing and implementing" curriculum, and create a structure and approach in which each partner remains semiautonomous in their traditional roles while also occupying new roles. The codesign work Ms. V and I developed demonstrated possibilities of a further deconstruction in codesign structure where these semiautonomous roles are completely dismantled. This coplanning, codesigning, coteaching, and coresearching model, we argue, positioned me, the researcher, as a full member of the learning environment, and Ms. V, the teacher, as a full member of the research process in the social space (Penuel et al., 2007b).

Social Spaces

As a social space (Penuel et al., 2013), this structure supported extended opportunities for collaboration between Ms. V and I when engaging in design and instruction. In an interview, Ms. V noted:

> I think it's important for the researcher to be on site . . . [because] the kids know you and are able to form those relationships with you, and also because it gives us [teachers and researchers] both more bandwidth . . . I think for any partnership to be successful, people need to be closely communicating. . . so that they have a shared understanding.

This idea of closely communicating was an essential practice Ms. V and I engaged in to support role negotiation. Our daily interactions in the classroom fostered a shared language and practice, a high level of trust, and development of new ways to work on our collaboration as we both were situated as teachers in the classroom space. Weekly codesign research meetings further provided us vital time to interpret areas of successes and areas of improvement in day-to-day lesson design, workshop new ideas for design features based on areas of improvement, and develop a common consensus about next steps for design to support both research and practice. In these spaces I—a researcher and former classroom teacher—was able to engage my teacher perspective to keep curricular content realistic, while also using a learning scientist's lens to inform principles of curricular design. Ms. V, as a researcher and teacher, was able to learn from and expand on these principles of design, while also iteratively designing curriculum to support student learning and engagement in ways that best supported her students.

Codesign partnerships are typically not structured with roles as immersed and deconstructed as those presented in this study. Traditional structures of codesign partnerships, I assert, increase possibilities of missed opportunities for in-the-moment revisions that could benefit curricular design and may elongate the process of developing new curriculum iterations. Based on the RPP structure we developed, I propose that weekly meetings and, at minimum, a 1-day-a-week researcher presence in the classroom during curricular implementation are essential practices for codesign partnerships. This structure supports frequent check-ins around strengths and weaknesses in design approaches, allows for regular curricular refinement, and supports recurrent negotiations of "problems of practice and their solution in design-based research," (Penuel et al., 2013, p. 243). This "close communication" structure provides a space for ongoing and shared dialogue between researchers and teachers, supports the reorganization of roles in partnership, and fosters shared ownership over curricular design (Gomez et al., 2017). Future researchers should consider and document the frequency of partner meetings and researcher responsibility in curricular implementation as essential points of discussion when engaging in codesign work.

Further, my immersion in classroom instruction supported my learning development about the community I was designing for. As CBS is grounded in place, designers must remain aware of factors that are significant to that place. Aikenhead (2006) argued when engaging in place-based science practice, problems arise as the teacher is positioned as the "local expert." I argue in place-based curricular design, researchers are often presented as "experts" as well, regardless of their knowledge of the community. Serving as a coteacher in the classroom supported my development as a community novice (not expert), as I was able to learn from and along with students about issues in their community. The findings suggested it is important to remember that when engaging in research in marginalized communities, it is not a researchers position to impose our beliefs nor work onto the teachers or students. Instead, we should learn from those individuals to support our work. As such, future researchers focused on curricular development in codesign partnerships should consider the ways in which the researcher is positioned, or positions themselves, as experts in these spaces.

Material Spaces

As a material space (Penuel et al., 2013b), this structure sustained ongoing dialogue during which Ms. V and I unpacked our understandings of what is and what it means to engage in CBS. Coming into this partnership, Ms. V and I both had narrow understandings of EJ, SJ, and community, and how these elements could be integrated in science practice. Ms V and I credited our many conversations around the purpose of this work in expanding our own boundaries of understanding and defining these concepts. In an interview, Ms. V stated:

> When our partnership started, I had a pretty limited idea of what environmental justice or community-based science could be, and working with you had broadened that idea . . . I can now think it's less about how "sciency" something is. I don't need to start from the science concept. Now I am able to start from the student and community experience and think about what science skills might help them explore and bring about change around their experience.

I followed these sentiments in this interview, stating, "I realized it was not always about teaching the science content, but it was the skills that the kids learn that they can apply to science learning, but also for their community and life experiences."

Bang et al. (2010) noted by engaging in CBS, students see shifts from seeing science as a "body of knowledge" to seeing science as a "set of practices for learning about the world," (p. 16). In this same fashion, I argue ongoing critical dialogue with our RPP required Ms. V and I to reflect and consider our own understandings and biases—and supported our own shifts from seeing community and culture as a "add-on" to learning—to instead, a foundational base from which science knowledge and learning are built. As noted by Philip et al. (2013), views of community can often be "one-dimensional," and dissociate the diversity of people, places, and histories that all intersect to create community. The social and material spaces of the codesign structure sustained our engagement in critical reflections of our ideologies, values, and beliefs around science practice, and allowed us to break away from a one-dimensional view of community and culture. I postulate that engaging in reflective practices supported our broadened idea of the possibilities and purpose of science education and facilitated our understanding of the possibilities of justice-oriented curriculum and pedagogies in science learning (Morales-Doyle, 2017). Future RPP work should consider creating structures that support purposeful reflective practices to position researchers and teachers to reflect on how their own ways of thinking may support or hinder boundaries and integration of community and culture in learning.

Implications for Educational Practice

In educational practice, I noted two essential configurations educators must consider when engaging in CBS work: structures of support for the engagement of students' FoK in practice, and breaking deficit notions of community change.

Structuring Funds of Knowledge Engagement

Findings from this study demonstrated it is both possible to engage students' FoK in science classroom learning, and that students can use those FoK to conceptualize science content. Similar to findings from Irish and Kang (2018), Ms. V and I noted students are rarely offered FoK without explicit structures of support. To disrupt contradictions between scientific and everyday life, teachers and researchers alike must purposefully structure strategies that position students to use these FoK in practice. These strategies, however, cannot just be designed into curricular instruction. Findings around communicative signals offer insight into the value of creating structures across curriculum, pedagogy, and dialogue to support the engagement of students FoK in learning. Teachers must make frequent, explicit requests across all tiers of instructions to create classroom environments that position students' FoK as embraced and leveraged in practice. Although we recognize this approach does not likely come naturally to teachers or students, who have been conditioned to teach and learn in a certain frame or approach, our research did indicate it is possible to break these molds, even in very small ways, to support new ideas of participation in science learning. Teachers must consider the ways in which their curriculum, pedagogy, and dialogue work in combination to either support or dismiss facets of students' lives in instruction. By working with researchers to consider how design and dialogue can support the inclusion of students' FoK, teachers may feel a greater bandwidth to put these ideas into practice and create space for students to use their voices, express their opinions, and engage in collaboration and critical reflection (Dimick, 2012; Emdin, 2016; Moore & Mallya, 2006).

Breaking Deficit Notions

Student conceptualizations suggested some students presented ideas of "hopelessness" when considering community EJ and SJ issues. They believed they were unable to engage in tangible actions supportive of change. Students' comments prompted us to consider the effects of engaging in critical science learning on the socioemotional well-being of students. McKnight (2010) argued engaging children in learning about environmental problems can create ecophobia in them, as they feel disheartened about abstract environmental problems. Our findings indicated this feeling was not just in reference to "abstract" environmental problems, but also around community environmental problems. Davis and Schaeffer (2019) postulated justice-oriented science pedagogy can place "an undue burden of responsibility" (p. 386) on children to address issues they did not create; therefore, they cautioned against critical science learning focused solely on the identification of environmental problems. In response to this caution—and to position students as capable of transforming their community spaces—it is essential, I argue, that all CBS learning around issues of EJ and SJ, focus much of its practice around the conceptualization of mechanisms for community change.

In our curriculum, for example, Ms. V and I sought to accomplish this objective by grounding each project in the development of a "change idea." These change ideas countered deficit views of students' knowledge in science (Gorski, 2013; Tolbert et al., 2017; Zipin et al., 2012) by pushing students to consider how their experiences and knowledge of and in their communities could be leveraged to create community transformation. CBS learning, I propose, should not only create spaces of empathy and sympathy, but also spaces of emancipation and healing, where deficit narratives are not the only stories told (Tuck, 2009). Teachers and researchers alike should engage in discussions around how their curricular design either propagates or pushes against these ideas of hopelessness in learning to position students as capable change agents in curriculum. Design efforts must work to consider how time and energy are maximized in the different elements of project-based learning (i.e., problem identification versus change ideas) around EJ and SJ issues, and the effects these elements can have on students' social and emotional well-being.

Study Limitations

Although this study provides important insight into the ways curriculum can be designed to attune to students' FoK in practice—and the ways in which students use these funds to conceptualize EJ and SJ issues—the nature of the COVID-19 global pandemic, online learning, and the length and setting of curricular implementation did serve as limitations.

Effects of the COVID-19 Global Pandemic

The COVID-19 global pandemic placed unbeknown burdens on people around the world, but specifically, on low-income urban communities of color. In our classroom, many students and their families suffered job loss, sickness, and a lack of healthcare, among a variety of other concerns. Further, lack of technology and internet access, responsibilities to care for younger siblings as parents worked, and an absence of parental supervision to push students to log on or stay online during class time affected student attendance. As a consequence, roughly 50% of our students consistently attended class, and many students who were present felt uncomfortable turning on their cameras or unmuting their mics due backgrounds and noise. This challenge left classroom dialogue mainly limited to the chat feature of Zoom. Although these were not factors we could control for, findings around curricular features and students' conceptualizations may have been different if the contexts of curricular implementation differed.

Online Learning

Additionally connected to the COVID-19 global pandemic, the nature of online learning played a significant role in limiting social interactions that were characteristic of engaging in CBS. Bang et al. (2010) noted CBS rests on the participation of all community members to address locally relevant scientific phenomena. Although curriculum design reflected the knowledge we gained from students and community members over the 3 years of our partnership, the final curriculum design was partly a reflection of EJ and SJ issues we were aware of in the community and thought were important to investigate. As circumstances of the pandemic made it challenging to engage community members in design, it is important to note that curricular design was, in large part, reflective of our understanding of significant issues. Furthermore, Ms. V and I struggled with community member participation as expert speakers, and rested on engaging community expert participation through other mechanisms such as students conducting interviews, observations, or surveys of community members. Future work with these curricular features, and CBS in urban schools in general, should engage more community members in practice to support the true nature of CBS learning as it has been developed in Indigenous methods.

Additionally, the nature of online learning further limited engagement among students, restricting group work and collaboration among peers, an essential element of CBS learning.

Although we created tools, structures, and plans to support group work (e.g., project boards and the use of breakout rooms), we struggled with consistent student engagement with these tools and in these spaces. In our end-of-the year interview, Ms. V stated:

> Instructional goals actually took the hardest hit this year because we really wanted them to work in groups and that didn't really materialize. . . . We ended up relying more on the DIN [digital interactive notebook] as the main spine of the course. I think the way that our DIN turned out was actually really robust, but I wish we could have made collaboration and teamwork happen to a greater degree.

As such, future researchers should investigate the implementation of these features in a face-to-face learning environment, where structures to support group learning are more likely to succeed. Researchers and educators may find some of these design features of more or less usefulness when CBS is implemented in a traditional classroom setting.

Setting and Length of Curriculum Implementation

As this curriculum was implemented in an elective science class, we were not confined by standards nor time constraints, providing us with certain freedoms to investigate topics that may not be traditionally studied in science. This setting does not discount, however, the multiple opportunities to use the design features presented in this study to investigate these issues, along with others, in standards-based science curriculum. The design features presented in this study are intended to remain malleable across contexts and provide educators with a foundation to build from that fit into their particular curricular contexts.

Further, although our students participated in a CBS class over an entire academic year, there were limits to its effects on student outcomes, specifically around views of themselves as transformative intellectuals and agents of change. As students have been engrossed in traditional learning environments across most of their academic careers, many continued to work in these conventional dimensions, searching for the right answer when completing work. Engaging in these CBS practices, which required students to think in real-world contexts, placed students in unfamiliar frames of thinking. As with findings in Irish and Kang (2018), students rarely volunteered their FoK on their own, even when their experiences were relevant to the topics. Ms. V and I believe that relative short-term engagement with CBS practices, in comparison to the students' academic careers, limited its effectiveness on student outcomes as they often resorted to customary frames of right and wrong in learning. To see significant changes in students' ways of thinking and views of themselves as community change agents, I argue, would necessitate students being engaged in these practices over an extended period of time. Future researchers should investigate the enactment of CBS curriculum over a multiyear period to determine the longitudinal effects of these practices on students. In doing this, researchers can further examine how or if students engage their community and cultural FoK without prompting ways in which students conceptualize locally and socially relevant phenomena as their communities grow and change, and determine if these practices help students to see themselves as agents of change in the long term.

Recommendations

In this section I present recommendations for research and practice, which seek to position community and culture as essential elements to the daily practice of science teaching and learning.

CBS Across Time

Although researchers in urban science classrooms have investigated place-based curricular practices that include students' FoK in instruction (e.g., Adams et al. 2014; Brkich, 2014; Davis & Schaeffer, 2019), few examples in either research or practice, have investigated the integration of these community-based practices over an extended period. Barton and Tan (2019) conceptualized “rightful presence” in STEM education as central to justice-oriented education to position students as legitimate members of the classroom community. They used this concept to extend the ways research and practice facilitate consequential learning (Birmingham et al., 2017), or opportunities for students to meaningfully participate in scholarship rooted in disciplinary engagement and community knowledge and practice. Although findings from this study demonstrated our features of design did position students as having a rightful presence in the science classroom by engaging their FoK in disciplinary science learning, there was evidence students did not necessarily view themselves as having a rightful presence as they continued to participate in learning in established ways. Further, students rarely offered their FoK in writing or dialogue without explicit structures (Irish & Kang, 2018).

In the limitations section, I noted that because students have been engendered in traditional science practice for the extent of their academic careers, seeing significant changes in their participation over a short period of time was not probable. As such, I argue science departments need to collectively determine mechanisms to scaffold in CBS learning over a multiyear period, so students engage in structures that dismantle hierarchies in scientific knowing and learning over an extended period. Students engagement in one unit or even 1 year of CBS that employs their FoK in learning efforts is not enough. Departmental personnel must work together to strategically plan practices to embed these structures across time, place, and subject. One departmental meeting per month should be set aside to exclusively focus on this strategic plan. In each of these meetings, educators should first engage in critical reflection around CBS beliefs through prompted journaling, community circles, or directed discussion.

Following these sessions, educators should purposefully plan the development and design of CBS structures that can be sustained in science learning at their school. As such, I offer several guiding questions and action steps for science departments to consider at each meeting as they determine how to structure CBS practices across time:

1. *Question*: How do our current epistemological beliefs around the purpose of community and culture in science hinder broadening visions of possibilities in/of science learning? *Action Step*: Structured time in departmental meetings that engage teachers in a critical reflection of their current thinking around CBS to determine how these modes of thinking support or hinder department-wide change efforts.
2. *Question*: How are our current practices either promoting or excluding students' FoK and community and culture in learning? *Action Step*: Determine areas of success and areas of improvement in current curricular practices for each science class.
3. *Question*: What are features of design that can be used across science subjects, and across years, that we can implement department-wide, to integrate community and cultural knowledge in learning? *Action Step*: Determine sustainable structures in curriculum design that all teachers can implement, no matter the subject, that work to promote the integration of students' FoK.

Future work should examine the enactment of prolonged engagement in CBS-aligned curriculum to determine how these structures affect student participation in science learning, as well as how they support students in understanding the relevancy of science, as a practice, to supporting social change.

Including Students in Curricular Design

Further, to remain culturally responsive in science learning, teacher development of a student-focused perspective to instruction is essential (Gay, 2010). In their study characterizing the knowledge and practices teachers use when engaging in cultural responsiveness in science teaching, Brown and Crippin (2017) presented the idea of repositioning to shift authority from the teacher to the student in instruction. They noted repositioning requires a centralization of students as intellectual leaders through the validation of their knowledge in science practice. Findings in my study noted students had trouble seeing themselves as transformative intellectuals, despite our curricular design striving to position them in this manner. The idea of repositioning offers a useful lens for researchers and practitioners engaging in curricular development to allocate students as another participant stakeholder in the codesign process. Positioning students as intellectual leaders who are capable of developing curriculum has two potential advantages. First, such positioning ensures students' firsthand knowledge and experiences are included in the curriculum, as students are directly involved in the design process, leading to a more grounded and relevant science curriculum reflective of the voices and realities of students. Second, as students are positioned as change agents in the classroom, it may support their understandings and views of themselves as change agents in other spaces.

Numerous studies (Barton & Tan, 2009; Ching et al., 2015; Ito et al., 2020; Santo et al., 2015) attested to the transformative power of engaging students in curricular development and suggest including students in the design process creates expanded learning opportunities that are connected, socially embedded, and interest driven. Future codesign work around the development of curricular and pedagogical practices that investigate local issues of EJ and SJ should consider the inclusion of students in curricular design and development. Doing so may support agency and transformation, across multiple levels, in learning, and disrupt dominant narratives held about students and communities as sources of knowledge to promote students' rightful presence in science (Barton & Tan, 2019). Teachers and researchers can incentivize student participation through extra credit or monetary compensation, and should conduct codesign meetings at times where students can participate (e.g., at lunch, before school, or after school). Further, teachers and researchers can also account for students in curricular design and determine which structures students feel do and do not support them in learning by asking for student feedback through class community circle meetings. Collectively, engaging students in the design process can be another mechanism to move away from predetermined ways of understanding about science (Mallya et al., 2012) and promote students' everyday experiences as tools to inquire about curricular concepts (Silseth & Erstad, 2018).

Conclusion

Urban communities are filled with rich and diverse people, histories, and sources of knowledge that are often unrecognized in science learning spaces. Although research efforts have shown the importance of including students' FoK in practice, there is still more work to be done to embrace the brilliance that students can, and do, contribute to the learning environment. As educators and researchers consider the purpose and presence of justice-oriented science learning, we cannot ignore the wealth of knowledge that can be found in our own students and their lives. At the nexus of FoK, CBS, and EJ and SJ, this study contributes to scholarship that engages this wealth in practice by connecting learning across mryiad contexts to engage students in relevant learning opportunities reflective and inclusive of their real-life experiences. Implementing the NGSS and saying we are working toward equitable science learning is no longer enough. Deep reflection on the ways our curricular design and dialogue structures perpetuate or stigmatize dominant narratives of “who” holds science knowledge, “where” science knowledge derives from, and “what” is considered scientific, along with how we address the social, political, and ethical dimensions of scientific phenomenon from sociocultural lenses is an essential practice. In these reflective spaces, I am optimistic about the potential and possibilities of the future of science education, and the reconstruction of science learning as a starting point to engaging students in transforming their community spaces.

Appendix A: Operational Definitions and Key Terms

This dissertation addresses key terms and concepts from various fields, including community-based science, design-based research, sociocultural theory, and education. The following are definitions of the key terms that are used in this paper.

1. Environmental Justice: "fair treatment and meaningful involvement of all people regardless of race, color, national origin or income, with respect to the development, implementation and enforcement of environmental laws, regulations and policies" ("Environmental Justice," 2020).
2. Social Justice: justice that addresses "issues of equity, power relations, and institutionalized oppression" (Goodman, 2011, p. 4) by actively working to change the systems and structures that cause and maintain injustices (Gutstein, 2006; Lynch & Baker, 2005; North, 2009).
3. Design-based Research: a methodology that seeks to provide interventions that improve the translation of educational research into educational practice (Anderson et al., 2012) by grounding the work in participant expertise (McKenney & Reeves, 2012).
4. Codesign: The process of collaboration between education stakeholders with varied expertise, to design an inquiry-based learning environment (Penuel et al., 2007).
5. Community-Based Science: Anchoring science in locally and socially relevant phenomena to provide students with opportunities to contribute and use their funds of knowledge in learning to conceptualize canonical science content and address community injustices
6. Sociocultural Theory: developed from psychological theory, sociocultural theory emphasizes the interaction and interdependence of social and individual processes in the construction of knowledge in cultural contexts (John-Steiner & Mahn, 1996; Polly et al., 2017; Ryu & Sandoval, 2011; Vygotsky 1978).
7. Funds of Knowledge: An emerging framework that capitalizes on the multigenerational, historically accumulated and culturally developed bodies of knowledge and skills students have acquired from their households and communities that often go untapped in schools (Moll et al., 1992).

Appendix B: Preyear Teacher Interview Protocol

Date:
Time:
Location:
Interviewee:

1. Tell me a bit about your background
    (a) Where did you grow up?
    (b) Were you an education major or moved to education later?
    (c) Why did you go into education?
2. What led to you becoming a science teacher
3. Why did you become a science teacher at The Community School, specifically?
4. How long have you been here?
5. What are you aiming for in your science teaching? What are your overall larger goals?
6. What do you feel are your responsibilities as a science teacher?

7. What are your beliefs and ethics around science education?
    (a) What do you see as the purpose of science education?
    (b) How do you think science education should be taught?

8. Take a moment and think about your current pedagogical practices? Have you always taken this/these approaches? If not, how have your practices evolved over the years?
    (a) What do you believe is important to students? Why?
    (b) What do you believe motivates students in science learning?
    (c) How to you believe science content should be connected to student's everyday lives?

9. Are you familiar with the term, funds of knowledge? If so, did you learn about this term in your teacher education program, or perhaps in professional development?
10. How would you describe funds of knowledge and thinking of students, in particular here?
11. Please describe your beliefs around the use of student funds of knowledge in science.
    (a) What funds, do you believe, can be used in science?
    (b) How can these funds be used?
    (c) How do you deal with instances where students funds don't agree with scientific data?
    (d) Why is important to include these funds of knowledge?

12. How would you define the term community assets? What do you believe are the community assets in this classroom, school, and community?

13. Talk about including community assets into your classroom culture and instruction.
    (a) What do you believe are the benefits of teaching in localized contexts?
    (b) What do you believe are the disadvantages to using these contexts in teaching?
    (c) What do you feel this brings to the classroom culture?
    (d) Why do/do not you think these local assets are important to learning?

14. Talk about the effects that teaching science based on student funds of knowledge and community assets.
    (a) How do you believe this can affect student learning?
    (b) How do you believe this can affect teaching practices?
    (c) Why or why not do you believe that using these practices are feasible in science?

15. Describe your student's current engagement in science.
    (a) What are their overall levels of interest?
    (b) Do you think your students are invested in their science learning? Why or why not?

16. Tell me your thoughts about researcher-teacher collaborations in lesson planning.
    (a) How do you believe a researcher-practitioner partnership can help in the planning process?
    (b) How do you believe these collaborations can help you achieve your personal and curricular goals for your students?
    (c) How do you believe these collaborations can help you achieve overall school/grade level instructional goals?

Appendix C: Postyear Teacher Interview Protocol

Date:
Time:
Location:
Interviewee:

1. Ask any clarifying questions from preinterview.

2. Describe the process of collaborating with the researcher to design this curriculum.
    (a) What aspects do you think were particularly productive? Why?
    (b) What aspects do you think were less productive? Why?
    (c) What recommendations would you have for future collaborative work?

3. Describe how you believe the codesign partnership supported you in developing curriculum materials.
    (a) How did our codesign work support your development in environmental social justice science content learning?
    (b) What were the benefits of creating material with the researcher?
    (c) What were the disadvantages of creating material with the researcher?
    (d) How should science content be connected to student's everyday lives?

4. If you were describing the work we did, together, how would you describe our approach to attempting to ground our practices in the CBEJ framework?
    (a) What value, if any, did it offer our codesign in general?
    (b) What value, if any, did it help the codesign effort with respect to helping you to recognize your student's funds of knowledge?

5. What, if any, would you say is the connection between the work we did using the CBEJ framework and efforts you made to affirm students' these funds of knowledge in class?
    **Discuss specific examples from data collection. **

6. Compare the ways that you incorporated student cultural and community assets in classroom culture and instruction prior to the codesign work, and how you incorporate those asses now.
    (a) Probe as needed:
        i. Role of collective planning
        ii. Role of coimplementing the curriculum

7. Describe how you planned lessons in the past for the inclusion of local relevance in science class, and the ways that you plan lessons now.
    (a) Probe about as needed:
        i. How did this effect your pedagogical practice?
        ii. How did this, if at all, shift student engagement?

8. When you are planning science lessons, in general, outside of the work we did in the codesign approach, what is your approach? In what ways, if any, has it changed as a result of our codesign efforts?

9. In what ways, if any has collaborating in curriculum design helped you to reach your personal, curricular, and instructional goals?
    - teacher to student, who holds knowledge, what is science, who hold scientific knowledge
    (a) Probe about as needed:
        i. What were the benefits?
        ii. What were the challenges or constraints?

10. Please look at the unit timeline. Look at each unit topic and the activity the student's completed for the topic. Tell me whether that activity was a high or low for you, and then explain why. Then tell me whether you believed it was a high or low for the student's and explain why. If you want to further explain out loud your answer as you are writing, or have any questions, please feel free to do so.

Date	**Unit**	**Topic Introduced/ Covered**	**Activities Completed**	**High or Low of the Unit for Teacher**	**Explanation**	**High or Low of the Unit for the Students**	**Explanation**

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