EQUITABLE MATHEMATICS TEACHING AND LEARNING IN PRACTICE: EXPLORING STUDENTS' NEGOTIATIONS OF IDENTITY AND POWER

By

Frances Kay Harper

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ABSTRACT

EQUITABLE MATHEMATICS TEACHING AND LEARNING IN PRACTICE: EXPLORING STUDENTS' NEGOTIATIONS OF IDENTITY AND POWER

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This dissertation builds on and extends research on the relationship between equity-minded mathematics teaching, specifically teaching mathematics for social justice, complex instruction, and project-based learning, and students' learning and identity development. Although different in their structures and strategies, equity-minded mathematics teaching approaches focus on supporting historically marginalized students to see themselves as capable learners, does, and users of mathematics by challenging power structures that perpetuate inequity within mathematics and mathematics classrooms.

Three manuscripts, which attend to how students who are historically marginalized in mathematics negotiate the focus on identity and power within equity-minded mathematics teaching approaches, make up the main portion of this dissertation. Each manuscript is a self-contained empirical study, with its own research questions addressed through relevant literature, data sources, analysis, findings, and discussion.

The first manuscript explores the possibilities and limitations of teaching mathematics for social justice to address racially-based inequities and injustices, in mathematics education and in society more broadly. Through a metasynthesis of thirty-five qualitative reports of social justice mathematics enactments in diverse classroom contexts, findings illuminate a set of evidence-based, promising practices that might help teachers manage tensions that arise when integrating

mathematics goals and social justice, towards ensuring anti-racist enactments of teaching mathematics for social justice.

The context for the other two manuscripts was a 9^{th} grade geometry class in a STEM-themed, open-enrollment magnet school with a diverse racial and ethnic student population. The teacher in this classroom strove to create an environment that encouraged out-of-school experiences and identities as part of mathematics activity by using a hybrid blend of project-based learning, complex instruction, and teaching mathematics for social justice. Over a yearlong ethnography, I observed classroom interactions and relationships, which were recorded through field notes, photos, and video, and I conducted interviews with individual students and focus groups. The analysis framed learning as identity development, which was operationalized using a figured worlds theoretical framework.

The second manuscript in this dissertation describes how students collectively negotiated the emphasis on identity and power across three project-based learning projects, which integrated complex instruction strategies and focused on exploring social justice questions about access to quality and affordable food. The third manuscript focused specifically on the voice of Black girls and their construction of "hands on" mathematics as humanizing within the project-based learning context. Together, findings amplify the voices and experiences of students who are historically marginalized in mathematics and contribute to the field's understanding of how students can reconstruct intended instructional goals and approaches on their own terms.

The other two chapters in this dissertation include an introduction and conclusion. The introduction provides an overview of this dissertation and describes how I came to this work. The concluding remarks summarize and synthesize the three empirical studies and offer possibilities for moving forward into an Assistant Professor position.

For Granny and Pa,
my shelter, my rock
love you

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They say it takes a village to raise a child. The year I started my doctoral studies, I also became an aunt. As part of the village helping to raise my nieces and nephew, I have developed a new appreciation for this widely quoted proverb over the last five years. But the last five years have also taught me something less widely recognized – it also takes a village to finish a PhD. Here, I attempt to express my gratitude for the village that has supported me along this journey.

To the teacher I call Olivia Stone and her 4th hour Geometry students: Thank you for welcoming me into your space and trusting me with your stories. Olivia, you are passionate, caring, and thoughtful, and I am fortunate to have had the opportunity to learn from and to work with you for several years now. I am in awe of the teacher you have become over the last five years, and I look forward to continue collaborating from a distance. To the students in 4th hour Geometry, thank you for letting me be a part of your class, for asking me questions and answering mine, and for so openly telling me your side of the story over pizza. I wish you all the best in your lives.

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KEY TO ABBREVIATIONS

CI Complex Instruction

CRT Critical Race Theory

TMSJ Teaching Mathematics for Social Justice

CHAPTER 1: INTRODUCTION

> *The classroom remains the most radical space of possibility in the academy. For years it has been a place where education has been undermined by teachers and students alike who seek to use it as a platform for opportunistic concerns rather than as a place to learn. With these essays, I add my voice to the collective call for renewal and rejuvenation in our teaching practices. Urging all of us to open our minds and hearts so that we can know beyond the boundaries of what is acceptable, so that we can think and rethink, so that we can create new visions, I celebrate teaching that enables transgressions – a movement against and beyond boundaries. It is that movement which makes education the practice of freedom (hooks, 1994, p. 12).*

In my heart, I am a teacher. And as a teacher, I celebrate the kind of teaching that hooks described in the above quote. Moments when teaching and learning shatter boundaries – when the teacher is the learner and the learners are teachers – when classroom experiences light up the world in new ways and vice versus – these are the moments that fuel my passion for teaching and for research on teaching and learning. As an undergraduate-Classics-major-turned-mathematics-teacher (who also finished pre-med requirements while taking a mathematics class and a music class each semester), I have been challenging boundaries in the academy for some time. This dissertation reflects my most recent efforts to move "against and beyond boundaries" by pushing the limits of what counts as research in mathematics education and by imagining, alongside other teachers and students, new directions and possibilities for mathematics teaching practices that transgress.

Contents of this Dissertation

The dissertation includes this introductory chapter, three manuscripts, and a concluding chapter. Each of the three manuscripts is designed around standalone research questions, addressed through relevant literature, data sources, analysis, findings, and discussion. In this introduction, I share how I came to the specific aspects of this overall study and my positionality in regards to the specific work. All three manuscripts are empirical studies, each of which drew on qualitative methods to explore the relationships between equity-minded mathematics teaching and students' learning, experiences, and identity development. By equity-minded mathematics teaching, I mean any instructional approach that has broad equity goals. In other words, equity-minded teaching attends not only to dominant dimensions of equity, such as mathematics achievement and access to high-quality mathematics teaching and curricula, but also to the under-recognized dimensions of identity and power (Gutiérrez 2012). I describe the constructs of identity and power in more detail in Chapter 3, but because these constructs are so central to the work in this dissertation, I provide a brief overview here.

Overview of Identity and Power

Students develop their mathematics identities – an understanding about their relationship with mathematics that influence how they engage with the subject (Horn, 2008) – based on dispositions and beliefs about their ability to learn, do, and use mathematics (Martin, 2006). Because mathematics historically and systematically marginalizes certain ways of knowing, students must negotiate their personal (racial, ethnic, gender, etc.) identities as they develop their mathematics identities, but students who are historically marginalized in mathematics[1] rarely have opportunities to see themselves as competent mathematics learners, doers, and users (Gutiérrez 2012; Martin 2006). Drawing on sociopolitical perspectives, I reject fixed views of identity, and instead, frame identity as "something you do, not something you are" (Gutiérrez, 2013, p. 45). Because identity is fluid and flexible and enacted differently in different contexts

[1] I use "students who are historically marginalized in mathematics" to refer to groups of students who have been historically and systematically marginalized in mathematics and mathematics education in the U.S. context. This includes students from historically and systematically marginalized racial and/or ethnic groups, students with disabilities, students whose first language is not English, students from low socioeconomic backgrounds, LGBTQ students, and girls. I recognize that using this phrase has limitations (e.g., does not recognize different sources and forms of marginalization), but I adopt this phrase for the sake of clarity and readability.

and at different moments, equity-minded mathematics teaching can create opportunities for students to enact identities as capable and confident mathematics learners and doers by reshaping what counts as mathematics. Introducing alternative ways of knowing in mathematics challenges traditional power structures in mathematics classrooms. Moreover, a more complex conception of equity attends to systemic power and takes up issues of social transformation such as whose voice is heard in mathematics and how mathematics shapes and can shape the world (Gutiérrez, 2012). Overall, this dissertation explores how students who are historically marginalized in mathematics negotiate (e.g., take up, shift, resist) the focus on identity and power within specific equity-minded mathematics teaching approaches.

Overview of the Three Manuscripts

The first manuscript is a qualitative metasynthesis of thirty-five qualitative reports of classroom-based investigations of social justice issues through mathematics (i.e., teaching mathematics for social justice; Gutstein 2003) in diverse classroom contexts. My goal in synthesizing the body of research on teaching mathematics for social justice (TMSJ) was to identify the possibilities and limitations of this particular equity-minded teaching approach to address racial inequities, specifically. The manuscript was written for a mathematics education research audience, and it has been accepted for publication in the *Journal for Research in Mathematics Education.*[2]

The other two manuscripts report on a yearlong ethnographic interpretive study in a 9th grade geometry class in a STEM-themed magnet school in which the teacher used a variety of equity-minded mathematics teaching approaches. The second manuscript asked how students

[2] When I make references to these manuscripts in the text of the dissertation, I cite them as such: (Harper, accepted/in preparation/under review [Chapter n], where *n* is the chapter in the dissertation. Because the three manuscripts are included in their entirety in the respective chapter, I do not include the citation in the reference lists of the dissertation.

experienced the intended instructional emphasis on identity and power within an innovative, hybrid instructional approach that blended three equity-minded mathematics teaching methods: (1) TMSJ; (2) complex instruction (CI) – an approach to cooperative learning with strategies to ensure equitable access and equitable interactions in small groups (Cohen et al. 1999); and (3) project-based learning – an approach in which students collaborate on projects to explore and solve authentic, real-world tasks or problems using a range of disciplinary knowledge and skills (Langer-Osuna 2011). The manuscript was also intended for a research audience, particularly in the area of sociocultural and sociopolitical perspectives in the learning sciences, and is in preparation for the *Journal of the Learning Sciences*. The final manuscript focuses more specifically on students' collective negotiation of one feature of the collaborative, project-based learning context. More specifically, I considered how Black girls constructed "hands on" mathematics as humanizing. This manuscript was written for a broader mathematics education audience, including researchers, teachers, and teacher educators. It is currently under review for the *Annual Perspectives in Mathematics Education 2018: Rehumanizing Mathematics for Students who are Black, Indigenous, and/or Latin@/x.*

How I Came to this Work

Growing up in poverty in a rural town in Tennessee, my odds favored a path of teenage pregnancy, life as a high school dropout, and survival on low-income wages as an industrial worker. I watched my mother struggle with this reality, and with her steadfast support, I found a different path. My mother taught me to view academic success as an opportunity for choice, and meritocracy worked for me. I was the first in my family to graduate from college, and to date, the only to pursue a terminal degree. These personal successes reinforced a belief in the power of individual effort to overcome poverty (which I only began to question once I started teaching) and fueled my passion for education. When I decided on a career in education, I chose to teach mathematics, specifically, because of its gatekeeping role – something I was aware of because I had seen how struggling in mathematics limited opportunities for my peers from high school.

Like most who choose to teach mathematics, my experiences as a mathematics student were largely positive. In high school, my mathematics teacher went above and beyond to support my love of learning – encouraging (and financially supporting) me to attend a summer camp to explore advanced topics in mathematics and guiding me through independent study in her classroom. My teacher's efforts to address my unique needs inspired me to do the same for my students. When I began teaching high school mathematics, I blended teacher exposition, collaborative learning, and independent study in an attempt to ensure success for each student. This strategy helped many students who had never experienced success in mathematics overcome their difficulties and develop the confidence to transition to algebra the following year. Years later, as an instructor at a supplemental K-12 mathematics and reading program, the individualized nature of the program allowed me to guide students through mathematics concepts at a pace suited to their needs. With adequate time and encouragement, many students gained confidence in mathematics and began to view themselves as capable mathematics learners as they progressed to more advanced topics. Such success among students inspired hope that mathematics achievement could be a reality for more children. Throughout my career, however, I struggled with the question of why many students, especially students of Color[3] and students from low socioeconomic backgrounds, dreaded mathematics study.

[3] I use students of Color to refer to students from traditionally marginalized racial and/or ethnic groups. I recognize that this term has limitations (e.g., essentializes racial groups; suggests White as race/color neutral), but I adopt this term for the sake of clarity and readability.

The desire to make enjoyment of and success in mathematics a reality for more students drove my decision to pursue graduate studies. While working as a K-12 mathematics and reading instructor, I earned my master's degree in mathematics for teaching. Through this program, I began to understand the importance of developing students' conceptual understanding in mathematics and to explore the possibilities for using CI for more equitable learning. I finished the program inspired to return to the traditional high school classroom setting where I attempted to implement CI strategies and to focus on conceptual understanding across the 9-12 mathematics curriculum. Teaching only intensified my interest in how collaboration could promote more equitable mathematics learning, and a desire to better understand CI in mathematics led me to pursue a second master's degree at Stanford University, the birthplace of this specific pedagogical approach.

My experiences at Stanford deepened my appreciation for CI as one way of fostering equity in mathematics teaching and learning, but I also started to recognize the limitations of 'good' mathematics teaching in a single classroom to meet the needs of historically marginalized students. I looked for other ways that teachers could attend to the challenges that historically marginalized students face both within the classroom and more broadly. Experiences at Stanford introduced me to thinking more explicitly about racialized experiences in education and about TMSJ as a pedagogical approach with potential to support students to advocate for themselves across classroom settings and beyond the school context. As I began my doctoral studies, I sought opportunities to explore both ideas further.

During the second semester of my first year, I took a course focused on using critical race theory (e.g., Delgado & Stefancic, 2012) in education. This course was significant in my development as a mathematics education researcher and teacher educator because it provided a space for me to reflect systematically on my experiences as a White teacher of students of Color. When I began my teaching career in a predominately African American high school, I had only limited understanding of the unique ways students of Color experience racism in educational contexts. Growing up in a house with a Black stepfather and biracial siblings and in a small conservative town where racism was commonly overt, I have known, for as long as I can remember, that racial identity matters and that my whiteness grants certain privileges. Nonetheless, as a (White, female) teacher, I had not recognized how meritocracy and its focus on individual effort and choice ignored and perpetuated systemic narratives and structures that privileged some groups of people while oppressing others. Critical race theory gave me tools to reflect on my eight years teaching in various classroom contexts and on my ongoing interactions with students and teachers in ways that centered the voices and experiences of students of Color (for a more detailed discussion of my evolving critical race consciousness as a mathematics (teacher) educator see Harper, 2016). This reflection lit up the world for me in new ways and continues to guide the work I do today. In particular, looking at mathematics education through a critical race lenses inspired me, even more, to understand, promote, and foster mathematics experiences within the mathematics classroom that historically marginalized students can leverage to advocate for themselves and to challenge the intersectional ways (e.g., race, socioeconomic status, gender, ability) in which they are marginalized in school and society.

During the same semester in my first year, I met the teacher, Olivia Stone,[4] who participated in this dissertation study. Olivia was a first year teacher at the time, and she shared similar goals for helping students use mathematics as a tool of power. In a book chapter we later published together, we described our shared motivation for TMSJ in this way:

[4] All names are pseudonyms.

> We see mathematics as a tool of power. People, who not only have a deeper understanding of mathematics but also have an understanding of mathematics in the context of local and global issues, are able to write the story our society hears about the issues. If students have a deeper understanding of mathematics in the context of the world, students will be able to analyze and critique information around them. With this understanding of mathematics, students would be able to look at a chart and question the story the creator was trying to tell, connect how the story relates to society as a whole, and what message the story sends to others. We also hope to help students develop the ability to write their own story using mathematics to represent and influence issues facing them locally and globally (Source blinded to protect the anonymity of the teacher).

When I met Olivia, she welcomed me into her classroom where I had an opportunity to observe some of her early attempts to integrate mathematics and social justice topics in algebra. These initial observations began a long-term collaboration that led up to this dissertation work and will likely continue beyond it.

During the first summer of my doctoral studies, I received funding to develop a small research project to focus on teacher learning about TMSJ, and I invited Olivia to participate. In preparation for this project, I facilitated several sessions focused on skills for collaboration and a weeklong social justice mathematics project with students at a local summer camp. Drawing on this experience, I designed a professional development in which I guided two early-career high school mathematics teachers (one was Olivia), three prospective secondary mathematics teachers, and one prospective elementary teacher to co-plan and co-teach a weeklong project about wealth inequality at the same summer camp. As the teachers and I reflected on the project enactment (during our debriefing session at the conclusion of the professional development), we struggled with the feeling that some of our well-intentioned teaching efforts may have inadvertently further marginalized students. We were troubled by interactions and reactions in the following vignette:

> Two sixth graders, Devon, a short, outspoken White boy, and Barry, a tall, quiet Black boy, paired up to collect data for their group. Devon read aloud the median incomes for local neighborhoods as Barry recorded the data on a table. They chatted about some

> initial observations, “Wow! $25,000 seems so low,” but their conversation halted when something prompted Devon to share, “People on welfare are lazy.” Barry’s reaction was immediate. Surprise and hurt quickly turned to anger. Barry held back tears and retorted, “My parents work hard,” as he stormed off and demanded someone else work with Devon.

Our efforts to teach mathematics for social justice drew on a variety of research-driven instructional features – sense making, authentic contexts relevant to students’ lives, and collaboration – all aimed at increasing students’ access to mathematics by supporting them to see themselves in the mathematics. Nevertheless, working with Devon to investigate mathematics questions about issues that hit too close to home further marginalized Barry. Barry’s experience illustrated the need for a better understanding of how students, particularly students of Color, take up, negotiate, or resist equity-minded teaching efforts, in general, and TMSJ, in particular. As White, adult females (Olivia and I, and most of the teaching force) seeking to support more equitable mathematics learning for racially diverse groups of adolescents, the most salient question seemed to be: Do students actually experience equitable mathematics teaching as equitable?

As a first step in addressing this question, Olivia and I continued to collaborate, focusing on planning and teaching with potential to create better experiences for students during social justice mathematics projects, specifically, and in mathematics, more generally. Most of our work together was informal. In other words, we met to discuss mathematics teaching and students’ experiences in Olivia’s class; we did some co-planning and shared resources; I observed in Olivia’s classroom. Only once, did we formally analyze and report on student work from a social justice lesson that we co-planned (source blinded to protect teacher anonymity). When sharing resources, I introduced Olivia to CI, and wanting to learn more, she attended a professional development (independent of me). As she attempted to integrate CI into a project-based mathematics class (the year prior to my observations for this dissertation), we informally talked about her teaching and continued to share resources. I have had the privilege of seeing Olivia's teaching mature during the first five years of her career, and I have also learned a great deal about what it means to be a mathematics education scholar who is justice- and change-oriented and collaborative with participants (Creswell, 2014). Working with Olivia has taught me the importance of staying connected to classrooms by building lasting and meaningful relationships with teachers and students. Supporting students' self-empowerment to use mathematics as a tool to critique and challenge systems of privilege and oppression requires teachers, students, and scholars to learn together.

The more time I spent in Olivia's classroom observing and talking informally with students, the more we realized the importance of systematically exploring students' experiences with Olivia's equity-minded teaching efforts. Although Olivia had taken significant steps towards improving her teaching and planning for students mathematics experiences, we still questioned whether or not students actually experienced Olivia's mathematics teaching as equitable. For example, we noticed students' (including students' of Color) resistance to talking about race during social justice mathematics lessons, but we also observed thoughtful and passionate conversations about social justice issues in the mathematics classroom. Thus, this dissertation reflects what we see as a next step in addressing this important question: Do students actually experience equity-minded mathematics teaching as equitable? Whereas my previous research centered teachers' efforts, in this dissertation, I instead strove to listen to, learn with, and speak alongside students.

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CHAPTER 2: A QUALITATIVE METASYNTHESIS OF TEACHING MATHEMATICS FOR SOCIAL JUSTICE IN ACTION: PROMISES AND PROBLEMS OF PRACTICE

With the sociopolitical turn in mathematics education (Gutiérrez, 2013), mathematics classrooms have increasingly become sites for critically investigating and reflecting on social justice issues (e.g., Bartell, 2013; Esmonde, 2014; Hendrickson, 2015; Wright, 2016). Some argue that teachers face a moral and ethical imperative to transform mathematics classrooms into spaces for the development of critical social awareness (i.e. critical consciousness) and social transformation (Stinson, 2014). Others have called for greater attention to the lives and experiences of those students, predominantly students of Color[1], whom mainstream research and reform efforts in mathematics education continue to marginalize (Berry III, Ellis, & Hughes, 2014; Martin, 2003). In response, educators and scholars often target classrooms with students of Color, generally with low socioeconomic status (SES), as sites for reforming mathematics teaching to include social justice goals (Brantlinger, 2013).

Proponents of using mathematics to explore social justice issues and to advance change (i.e., teaching mathematics for social justice – TMSJ) aim to place the best interests of students of Color at the center of reform efforts; however, tensions arise when teachers attempt to translate theories of TMSJ into practice (Bartell, 2013; Pais, Fernandes, Matos, & Alves, 2012; Skovsmose, 1985). For example, time spent meaningfully discussing social issues naturally takes some time away from the direct focus on mathematics, which may cause students of Color's mathematics achievement to suffer. Moevoer, in classrooms with white/affluent students,

[1] For the remainder of this paper, I use students/teacher/communities of Color to refer to people from traditionally marginalized racial and/or ethnic groups. I recognize that this term has limitations (e.g., essentializes racial groups; suggests white as race/color neutral), but I adopt this term for the sake of clarity and readability. I chose to capitalize 'Color', but not 'white', to challenge the ways these standard grammar conventions reinforce systems of privilege/oppression.

inadequate time for discussion during social justice explorations might have unintended consequences, such as essentializing the experiences of people of Color or perpetuating racial stereotypes (e.g., Bartell, 2013; Esmonde, 2014). Given the difficulty in both translating theories of TMSJ into practice and confronting issues of race and racism in the mathematics classroom for white teachers and teachers of Color alike (Bartell, 2013; Gonzalez, 2009), scholars have raised questions about what TMSJ means for different groups of students (Skovsmose, 2016) and what capacity TMSJ has for confronting racial injustice (Larnell, Bullock, & Jett, 2016). The purpose of this study is to critically analyze the potential for TMSJ practices in diverse classroom contexts to both challenge/alleviate and perpetuate/exacerbate racially-based educational and societal inequities. In other words, what are the possibilities and limitations of TMSJ, in practice, to address racially-based inequities and injustices?

A growing body of 'thick descriptions' (Geertz, 1972) of TMSJ enactments exists. The hope is that these "case studies of [TMSJ] in K-12 mathematics classrooms may help us understand critical features of such pedagogy and some of the associated enabling and disabling conditions, and they may ultimately help us move toward a more just and equitable society" (Gutstein, 2003, p. 41). The context-specific nature of these cases, however, presents a significant obstacle to identifying the strengths and limitations of TMSJ and to making evidence-based recommendations to inform the practice of TMSJ. In this study, I use qualitative metasynthesis to analyze the body of evidence and to synthesize findings across a range of qualitative reports of TMSJ in practice (Paterson, Thorne, Canam, & Jillings, 2001; Sandelowski, Docherty, & Emden, 1997; Thorne, Jensen, Kearney, Noblit, & Sandelowski, 2004; Thorne, 2009). Although currently underutilized in mathematics education, qualitative metasynthesis holds promise for systematically integrating qualitative findings to offer greater insight towards more evidence-based, claims (Thorne, 2009; Thunder & Berry, 2016), in this case, to inform TMSJ practices that address racially-based educational and social inequities across various classroom contexts.

Process and Methods for Qualitative Metasynthesis

I followed guidelines for meta-study outlined by Paterson and colleagues (2001) and used examples of qualitative metasyntheses of educational research as models (Au, 2007; Berry & Thunder, 2012; De Gagne & Walters, 2009). In this section, I describe this study's methods for each stage of the metasynthesis process, outlined in major headings below.

Formulating Research Questions

As in most research, the initial research question in qualitative metasynthesis is guided by the researchers' knowledge of the phenomenon under study, but unique to qualitative metasynthesis, a research question must be metaquestion –"a question that has already been studied qualitatively" (Thunder & Berry, 2016, p. 322). The research questions guiding much of the research on TMSJ explore possibilities for TMSJ in practice, and drawing on my own knowledge of the field, I recognized that most studies of TMSJ enactments involved either students of Color or included topics related to race/racism. Thus, the overarching research question represents a metaquestion: how do TMSJ practices in diverse contexts challenge/alleviate and/or perpetuate/exacerbate racially-based educational and societal inequities? As in all qualitative research, the initial research question is operationalized using a guiding theoretical framework (Paterson et al., 2001) and questions are further revised and refined throughout iterative rounds of data analysis in order to allow definitions to emerge from the data (Thunder & Berry, 2016). In this section, I present the final version of the research questions alongside explanations of key concepts based on the guiding theoretical framework.

I chose a theoretical framing that would allow me to center race in this analysis. The focus on race is grounded in the tradition (e.g., Anyon, 1980; Fennema & Sherman, 1977; Lubienski, 2002; Secada, 1992) of interpreting students' mathematics experiences and achievement "as a social issue rather than as a matter of individual differences" (Secada, 1992; p. 627). I draw especially from the field's evolving understanding of mathematics education as racialized (Martin, 2009b). Researchers within classic research traditions in mathematics education sometimes ask "Where's the math?," meaning, "How is research on race unique to the mathematics classroom?" I (and other mathematics education researchers) argue that students' mathematical experiences are inseparably interwoven with their racialized, gendered, etc. experiences. Mathematics content is crucial in enactments of mathematics lessons, but sociopolitical factors are equally important. Mathematics teaching and learning cannot be understood without attending to both the mathematics content and sociopolitical influences on mathematics learning. The decision to center race is an intentional one, made with the aim of drawing attention to how a typically marginalized topic (i.e., race) is central to making progress towards more equitable *mathematics* learning and achievement for students of Color. (See Martin et al., 2010; Parks & Schmeichel, 2012). Centering race in this analysis is particularly important for evaluating claims that TMSJ addresses the needs of students of Colors where previous reforms have failed. I selected Critical Race Theory (CRT) as the theoretical framework for defining key concepts related to race/racism and generating research questions (Paterson et al., 2001).

CRT. Scholars of Color designed CRT to provide new theories and strategies for combating racism in society (Delgado & Stefancic, 2012). In 1995, Ladson-Billings and Tate, two scholars of Color, introduced CRT into the dialogue on education, more broadly (Ladson-

Billings & Tate, 1995). Ladson-Billings argued that CRT offers “innovative theoretical ways for framing discussions about social justice and democracy and the role of education in reproducing or interrupting current practices” (Ladson-Billings, 2009, p. 19). More recently, mathematics education scholars have adopted or advocated for CRT as a framework for understanding mathematics teaching and learning as racialized (Berry III, 2008; del Rosario Zavala, 2014; Gutiérrez, 2013; Martin, 2006; Stinson, 2006). Prior to CRT becoming part of the dialogue in mathematics education, various approaches to understanding the role of race in mathematics education existed. Much of this research focused on the influence of social factors, more broadly (e.g., Apple, 1992; Secada, 1992, 1995). Some research centered race exclusively by comparing the experiences or achievement of students of Color to white students (e.g., Lubienski, 2002). These approaches are problematic because they either fail to center race, or they center race in a way that valorizes the mathematical experiences or achievement of white students as the norm and encourages a view students of Color as deficit (Gutiérrez, 2008). CRT seeks to avoid these pitfalls by honoring the experiences of people of Color in their own right, rather than in comparison to the experiences of white people. From this perspective, differences among students of Color and their white peers can indicate brilliance rather than a deficit (e.g., Leonard & Martin, 2013). By the nature of being a theoretical framework, CRT establishes particular assumptions that provide a foundation for centering the experiences of students of Color. In other words, CRT allows for analysis *given* that racism is ordinary and permanent rather than requiring the analysis to focus on whether or not racism exists in a particular context. I have chosen to use CRT in this analysis of TMSJ specifically because this framework provides a way of considering the possibilities and limitations of TMSJ enactments to challenge racism, while at the same time, challenging racism in mathematics education through the analysis itself. Next, I outline select

CRT tenets, connect them to mathematics education, and present the research questions derived from each tenet.

Racism is ordinary and permanent / critique of liberalism. CRT asserts that race is a social construction but a permanent and salient one. Racism permeates all aspects of society, from individuals to institutions (e.g., legal, educational). Moreover, CRT maintains that whites, regardless of SES, benefit from racism, even if they reap these benefits unintentionally or unconsciously (Delgado & Stefancic, 2012). Because mainstream society easily fails to acknowledge the subtle workings of racism, CRT promotes a *critique of liberalism* (Delgado & Stefancic, 2012). Although a liberal (e.g., progressive; politically left-leaning) perspective acknowledges that (overt) racism is problematic and should be challenged, liberalism generally situates (systematic) racism as a historical problem, rather than a current one, and promotes colorblindness (i.e., race is not acknowledged because of a view that racial equality has been achieved). This liberal dismal of systematic racism places the burden of (in)equality at the individual level (e.g., people live in poverty because of their own actions) and ignores the ways that systems of privilege perpetuate inequalities (Lynn & Dixson, 2013). A critique of liberalism in education challenges claims of objectivity and neutrality, such as meritocracy, fairness and colorblind policies, that camouflage subtle forms of racism (Howard, 2008). This critique reveals the ordinariness and permanence of racism in education, upheld by policies that claim objectivity. For example, 'neutral' curriculum maintains a "White supremacist master script;" 'colorblind' instruction presumes that "African American students are deficient;" 'fair' assessments legitimize "African American student deficiency under the guise of scientific rationalism;" and "inequality in school funding is a function of institutional and structural racism" (Ladson-

Billings, 2009, p. 29-31). Such assumptions of neutrality and colorblindness are particularly relevant in mathematics education (Garii & Rule, 2009; Gutiérrez, 2012).

Under these tenets, TMSJ, aimed at challenging racially-based educational and social inequities, necessarily acknowledges the ordinariness of racism and challenges liberal assumptions of neutrality and colorblindness. The first research question and its sub-questions focus on the extent to which TMSJ enactments attend to issues of race and racism in ways that critique liberalism:

Q1. How do teachers and students attend to (or not) issues of race and racism during TMSJ enactments?

Q1a. How do teachers and students challenge (or not) liberalism during TMSJ enactments?

Q1b. To what extent do teachers and students (1) counteract essentialism and (2) position as central race/racism in the TMSJ enactments?

To clarify, I do not mean for Q1b to imply that all TMSJ enactments exclusively focus on issues of race or racism. Nonetheless, TMSJ enactments, which position race as peripheral to the mathematics or to other social justice issues, could further marginalize students of Color or perpetuate colorblind or deficit views. For example, an investigation of the gender wage gap (Hegewish, Williams, & Edwards, 2013) would naturally center sexism; however, opportunities for considering the intersection of race and gender in relation to the gender wage gap exist.

Q1b aims to uncover the extent to which all TMSJ enactments, not just those focused directly on racism, provide opportunities for considering *intersectionality*, or the ways in which membership in more than one marginalized group creates unique experiences with oppression (Crenshaw, 1991; Wing, 2003). Investigating salaries by gender and race might help students to recognize the ways in which women can experience discrimination differently, but simply adding race as an additional variable, without meaningful discussion of the intersection of race and gender, might encourage essentialized, deficit views of women of Color. Thus, race must share the central focus with gender, for at least part of the lesson or project. A meaningful focus on intersectionality allows teachers and students to investigate racism more critically – counteracting essentialism, or assumptions that people of Color experience oppression in the same way, while at the same time recognizing shared experiences with interpersonal and systemic racism (Wing, 2003).

Interest convergence. The concept of interest convergence maintains that reforms towards racial equality will most likely occur when the interests of white people converge with the interests of people of Color (e.g., end of state-mandated school segregation). Moving towards racial equality, however, requires White people to concede some privilege, and as liberal, colorblind perspectives grow, so does the divergence of interests that make change towards racial equality less likely (Bell, 1980). In general, whites will only advocate for the interests of people of Color to the extent that their interests are not threatened, thus perpetuating a system that privileges whiteness and ensures the permanence of racism (Delgado & Stefancic, 2012). In education, when using CRT to analyze initiatives resulting from policies such as *No Child Left Behind* (*NCLB)*, interest convergence explains why white parents oppose efforts to improve the achievement of students of Color if they perceive a threat to their own children's education. Moreover, interest convergence highlights the ways in which *NCLB* has perpetuated students of Color's almost exclusively rote and procedural learning of mathematics (Berry III, 2015; Berry III et al., 2014).

Because the teaching force is predominantly white (Nieto & McDonough, 2011), interest convergence would suggest that teachers' motivations for TMSJ may conflict with the interests of people of Color. When interest convergence underlies educational policy and reforms, students of Color's may make some educational gains but what is in their best interests is largely dismissed (Baber, 2015; Berry III, 2015). Because of the gatekeeping nature of mathematics, teachers have a responsibility to prepare students to navigate the required mathematics curriculum (however problematic that curriculum may be). Thus, I consider evidence that TMSJ enactments limit students of Color's access to the dominant mathematics curriculum to indicate possible interest convergence. Teachers may incorporate mathematics from outside the dominant curriculum for sound and well-intentioned reasons, but doing so may not serve the best interests of students of Color in regards to traditional measures of mathematics achievement and opportunities for advanced mathematics study. Resistance to TMSJ from students, parents, or communities of Color might also indicate that TMSJ does not serve the best interests of students of Color. Question two and its sub-questions aim to explore possible evidence of interest convergence:

Q2. What role does interest convergence play in teachers' enactments of TMSJ?

Q2a. To what extent do TMSJ enactments engage students with mathematics content that is part of the dominant curriculum?

Q2b. To what extent do students, parents, or communities of Color support (white) teachers' efforts to teach mathematics for social justice?

Unique voice of Color. CRT holds that people of Color, because of their lived experiences, understand and can communicate racism in ways that white people cannot (Delgado & Stefancic, 2012). Although the coexistence of the unique-voice-of-color thesis and another central tenet of CRT, anti-essentialism (described above in relation to intersectionality), creates some uneasy tension, CRT emphasizes *counterstorytelling* as a means of empowering people of Color to speak about racism (Delgado & Stefancic, 2012). By recognizing counterstorytelling as a valuable tool for investigating racial discrimination and inequity, CRT draws on experiential knowledge as it honors the rich history of communities of Color whose storytelling traditions are often shunned (Howard, 2008).

In education research, scholars use CRT as a methodological framework in qualitative studies to privilege the voice and experiences of students of Color. Such efforts to understand educational experiences, from students' perspectives, have shed light on students' forms of resistance to racism and have provided insight into students' beliefs about how race and racism impact educational opportunities (e.g., Carter, 2008; Fernández, 2002; Howard, 2001). Fernández (2002) argued that students' counterstories should take center stage in education research when students of Color are participants, as is the case in much of the research on TMSJ. Even when the participants are white teachers (e.g., Bartell, 2013), students of Color are often indirect participants via their participation in TMSJ enactments. CRT offers a way of understanding the nuances of students' complex, racialized experiences in TMSJ. Similarly, when the participants are white students (e.g., Esmonde, 2014), TMSJ enactments that center the voice of Color have potential to challenge racial stereotypes, white privelege, etc. in mathematics and society. Question three aims to explore the extent to which and how people of Color's voices guide the integration of mathematics and social justice goals in classrooms:

Q3. How do students/people of Color's voices, perspectives, and questions serve (or not) as the foundation for enactments of TMSJ?

Data Collection

Data collection involved conducting a comprehensive search of relevant literature and identifying specific criteria for selecting and appraising appropriate primary research, which served as the data set for the meta-analysis (Thunder & Berry, 2016; Thorne et al., 2004). To locate relevant literature, I searched the Educational Resources Information Center (ERIC) database and used EBSCO*host* to search the following databases simultaneously: eBook Academic Collection; eBook Collection; Education Abstracts (H. W. Wilson); Education Full Text (H. W. Wilson); Educational Administration Abstracts; and Teacher Reference Center. I conducted a subject term search through EBSCO*host*, using this protocol: mathematics; AND ("social justice" or critical or "culturally relevant"); NOT ("critical thinking"), and I limited my search to publications from 2003 or later (see rationale below). This search produced 91 unique results. I conducted multiple searches through ERIC using combinations of keywords: mathematics AND "social justice" (133 results); mathematics AND "critical pedagogy" (15 results); "critical mathematics" OR "criticalmathematics" (73 results); and mathematics AND "culturally relevant" (184 results). By reading abstracts and skimming articles/chapters, I further refined the data set to include 23 journal articles and 12 book chapters (Table 2.1) based on six inclusion/exclusion criteria for establishing topical similarity and methodological comparability.

Table 2.1

Articles and chapters included in the metasynthesis.

Articles (Primary)	**Article (Supporting)**	**Book Chapters (Supporting)**
Gutstein (2003)	Staats (2007)	Peterson (2012)
Matthews (2003)	McCoy (2008)	Stocker (2012)
Enyedy & Mukhopadhyay (2007)*	Murphy (2009)*	Aguirre et al. (2013)
Gonzalez (2009)	Walker & Waldron (2009)	***Rethinking Mathematics* (2013)**
Leonard et al. (2009)*	Shibli (2011)*	Aguirre & del Rosario Zavala
Turner et al. (2009)	Pais et al. (2012)	Allman & Opeyo

(Table 2.1, cont'd)

Terry (2010)*	Stinson et al. (2012)*	Dean
Bartell (2013)	Hendrickson (2015)	Denny
Brantlinger (2013)*	Chao & DeAndrea (2016)	Renner et al.
Gregson (2013)	McNeil & Fairley (2016)	Staples
Esmonde (2014)*		Steele
Voss & Richards (2016)*		Trexler
Wright (2016)*		Turner & Strawhun

**Article appears outside of mathematics education specific journal*

Table 2.1

Criteria for appraising topical, population, and temporal similarity. An initial step in establishing inclusion/exclusion criteria involved determining topical, population, and temporal similarity of studies in regards to the metaquestion (Sandelowski et al., 1997; Thunder & Berry, 2016). The first five criteria were revised and refined throughout the search process as I encountered results that were unanticipated based on working definitions from the research questions, theoretical framework, and my knowledge of the field (Thunder & Berry, 2016). The first three criteria address topical similarity; the fourth population similarity; and the fifth temporal similarity.

Criterion 1: Explicit social justice focus. Determining topical similarity (i.e., whether or not studies were about TMSJ) presented a significant challenge because the field lacks general agreement on what TMSJ means both in theory and in practice. Generally, TMSJ involves integration of mathematics education and critical pedagogy (i.e., education that questions who holds power and why, Stinson, Bidwell, & Powell, 2012), and efforts towards this integration began in the early 1980's (e.g., Frankenstein, 1983; Skovsmose, 1985). Recent studies of TMSJ (e.g., Brantlinger, 2013; Wright, 2016) build on the work of Gutstein (2003), who identified general goals for teaching for social justice, which he mapped onto objectives for teaching mathematics. In this conception of TMSJ, (1) developing critical consciousness maps to *reading* *the world* using mathematics; (2) developing students' sense of agency maps to developing mathematical power or *writing the world* with mathematics; and (3) developing positive social/cultural identities maps to positive dispositions towards mathematics (Gutstein, 2003).

Because Gutstein (2003) derived his conception of TMSJ both from critical pedagogy and culturally relevant pedagogy (i.e., education that uses cultural referents with students of Color, Ladson-Billings, 2009b), I acknowledge these pedagogical approaches can be synonymous with TMSJ in certain contexts. Thus, TMSJ encompasses diverse teaching and learning practices (e.g., ethnomathematics, d'Ambrosio, 1985; culturally relevant mathematics pedagogy, Gutstein, Lipman, Hernandez, & de los Reyes, 1997; democratic mathematics education, Woodrow, 1997), and some argue that TMSJ simply involves equitable (e.g., relational equity, Boaler, 2008) or 'good' mathematics teaching (Ladson-Billings, 1995). Although the goals of such approaches may overlap with goals for TMSJ, many of these approaches leave students unaware of the social justice focus because critiques of systems of power and oppression remain implicit.

One possible distinguishing approach to translating goals for TMSJ into practice involves linking mathematics and social justice issues explicitly in mathematics lessons or projects. Even though mathematical exploration of social justice issues represents only one part of broader TMSJ efforts, establishing this particular criterion helped ensure topical similarity of studies. Thus, I targeted only studies involving mathematics lessons or projects that included an explicit social justice focus.

Criterion 2: TMSJ practice. This study focuses on the potential of TMSJ, in practice, to address racially based inequities; therefore, I excluded theoretical work on TMSJ (e.g., Kokka, 2015; Leonard, Brooks, Barnes-Johnson, & Berry, 2010). I included studies that focused both on teaching practices for TMSJ (e.g., lesson planning and enactment, Bartell, 2013; lesson planning, Gonzalez, 2009) and student learning through TMSJ (e.g., Esmonde, 2014). Moreover, I refined the set of studies to those in which the teacher participants worked directly with students. In other words, I excluded studies of pre-service teachers and descriptions of TMSJ lessons when there was no evidence that lessons or practices were enacted with PK-12 students (e.g., Garii & Rule, 2009; Leonard, 2010). I included studies in diverse settings, such as traditional mathematics classrooms (e.g., Bartell, 2013), afterschool programs (e.g., Leonard, Napp, & Adeleke, 2009), and summer programs (e.g., Terry, 2010, 2011).

Criterion 3: Mathematics education. I considered ways to situate this analysis firmly within the field of mathematics education research to ensure topical similarity and to address concerns that research on race and identity belongs outside of the field. Peer-reviewed journals served as the primary source for the data set because dissertations, for example, are difficult to situate within a particular field. I focused on selecting articles published in mathematics education specific journals (e.g., *Journal for Research in Mathematics Education, Educational Studies in Mathematics*). I also included chapters from three books (Aguirre, Mayfield-Ingram, & Martin, 2013; Gutstein & Peterson, 2013; Stinson & Wager, 2012) clearly targeting a mathematics education audience.

Pushing the boundaries of what is valued as core research in mathematics education means that critical mathematics education research is often marginalized within the field (Martin et al., 2010; Pais et al., 2012). Thus, I expected to find a number of articles on TMSJ outside of mathematics education specific journals. Given the limited research on TMSJ in practice, I did not want to exclude important findings unnecessarily. For this reason, I included 10 articles in this analysis that appeared outside of mathematics education specific journals or books (Table

2.1). Authors of these articles have either published other research reports in mathematics education specific journals/books or are mathematics teachers, suggesting that these researchers/practitioners and their work are situated within mathematics education even if these specific articles are not.

Criterion 4: PK-12 content. Because I was interested, specifically, in the potential of TMSJ to address racially based inequities among the PK-12 mathematics population, I narrowed the literature to include TMSJ enactments involving only PK-12 mathematics content (e.g., National Governors Association Center for Best Practices & Center of Chief and State School Officers, 2010). Most studies also took place in PK-12 contexts, with the exception of two studies that incorporated PK-12 mathematics content in postsecondary mathematics classrooms (Table 2.2). I included these studies because of their similarity to TMSJ with high school students (i.e., adolescents learning algebra content), but excluded postsecondary TMSJ enactments that took place exclusively in teacher education courses (e.g., Simic-Muller, 2015).

Criterion 5: Published 2003 or later. Gutstein's (2003) study of TMSJ offered one of the earliest examples of TMSJ in PK-12 classrooms and established goals for TMSJ that served as a foundation for much of the subsequent research on TMSJ. Thus, I anticipated an increase TMSJ research in PK-12 classrooms following 2003, and I expected that temporal similarity would ensure greater similarity in conceptions of TMSJ.

Criteria for determining methodological comparability. I used information about methodology and data sources to verify that studies met the sixth criterion: study uses qualitative methods and reports on a unique classroom context. In my initial review of articles, I excluded quantitative studies (e.g., Winter, 2007) and multiple works by the same author in cases where those multiple reports described the same classroom context. I chose only one research report for each classroom context in order to avoid over representing particular contexts and TMSJ enactments. If multiple reports existed, I selected the article/chapter with information to most effectively answer analysis questions. For example, I selected *Between politics and equations: Teaching critical mathematics in a remedial secondary classroom* (Brantlinger, 2013) over *Rethinking critical mathematics: A comparative analysis of critical, reform, and traditional geometry instructional texts* (Brantlinger, 2011), because the former provided more vivid description of TMSJ enactments in the classroom. I included multiple articles from the same journal or multiple chapters from the same edited book as long as those chapters/articles reported on unique classroom contexts.

Once I had identified the core set of qualitative reports on TMSJ (Table 2.1), I assessed the quality of research in each study using the rubric adapted by Thunder and Berry (2016). Following their example, I considered the thirteen studies, which scored 11 (of 15) or higher, to reflect high-quality qualitative research (see "Articles (Primary)" in Table 2.1). The remaining ten articles (see "Articles (Supporting) in Table 2.1) and the twelve chapters (see "Book Chapters (Supporting)" in Table 2.1) scored less than 11 (of 15) because the reports were written for a practitioner audience and/or relied on teachers' self study of their practice and students' learning. I argue that the qualitative descriptions in these articles/chapters represent findings from practitioner research, which should be valued as a form of qualitative research because classroom teachers offer valuable perspectives on TMSJ in practice. Practitioner research on TMSJ is common even in the thirteen high-quality qualitative studies (e.g., Brantlinger, 2013; Gutstein, 2003; Turner et al., 2009), making methodologies similar across all thirty-five articles/chapters. Although I acknowledge that the lower-scoring articles/chapters rely on less systematic analysis than their higher-scoring counterparts, Sandelowski and colleagues (1997) warn against excluding studies because of their quality. Instead, they recommend accounting for variations in qualitative approach in other ways (Paterson et al., 2001; Sandelowski et al., 1997). I accounted for this variation by relying on the thirteen high-scoring articles as primary data sources and the remaining articles/chapters as supporting (i.e., confirming) data sources. In other words, I identified major themes from the primary articles first and used the supporting articles/chapter to confirm themes and provide additional examples.

Analysis and Synthesis

Metasynthesis relies on meta-data-analysis (i.e., the analysis and interpretation of similarities and differences across findings from primary studies, Paterson et al., 2001), which allows the researcher to synthesize across multiple qualitative studies. Meta-data-analysis requires selecting a particular analytic strategy for developing a coding system to categorize data (i.e., primary qualitative studies) (Paterson et al., 2001). I chose template analysis because this particular method of analysis allows for categorizing and identifying themes in textual data. Template analysis is a structured process yet is flexible enough to adapt for the specific needs of the study (King, 2012). Template analysis first involves creating a coding scheme, or template. Following the structure of template analysis, I first created a priori codes based on CRT, and then I used an initial exploration of a subset of data to refine and add codes to the initial template. Once I established the initial template, I applied codes to the entire data set, continuing to add and refine themes (Au, 2007; Crabtree & Miller, 1999; Waring & Wainwright, 2008) until they were exhaustive. The final template (Appendix) included hierarchical codes, which marked different levels of specificity used to identify both broad themes and more narrow ones (Au, 2007; King, 2012). Finally, I created cross-case displays and summaries by sorting segments of text in a spreadsheet by theme and by article/chapter and creating the tables included in this findings section (Thunder & Berry, 2016). I synthesized by reading segments and comparing tables to make connections within and across themes in relation to the research questions in order to arrive at the findings (Au, 2007; Crabtree & Miller, 1999; King, 2012; Waring & Wainwright, 2008).

Findings

In this section, I present findings related to the broader question: What are the possibilities and limitations of TMSJ enactments to address racially based inequities and injustices? Given the conceptual nature of this analysis, I provide illustrative examples when appropriate rather than supplying an exhaustive review of all thirty-five articles and chapters. Table 2.2 provides information about the context of each TMSJ enactment that the reader may find helpful when reading this section.

Table 2.2

Summary of findings from analysis of study context.

Grade Level		
PK-5	MA, TU (*see key below*) mu, ww, cd, pe	6
6-8	GU, GR, ES he, sto, ag, dea, den, ts	9
9-12	EM, GO, LE, TE, BA, BR, ES, VR, WR mc, sh, pa, sti, mf, ad, ao, re, stap, ste, tr	20
Postsecondary	staa, sti	2
School or Class Type		
Public School	(*divided by type of public school below*)	21
Traditional	GU, MA, GO, BA, VR, WR Staa, sti, he, cd, mf, ag, dea, tr, ts	15
Social Justice Focus	GR pe, sto, re	4
Alternative	BR ao	2
Private School	ES den, stap	3
After school or summer program	EM, LE, TU, TE pa, pe, sto, ad	8
Unknown	mc, mu, ww, sh, ste, tr, ts	7

(Table 2.2, cont'd)

Race of teacher(s)		
Black	MA, GO, LE, TE cd, mf	6
Latinx	GO ad	2
Asian or Asian American	LE	1
White	GU, MA, LE, TU, BA, BR, GR, VR staa, mc, mu, pa, sti, he, pe, sto, ag, ao, dea, den, re, stap	22
Unknown	EM, TU, ES, WR ww, sh, ste, tr, ts	9
Race of Students		
Black	MA, EM, GO, LE, TU, TE, BA, BR, GR staa, mc, sti, cd, mf, ad, dea, tr, ts	18
Latinx*	GU, EM, GO, BA, BR staa, mf, pe, ag, ad, dea, tr, ts	13
Asian or Asian American	BR, ES staa, ag, ad	5
Native American	mf	1
White	BA, ES mc, pa, sti, mf, sta	7
Diverse (Unspecified)	WR ao, den, re	4
Unknown	VR mu, ww, sh, he, sto, ste	7

Key to Abbreviations					
GU	Gutstein**	staa	Staats***	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**I use Latinx to refer, generally, to groups of people with cultural ties Latin America, regardless of race. I chose Latinx over Latino/a in order to problematize the gender binary.*
***All caps indicate that article is a primary data source.*
****All lowercase indicates that article or chapter is a supporting data source.*

Table 2.2

My analysis produced three major findings. First, explicitly attending to race and racism in TMSJ enactments provided opportunities for centering people of Colors' voices and experiences in various mathematics classroom contexts. Second, explicitly attending to race and racism alone, however, was insufficient for addressing racially based inequities and injustices. Critiques of liberalism provided students opportunities to construct counterstories that challenged mainstream claims of objectivity and neutrality, such as meritocracy, fairness, and colorblind policies that camouflage subtle forms of racism. Third, TMSJ had the potential to support substantial and authentic mathematical work and practices, but this mathematical work did not necessarily connect to the dominant mathematics curriculum.

Finding 1: Explicitly attending to race and racism in TMSJ enactments provided opportunities for centering people of Colors' voices and experiences in various mathematics classroom contexts.

Approximately two thirds of analyzed reports presented evidence that TMSJ enactments explicitly attended to race or racism (Table 2.3: 3.1). In sixteen studies, including both teachers of Color and white teachers, TMSJ lessons topics focused on race/racism (Table 2.4: 2.2.1), and race/racism was a central focus in twelve of those lessons (Table 2.3: 3.). Teachers centered race/racism in TMSJ enactments alongside a variety of other social justice topics (Table 2.3: 3.1.5, Table 2.4: 2.2). For example, students considered how systematic racism might influence (their own) educational opportunities and outcomes by examining standardized test scores by race (Gutstein, 2003), comparing teacher quality in schools located in communities with different SES and racial demographics (Enyedy & Mukhopadhyay, 2007), and examining disciplinary data for evidence of racial profiling by school administrators and teachers (Aguirre, Mayfield-

Ingram, & Martin, 2013). By looking for patterns across cross-case data displays, I identified three subfindings.

Table 2.3

Findings from analysis of explicit attention to race/racism in TMSJ enactments.

3 Attention to race and racism		
3.1 Explicitly acknowledged race or racism in TMSJ enactments		**20**
3.1.1 Teacher initiates or sustains discussion of race/racism	GU, EM, LE, TE, BR, GR (*see key below*) cd, mf, pe, ao, den	11
3.1.2 Students initiate or sustain discussion of race/racism	GU, EM, TU, TE, BA cd, mf, ag, ao, ts	10
3.1.3 Race/racism was the central social justice topic	GU, EM, LE, TE sti, cd, mf, pe, ag, ao, den, re	12
3.1.4 Race/racism peripheral to math or other social justice topic(s)	TU, BA, BR, GR mc, sti, pe, sto, tr, ts	10
3.1.5 Race/racism considered alongside other social justice topic(s) (i.e., intersectionality)	GU, EM, LE, TU, BR mf, pe, sto, ag, den, re, ts	12
3.2 Race or racism not acknowledge explicitly in TMSJ enactments		**16**
3.2.1 Intentional avoidance of discussions about race/ racism	BA	1
3.2.2 Influence of race or racism implied	GO, ES mu	3
3.2.3 No evidence of implied attention to race/racism nor intentional avoidance	MA, VR, WR staa, ww, sh, pa, he, ad, dea, stap, ste	12

Key to Abbreviations

GU	Gutstein*	staa	Staats**	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**All caps indicate that article is a primary data source.*
***All lowercase indicates that article or chapter is a supporting data source.*

Table 2.3

Table 2.4

Findings from analysis of social justice topics in TMSJ enactments.

2 TMSJ lesson or project topics		
2.2 Central social justice topics(s)		
2.2.1 Racism or racial profiling	GU, EM, LE, TE, BR, GR (*see key below)* sti, cd, mf, pe, ag, ao, den, re, tr, ts	16
2.2.2 Education	GU, EM, GO, TE, BA, BR mc, ag, ao, re, tr, ts	12
2.2.3 Inequality (e.g., wealth, power)	GU, EM, BR, ES, VR, WR mc, mu, ww, sh, cd, mf, pe, ad, re, stap	16
2.2.4 Local issues	GU, MA, EM, TU, ES he, re, ts	8
2.2.5 Economics or consumerism	GU, MA, LE, WR staa, pa, ste	7
2.2.6 Labor issues	WR sti, pe, dea, re, ste	6
2.2.7 Women's issues	MA mf, st, den	4
2.2.8 Health; food/water access	LE, VR staa, ww, tr	5
2.2.9 Incarceration	TE, BA	2
2.2.10 Government issues	WR sh, pe, den	4
2.2.11 Immigration	LE, WR tr	3

Key to Abbreviations

GU	Gutstein*	staa	Staats**	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**All caps indicate that article is a primary data source.*

***All lowercase indicates that article or chapter is a supporting data source.*

Table 2.4

Finding 1.1: Many teachers recognized racism as an issue relevant to *all* students' lives. Teachers' cited their primary motivations for TMSJ as developing students' critical consciousness using mathematics, connecting mathematics to relevant issues in students' lives, fostering students' sense of mathematical agency, and helping students use mathematics as a tool for social transformation (Table 2.5: 4.1). The frequency with which teachers selected social justice topics to center race/racism in contexts with predominantly students of Color and predominantly white students (Table 2.2: race of students; Table 2.4: 2.2.1) considered alongside teachers' motivations for TMSJ (Table 2.5: 4.1) suggests that teachers viewed race/racism as relevant in *all* students' lives and recognized an understanding of racism as important to developing critical consciousness. For example, Allman and Opevo (2013), who worked with a diverse group of students of Color, explained, "It is our hope that using data and research to discuss these relevant and meaningful issues [systematic racism and educational opportunities] helped convince them of the power of mathematics to not only measure what was happening to people like themselves, but also to be a tool to help them ask and answer the questions behind their stories as well" (p. 144). This quote captures how the teachers viewed TMSJ as a way for students of Color to use mathematics to understand, critically and deeply, the educational inequities impacting their lives.

Table 2.5

Findings from analysis of teachers' motivation for TMSJ and of student support/resistance.

4 Interest Convergence		
4.1 Teacher's stated motivation for TMSJ		
4.1.1 Make math meaningful, relevant, or more interesting to students (and teacher)	GU, EM, ES, WR sh, pa, sti, mf, pe, st, ag, ao, dea, den, stap, tr, ts	17
4.1.2 Student agency, ownership of, or positive relationship with math	GU, BA, VR, WR staa, mu, pa, sti, cd, pe, tr	11
4.1.3 Develop critical consciousness using math	GU, TU, TE, BA, BR, GR, VR mc, mu, sh, pa, he, cd, mf, ad, de, stap, ste	18

(Table 2.5, cont'd)

4.1.4 Help students use math as a tool for social action or change; agency or ownership of social issues	GU, GO, TE, BA, BR, BR, ES, VR, WR cd, pe, dea	12
4.1.5 Increase math achievement and academic opportunities	BA, GR, ES ad, dea, re	6
4.5 Students of Color resisted TMSJ enactments	GU, TU, BA, BR, WR sti, tr	7
4.5 Students of Color supported TMSJ enactments	GU, LE, TU, TE, GR, WR staa, mf, pe, ag, ad, re, ts	13
4.5 & 4.6 Not applicable because either no students of Color or race of students unknown	VR mu, ww, sh, pa, he, sto, stap, ste	9

Key to Abbreviations

GU	Gutstein*	staa	Staats**	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**All caps indicate that article is a primary data source.*
***All lowercase indicates that article or chapter is a supporting data source.*

Table 2.5

Teachers working with white students also recognized the relevance of racism to their students' lives. For example, Birdwell shared, "I decided on the topic of racial profiling – a topic in which I felt the majority White students had little exposure but one that could possibly have an effect on their lives" (Stinson et al., 2012, p. 83). Although Birdwell did not elaborate further on what she meant by racial profiling possibly affecting white students' lives, she expressed a desire for students to consider the possibility of racial profiling in their own local community and how racism might impact the lives of local people of Color. This suggests that Birdwell aimed to make the lesson relevant by focusing on the local community, while at the same time developing white students' critical race consciousness.

Finding 1.2: Teachers and students took up opportunities to center people of Colors' voices and experiences to varying degrees. Naturally, teachers and/or students discussed race or racism explicitly in those TMSJ enactments that centered race/racism as a topic (Table 2.3: 3.1), and in four cases, students (Bartell, 2013; Turner et al., 2009) or the teacher (McCoy, 2008; Stocker, 2012) introduced explicit considerations of race/racism, even though race/racism was not central to the social justice topic (Table 2.3: 3.1.1-2, Table 2.4: 2.2.1). Across the twenty reports which described teachers and/or students discussing race/racism explicitly, the extent to which teachers and students took up opportunities to center people of Colors' voices and experiences varied.

In most cases when race was discussed, both teachers and student engaged in conversations about race/racism (Table 2.3: 3.1.1-2; Allman & Opeyo, 2013; Chao & Jones, 2016; Enyedy & Mukhopadhyay, 2007; Gutstein, 2003; Keith McNeil & Fairley, 2016; Terry, 2010), but in a few cases (Brantlinger, 2013; Denny, 2013; Gregson, 2013; Leonard et al., 2009; Peterson, 2012) no evidence suggested that students took up teachers' efforts to highlight race/racism during the social justice investigations (Table 2.3: 3.1.1-2). In one of these cases, students of Color resisted their White teachers' efforts to center race in the mathematics classroom (Brantlinger, 2013), but in other cases, reports suggested that students supported TMSJ even in they did not take up conversations about race/racism (Table 2.5: 4.6; Table 2.3: 3.1.1-2; Gregson, 201; Leonard et al., 2009; Peterson, 2012).

In some cases when students took up conversations about race, evidence suggested TMSJ enactments still met resistance in the form of "ambivalence and equivocation" (Gutstein, 2003, p. 53; Table 2.3: 3.1.2; Table 2.5: 4.5). For example, Bidwell noted, "Surprisingly, one of the few African American students in the class was resistant to the [social justice] topic altogether" (Stinson et al., 1983, p. 83). Resistance often took the form of questions such as, "Where's the math?" and "Why are we talking about race in math class?" (e.g., Brantlinger, 2013; Trexler, 2013). Wright's (2016) group of teacher researchers noticed, "the highest attaining students showed the least enthusiasm towards [TMSJ, even when race was not a consideration], perhaps because they associated their own relative success with conventional teaching approaches" (p. 113).

Four cases provided evidence that the students themselves focused on race/racism in relation to the social justice topic without direct prompting from the teacher (Table 2.3: 3.1.1-2 ; Aguirre et al., 2013; Bartell, 2013; Turner & Font Strawhun, 2013; Turner et al., 2009). For example, when school administrators allocated space to a predominantly white magnet school instead of to her predominately Black and Latinx school with severe overcrowding, Front Strawhum enacted a lesson focused on collecting mathematical evidence of overcrowding to present to the school board. During their investigation, the students raised questions about whether racism played a role in the school board's decision to allocate space to the magnet school. Students suggested those in power protected the interests of white students because of a shared racial identity (Turner & Font Strawhun, 2013). Although students rarely introduced the focus on race/racism, this example is typical of other such examples. In all four cases, the students who raised race/racism were students of Color and were drawing on their lived experiences to interpret the social justice issue.

The frequency with which students participated in conversations (10 of 20; Table 2.3: 3.1.2) about race suggested that a sizable number of teachers normalized "courageous" conversations about politically taboo topics such as racism, to some extent. For example, McCoy (2008) emphasized the importance of "a respectful and objective environment" in welcoming students' personal insights and experiences (p. 457). Nevertheless, evidence that race/racism played only a peripheral role in TMSJ enactments when race/racism was central to the social justice topic suggests some reluctance to focus on race/racism in mathematics classrooms (Table 2.3: 3.1.4; Table 2.4: 2.2.1; e.g., Brantlinger, 2013; Gregson, 2013; Peterson, 2012; Stinson et al., 2012; Trexler, 2013; Turner & Strawhun, 2013). The focus on race/racism moved to the periphery when students resisted (e.g., Brantlinger, 2013; Trexler, 2013) or when teachers did not take up the focus on race/racism (e.g., Bartell, 2013, Turner, et al., 2009).

Finding 1.3: About a third of studies provided no evidence of explicit attention to race/racism during TMSJ enactments, but evidence of intentional avoidance of race/racism was rare. Twelve descriptions of TMSJ enactments provided no evidence suggesting that race or racism received any attention during lesson enactments (Table 2.3: 3.2.3). This lack of evidence does not necessarily mean that teachers and students did not discuss racism because there was limited information in some articles/chapters (e.g., Staats, 2007; Staples, 2013). Moreover, I do not mean to suggest that all teachers and students *should* have discussed racism in all TMSJ enactments. For example, topics such as sexism (e.g., Stocker, 2012) or environmental issues (e.g., Hendrickson, 2015) logically focus on other forms of inequity and injustice. In other cases, however, evidence suggested that explicit considerations of racism could deepen students' understanding of inequities or injustices. For example, Esmonde (2014) described a teacher's enactment of TMSJ in which students discussed colonialism but never explicitly discussed "why some regions got richer when they were taken over [e.g., North America] whereas others got poorer" (p. 362). The notable absence of this discussion allowed both the white teacher and her white students to ignore important considerations such as racism and genocide (based on Esmonde's analysis of classroom transcripts). Classrooms that included students of Color also lacked explicit acknowledgment of race/racism. For example, Staats (2007) described her own TMSJ practices, noting how "class diversity was a significant resource for discussions on the impact of infectious diseases" (p. 6); however, she did not provide evidence that class diversity contributed an *explicit* connection between racism and underdevelopment/infectious disease.

Bartell (2013) provided the only evidence that white teachers intentionally avoided issues of race and racism inherent in the social justice topics chosen for their lessons during both planning and enactments (Table 2.3: 3.2.1). During a graduate course on learning to teach mathematics for social justice, two groups of teachers provided different reasons for avoiding conversations about racism. One group of teachers explicitly considered the relevance of race and racism to their chosen social justice topic during lesson planning but decided to avoid conversations about race explicitly during the enactment because the ideas could not be explored deeply enough in the time allocated for the lesson. The second group of teachers, however, never explicitly considered connections between their social justice topic and racism. This avoidance of racism was particularly noteworthy because the later group of teachers refused to acknowledge racism, even when students made explicit comments, during class discussions and in written reflections, linking racism to their mathematical analysis of the social justice issue. Instead, the white teachers redirected the students of Color's focus, promoting the teachers' own interpretation of the issue (related to classism), giving no attention to racism.

Finding 2: Critiques of liberalism provided opportunities to challenge mainstream liberal claims.

In analyzing each article/chapter, I considered evidence that TMSJ enactments offered opportunities to critique liberalism, which would involve challenging mainstream claims of objectivity and neutrality, such as meritocracy, fairness, and colorblind policies that camouflage subtle forms of racism and perpetuate stereotypes and deficit perspectives of people of Color. These critiques are necessary for constructing counterstories. Most cases of TMSJ presented evidence to suggest that teachers and students critiqued liberal perspectives (Table 2.6). Two sub-findings further illustrate how teachers and students did or did not take advantage of opportunities to critique liberalism in order to construct counterstories.

Table 2.6

Findings from analysis of critiques of liberalism in TMSJ enactments

3 Attention to race and racism		
3.4 Critique of liberalism present in TMSJ enactment		
3.4.1 Challenged meritocracy or individualism	**GU***, **LE**, **BA**, **BR** (*see key below*) **mc**, **ao**, dea, ste	8
3.4.2 Challenged colorblindness, neutrality, or objectivity	**GU**, **TU**, **TE**, **BR**, **GR** **cd, mf, pe**, **sto**, **ag**, ad, **ao**, dea, **den**, **re**, ste, **tr**, **ts**	18
3.4.3 Teacher challenged liberalism	**GU**, **EM**, **LE**, **TU**, **BA**, **BR**, **GR**, WR **mc**, sh, **cd**, **mf, sto**, ad, **ao**, dea, **den**, ste	18
3.4.4 Students challenged liberalism	**GU**, **EM**, **TU**, **TE** staa, **mc**, sh, **sti**, **cd**, **mf**, **pe**, **sto**, **ag**, dea, **re**, **ts**	16
3.4.5 Counterstory connected explicitly to math evidence	**GU**, **EM**, **LE**, **TU**, **TE** staa, mu, **sti**, **mf**, **pe**, **sto**, **ag**, dea, **re**	14
3.5 Critique of liberalism not present in TMSJ enactment		
3.5.1 Teacher expressed liberal views	EM, GO, **BA**	3
3.5.2 Students expressed liberal views and/or resisted teacher's critique of liberalism	**GU**, **LE**, **BR**, ES staa, sh, **sti**, **ao**, sta	9
3.5.3 Insufficient time for critique of liberalism	**GR** staa, **sti**	3
3.5.4 Teaching goals did not include critique of liberalism	MA, **GR**, VR ww, pa, **sti**, he	7
3.5.5 Math evidence used to support liberal claims	ES staa, **sti**	3

(Table 2.6, cont'd)

Key to Abbreviations					
GU	Gutstein**	staa	Staats***	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**Bold indicates that explicit attention to race/racism in TMSJ enactment.*
***All caps indicate that article is a primary data source.*
****All lowercase indicates that article or chapter is a supporting data source.*

Table 2.6

Finding 2.1: Critiques of liberalism arose across a variety of social justice issues in TMSJ enactments, especially in those enactments that explicitly addressed racism. Analysis of TMSJ enactments revealed a variety of ways that teachers and students critiqued liberalism related to diverse social justice topics (Table 2.6: 3.4; Table 2.4: 2.2). For example, teachers and students challenged the notion that hard work lead to wealth (i.e., meritocracy) (Gutstein, 2003), and teachers drew attention to how people in power have historically made voting more difficult for Blacks and Latinxs (Denny, 2013). All of the TMSJ enactments with explicit attention to racism (highlighted in bold in Table 2.6) also offered critiques of liberalism, but some enactments that did not explicitly address racism also provided opportunities to critique liberalism (e.g., Dean, 2013; Murphy, 2009; Wright, 2016) For example, Steele (2013) challenged his students' assumptions that jobs are solely the result of personal choice and that labor unions are always an option for employee resistance to poor working conditions or low wages. At times the push to question assumptions came from teachers (e.g., Allman & Opeyo, 2013; Gregson, 2013; Peterson, 2012; Steele, 2013; Stocker, 2012); however, in some cases, students challenged each other (and their teachers) to critique taken-for-granted assumptions (e.g., Aguirre et al., 2013, Bartell, 2013; Renner et al., 2013).

Finding 2.2: A number of reasons explained why critiques of liberalism were absent in some TMSJ enactments. Many reasons help to explain why some teachers and students did not critique liberalism during TMSJ enactments. In some cases, teachers did not prioritize challenging school and societal structures (e.g., Matthews, 2003; Stinson et al., 2012; Table 2.6: 3.5.4). Other teachers, both white teachers and teachers of Color, held liberal views, particularly beliefs about academic effort and achievement as a means of individual future success (e.g., Bartell, 2013; Gonzalez, 2009; Table 2.6: 3.5.1). In other instances, allocated time for TMSJ enactments was insufficient to discuss different interpretations of data (e.g., Staats, 2007; Table 2.6: 3.5.3). A final reason stemmed from students' resistance to alternative interpretations of data and conclusions about social justice issues, as evidenced by students' liberal statements (e.g., Brantlinger, 2013; Esmonde, 2014; Staples, 2013; Table 2.6: 3.5.2).

Finding 3: Most TMSJ enactments created opportunities for substantial and authentic mathematical work.

Most accounts of TMSJ enactments provided evidence to suggest that students engaged in deep/substantial and authentic mathematical analysis of social justice issues. By deep/substantial, I mean that students did significant mathematical work that went beyond a few straightforward procedural calculations or that students learned new mathematical content through the lesson enactment (Table 2.7: 4.2.1.1). By authentic, I mean that students engaged in mathematical practices identified as central to the discipline of mathematics (e.g. Standards for Mathematical Practice, National Governors Association, 2010; Table 2.7: 4.2.1.2). In fact, only four reports suggested students engaged exclusively in straightforward procedural work or with previously learned mathematical content (Bartell, 2013; Esmonde, 2014; Gonzalez, 2009; Trexler, 2013; Table 2.7: 4.2.1-3). Four sub-findings further elaborate on the mathematical work involved in TMSJ enactments.

Table 2.7

Findings from analysis of mathematics work and student input in TMSJ enactments.

<table>
<tr><th colspan="4">4 Interest Convergence</th></tr>
<tr><td colspan="3">4.2 Cognitive demand of mathematics work</td><td></td></tr>
<tr><td rowspan="2">4.2.1 Higher-order thinking and problem solving</td><td>4.2.1.1 Learned new math content</td><td>GU, EM, TU, BR, GR
staa, sti, he, pe, sto, ad, ao, dea, den, re, stap, ste, ts</td><td>18</td></tr>
<tr><td>4.2.1.2 Used authentic math practices</td><td>GU, MA, EM, LE, TU, TE, VR
staa, mc, mu, sti, he, cd, mf, pe, sto, ag, ad, ao, dea, re, ts</td><td>22</td></tr>
<tr><td rowspan="2">4.2.2 Lower-order thinking</td><td>4.2.2.1 Mostly procedural calculations</td><td>MA, GO, VR</td><td>3</td></tr>
<tr><td>4.2.2.2 Review of previously-learned material</td><td>BA, BR, ES
tr</td><td>4</td></tr>
<tr><td>4.2.3 Students struggled with math work</td><td colspan="2">GU, LE, TU
he, pe, sto, ad, ao, ts</td><td>9</td></tr>
<tr><td colspan="3">4.3 Alignment of content to dominant curriculum</td><td></td></tr>
<tr><td colspan="2">4.3.1 Content was grade-level appropriate</td><td>GU, GO, BA, BR, ES, VR, WR
staa, mu, ww, sti, he, cd, mf, pe, sto, ag, ad, ao, dea, den, re, stap, ste, tr, ts</td><td>26</td></tr>
<tr><td colspan="2">4.3.2 Content was advanced for grade-level</td><td>GU, TU
ste, ts</td><td>4</td></tr>
<tr><td colspan="2">4.3.3 Content was remedial for grade-level or not included in dominant curriculum at all</td><td>MA, GO, LE, BR, WR</td><td>5</td></tr>
<tr><td colspan="2">4.3.4 Teacher purposefully selected math content</td><td>GU, MA, EM, GO, LE, BA, BR, GR, ES, VR
staa, mc, mu, sh, pa, sti, cd, mf, pe, sto, ag, ad, ao, dea, den, re, stap, ste, tr</td><td>29</td></tr>
<tr><td colspan="2">4.3.5 Teacher allowed math content to arise naturally from social justice questions</td><td>GU, TU, TE
he, sto, ag, ad, den, ts</td><td>9</td></tr>
</table>

(Table 2.7, cont'd)

5 Unique Voice of Color		
5.1 Students raised social justice questions for TMSJ enactments		
5.1.1 Prior to enactment	TU, TE **he*,** ag	4
5.1.2 During enactment	GU, TU, TE **ww, he,** cd, dea, den, ts	9
5.2 Teachers chose social justice questions or topic for TMSJ enactments		
5.2.1 Teacher solicited student input on topic choice prior to enactment or teacher based topic choice on knowledge of students	GU, BA, **VR** **pa**, pe, ad, ao, tr, ts	9
5.2.2 Teacher solicited student input and interpretations during enactment	GU, MA, EM, BR, GR, ES staa, **sh,** sti, cd, mf, pe, **sto,** ad, ao, dea, den, re, tr	19
5.2.3 No evidence that teacher solicited student input	GO, LE, WR mc, **stap**, **ste**	6
5.3 Student took action steps		
5.3.1 Communicated to an authentic audience	GO, TU, TE, **VR** **ww,** mf, **sto**, ag, dea, ts	10
5.3.2 Joined existing social activism	TU, **VR** Ww**, pe,** sto	5

Key to Abbreviations

GU	Gutstein**	staa	Staats***	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**Bold indicates that either there were no students of Color or races of students were unknown. I included these studies in the analysis of student voice, even though it is unclear whether or not the student voice involved students of Color.*
***All caps indicate that article is a primary data source.*
****All lowercase indicates that article or chapter is a supporting data source.*

Table 2.7

Finding 3.1: The mathematics needed to investigate social justice issues often required challenging mathematical work. For the most part, teachers selected social justice topics, and solicited some input from students (Table 2.7: 5.2.1-2). Selecting social justice topics in advance allowed most teachers to tailor TMSJ enactments to fit grade-level appropriate mathematics content (Table 2.7: 4.3.1, 4.3.4). In nine cases, however, teachers allowed the mathematics needed to investigate social justice issues to naturally arise from students' questions (Table 2.7: 4.3.5; 5.1; 5.2.2). For example, students of Color developed their own social justice questions, collected data, and engaged in quantitative analysis, involving sustainable mathematics (e.g., Terry, 2010). In such cases, the teacher did not choose specific mathematical content for the TMSJ lesson in advance. Instead, the teacher provided instruction on mathematical content that seemed most appropriate for addressing students' questions as the need for the mathematics emerged.

When the mathematics naturally arose from students' questions, students often struggled to use mathematics to investigate the social justice issues (Table 2.7: 4.3.5 & 4.2.3). Sometimes students struggled because the mathematical content was advanced, meaning that mathematical work involved content typically found at a higher grade level than the students' current grade level (Gutstein, 2003; Turner & Font Strawhun, 2013; Turner et al., 2009; Table 2.7: 4.3.4 & 4.3.5). For example, Turner and colleagues (2009) found that third through sixth graders struggled with the mathematical content that naturally arose from their questions. The mathematical work involved finding areas of irregular shapes and using different scales to represent the same object. The teachers stepped away from the social justice investigation at hand to explore the necessary mathematical topics in more depth. Nevertheless, some students "remained unconvinced that a larger to-scale drawing did not mean a larger park" (p. 147), illustrating how students struggled with advanced mathematical concepts and procedures, even when instructional time was dedicated to these mathematical topics. In other cases, the mathematics was grade-level appropriate, but the application of the mathematics to the issue at hand proved challenging (Aguirre & Del Rosario Zavala, 2013; Allman & Opeyo, 2013; Hendrickson, 2015; Leonard et al., 2009; Peterson, 2012; Stocker, 2012; Table 2.7: 4.2.3 & 4.3.1 or 4.3.3). For example, Hendrickson (2015) described how students' exploration of "fracking" required ongoing revisions of their questions and how they struggled to connect their research findings to mathematical evidence.

Finding 3.2: A practical need to understand and use mathematics helped students navigate advanced and substantial mathematical work. Communicating findings from mathematical analyses of social justice issues to an authentic audience held potential to bolster the meaningfulness of TMSJ enactments and necessitate that students deeply understand the advanced and challenging mathematics they would use to support claims (e.g., Turner & Font Strawhun, 2013; Voss & Richards, 2016; Table 2.7: 5.3). One example of students communicating mathematical interpretations of social justice issues to authentic audiences came from the Black and Latinx school in New York City described previously (Turner & Font Strawhun, 2013). The mathematical work required advanced concepts and procedures (e.g., proportional reasoning, area and volume measurement), but because students wrote letters, including fact sheets, to the school district and spoke at a school board meeting, they persisted in the face of challenging, substantial mathematical work. As a result of students' mathematical evidence-based arguments about overcrowding, the school board abandoned plans to increase the student body population in the upcoming school year (Turner & Font Strawhun, 2013). Effecting real change necessitated that mathematical analyses be appropriate for analyzing the social justice issue, that mathematical evidence be accurate, and that students' mathematical understanding be deep enough to be effectively communicated.

Finding 3.3: TMSJ enactments took considerable time, but teachers found ways to manage time constraints. TMSJ enactments, which involved substantial mathematical work, data collection and analysis, or taking action towards effecting change, generally took considerable time (e.g., 2 weeks, Keith McNeil & Fairley, 2016; 10 weeks, Voss & Richards, 2016). About half of TMSJ enactments took place in alternative classroom spaces (e.g., afterschool programs, alternative schools; Aguirre & del Rosario Zavala, 2013; Leonard et al., 2009; Pais et al., 2012; Terry, 2010; Turner et al., 2009; Table 2.2), where time constraints were less demanding. Teachers, particularly those in traditional public schools, responded to time constraints in a variety of ways.

Table 2.8

Findings from analysis of teachers' negotiation of tensions in TMSJ.

4 Interest Convergence		
4.4 Teacher's negotiation of tensions		
4.4.1 Sacrificed math accuracy or higher-order thinking to make work more feasible	GU, TU	2
4.4.2 Made superficial connections between math and social justice issue	GU, MA, EM, GO, LE, TU, BA, BR, ES staa, sti,	11
4.4.3 Used previously collected data	EM, GR, VR staa, mc, sh, sti, he, pe, sto, de	11
4.4.4 Connected to relevant and familiar community issues or other content areas/classes	GU, MA, EM, TU, TE, GR mu, ww, sti, he, cd, mf, pe, ao, re	15
4.4.5 Other ways	WR	1
Key to Abbreviations		

GU	Gutstein*	staa	Staats**	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.

(Table 2.8, cont'd)

BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

**All caps indicate that article is a primary data source.*
****All lowercase indicates that article or chapter is a supporting data source.*

Table 2.8

In a case when the mathematical work proved challenging for students, one group of teachers sacrificed some mathematical accuracy (e.g., irregular dimensions of a park, Turner et al., 2009; Table 2.8: 4.4.1). In another example, the teacher (Gustein, 2003) compromised by changing his mathematics teaching approach. In mathematics lessons, outside of TMSJ projects, he preferred students to explore mathematical conceptions without direct instruction. Gutstein found himself directing students through procedures more often in TMSJ enactments because of the complexity of both the mathematics and the social issue. Other teachers, both white teachers and teachers of Color, emphasized only superficial connections between mathematics and social justice issues (e.g., talking about mathematicians of Color; Gonzalez, 2009; dividing the focus on mathematics and social justice; Bartell, 2013; Brantlinger, 2013; Table 2.8: 4.4.2). For example, Brantlinger (2013) described how he separated mathematical and critical components of TMSJ projects to help students negotiate the complexities, but he "observed no powerful synthesizing moment in which students reached a deeper and more critical understanding of social reality through 'doing the mathematics' " (p. 1070).

Some teachers, however, found other ways to manage time constraints, while still effectively allowing for mathematical and social justice connections. Ideally, authentic social justice investigations may necessitate students collect their own data, but teachers managed time constraints by drawing from social issues in which mathematics was already a part of the debate and by using previously collected data (e.g., Denny, 2013; Enyedy & Mukhopadhyay, 2007; Gregson, 2013; McCoy, 2008; Shibli, 2011; Table 2.8: 4.4.3). Supporting students in social activism can also take considerable time and effort, but teachers navigated this challenge by connecting to previously existing social activism efforts (e.g., Peterson, 2012; Stocker, 2012) or by taking small, feasible steps towards change, such as writing advocacy letters (e.g., Aguirre et al., 2013; Turner & Font Strawhun, 2013).

Another effective strategy used by teachers to navigate time constraints involved connecting to ongoing conversations about social justice topics across disciplines (Table 2.5.4.4). At the elementary school level, integrating mathematics and social studies, history, or English Language Arts lessons provided one way of leveraging more time for deeply considering social justice issues (e.g., Chao & Jones, 2016; Murphy, 2009; Peterson, 2012; Walker & Waldron, 2009). At the middle school level, Gregson (2013) reported on how the teacher collaborated with teachers in other disciplines so that students could write advocacy letters as part of their English Language Arts class. Collaborations also existed at the high school level. For example, collaboration between a statistics teacher and an algebra teacher provided opportunities for ninth graders to learn from seniors. Statistics students (seniors) provided more one-on-one support for algebra students (ninth graders) in making sense of advanced mathematics and also in challenging liberal assumptions (Renner et al., 2013). In addition, McNeil & Fairley (2016) provided an example of an interdisciplinary literature and mathematics project at the high school level.

Finding 3.4: TMSJ enactments do not necessarily relate to the grade-level appropriate dominant mathematics curriculum, particularly at the secondary level.

Statistics and proportional reasoning served as the most common mathematical topics in TMSJ enactments (Table 2.9). In some cases, this mathematical focus deepened students' understanding of mathematical concepts and procedures included in the grade-level appropriate mathematics curriculum (Table 2.9 & Table 2.7: 4.3.1). For example, Aguirre and del Rosario Zavala (2013) described how pushing students to justify their claims about fairness mathematically helped students who were struggling with transitioning from additive to multiplicative reasoning, which is essential in algebra. Nonetheless, evidence suggested that integrating TMSJ lessons with the secondary mathematics curriculum proved more challenging than at the elementary or middle school levels. At the elementary and middle school levels, the dominant mathematics curriculum already includes statistics and proportional reasoning (e.g. Aguirre et al., 2013; Dean, 2013; Denny, 2013; Gregson, 2013), allowing teachers to link TMSJ enactments more easily to required grade-level-specific mathematical topics. Several high school TMSJ enactments reviewed previously learned mathematical content, focusing on integration of these topics with the social justice investigate, rather than introducing new topics relevant to the grade-level appropriate mathematics curriculum (e.g., Bartell, 2013; Gonzalez, 2009; Esmonde, 2014; Table 2.7: 4.2.2.2 & 4.3.3). The application of previously learned material can offer opportunities for engaging in important mathematical practices, such as modeling. Some teachers (but none from the primary data sources) also linked topics from the secondary curriculum, such as linear and exponential relationships (e.g., McNeil & Fairley, 2016; Trexler, 2013), to social justice issues. In addition, social justice connections were relevant to the secondary curriculum in statistics courses (e.g., Renner et al., 2013; Stinson et al., 2012). Secondary teachers noted that mathematics topics, such as geometry and calculus, however, were more difficult to connect to social justice issues (Brantlinger, 2013; Stocker, 2012), and secondary mathematics topics received less attention in TMSJ enactments (Table 2.9).

Table 2.9

Findings from analysis of mathematics topics from TMSJ enactments

2 TMSJ Lesson or Project Topics		
2.1 Central mathematics topic(s)		
2.1.1 Statistics or data analysis	GU, EM, GO, LE, TU, TE, BA, BR, GR, VR mc, ww, sh, pa, sti, he, pe, sto, ag, ao, den, re, ste, tr	24
2.1.2 Proportional reasoning	GU, GO, TU, BA, ES, VR ww, he, pe, ag, ad, de, tr, ts	14
2.1.3 Geometry or measurement	MA, TU, BR, ES ww, cd, pe, sto, ts	9
2.1.4 Number sense or computation	MA, VR mc, mu, he, cd, pe	7
2.1.5 Linear relationships	mc, sti, mf, ao, dea, re, tre	7
2.1.6 Exponential relationships	staa, sti, mf	3
2.1.7 Calculus	stap	1

Key to Abbreviations					
GU	Gutstein*	staa	Staats**	pe	Peterson
MA	Matthews	mc	McCoy	sto	Stocker
EM	Enyedy & Mukhopadhyay	mu	Murphy	ag	Aguirre et al.
		ww	Walker & Waldron	ad	Aguirre & del Rosario Zavala
GO	Gonzalez	sh	Shibli	ao	Allman & Opeyo
LE	Leonard et al.	pa	Pais et al. (2012)	dea	Dean
TU	Turner et al.	sti	Stinson et al.	den	Denny
TE	Terry	he	Hendrickson	re	Renner et al.
BA	Bartell	cd	Chao & DeAndrea	stap	Staples
BR	Brantlinger	mf	McNeil & Fairley	ste	Steele
GR	Gregson			tr	Trexler
ES	Esmonde			ts	Turner & Strawhun
VR	Voss & Richards				
WR	Wright				

***All caps indicate that article is a primary data source.*
****All lowercase indicates that article or chapter is a supporting data source.*

Table 2.9

Discussion

The goal of this analysis was to reveal the possibilities for and limitations of TMSJ to challenge racially-based inequities and injustices in mathematics education. Findings shed light on how certain dilemmas arise in TMSJ enactments that teachers must address in order to prevent further marginalizing the unique voice of Color in mathematics. Other researchers have identified many of these same tensions (e.g., Bartell, 2013; Gregson, 2013; Gutstein, 2003), but the diverse contexts for TMSJ enactments considered in this analysis serve as an important source for making claims that extend beyond individual studies of TMSJ. I analyzed reports of TMSJ enactments across all grade levels (elementary through postsecondary), across a range of school contexts (public, private, and afterschool/summer), and with varying student demographics (white, Black, Latinx, and Asian/Asian American). By synthesizing across the literature on TMSJ in these diverse contexts, analysis allowed for findings that would not be possible in a single study of TMSJ enactments. In this section, I discuss findings that shed light on the promising practices for intentionally antiracist TMSJ enactments. In this discussion, I consider particular tensions that arose from the findings and reflect on the ways certain practices helped to manage those tensions.

Promising practice: Normalize conversations about race in mathematics classrooms, in general, so that TMSJ enactments can center the unique voice of Color

Findings suggest that TMSJ enactments, which explicitly attend to race and racism, can create opportunities for centering people of Colors' voices and experiences in mathematics classrooms (Finding 1). Such opportunities are important because the voices of people of Color are often marginalized in mathematics and mathematics education (Parks & Schmeichel, 2012; Stinson & Wager, 2012). Both white teachers and teachers of Color enacted TMSJ, which explicitly attended to race/racism, in a variety of classroom contexts. This suggests that teachers recognized the importance of developing *all* students' – white students' and students of Color's – critical race consciousness as part of broader social justice efforts (Finding 1.1). Moreover, the diversity of social justice topics linked explicitly to racism suggests that both white teachers and teachers of Color recognized the pervasiveness and ordinariness of racism. This recognition creates possibilities for centering the voice of people of Color in any mathematics classroom context and for doing so in ways that acknowledge people of Color's experiences. Centering people of Color's voices in mathematics classrooms with students of Color is important for helping students see themselves in mathematics, a discipline typically viewed in Eurocentric ways (Stinson & Wager, 2012). Highlighting the voice of people of Color in mathematics spaces may be one way of promoting students of Color's positive and productive mathematics learner identities (Berry III, 2008; Martin, 2000, 2009a). Although proponents of TMSJ often target urban classrooms for these reasons, students from privileged groups (e.g., white, high socioeconomic status) also benefit from the centering of voices of people of Color in TMSJ enactments. In general, white students have limited understanding of racism and minimal experiences with people of Color; therefore, TMSJ enactments, which explicitly center race or racism, provide important opportunities for white students to interrogate their own whiteness and develop the critical race consciousness necessary for contributing to anti-racist and social justice efforts (Kivel, 2002; Tatum, 1994).

Although some TMSJ enactments might justifiably center issues other than racism, avoiding naming race in TMSJ enactments was problematic when race/racism was central to the chosen social justice issue but omitted nonetheless (Finding 1.3). Omission of race and racism in TMSJ enactments can be problematic across classroom contexts with white students and students of Color. The example from Esmonde (2014), which was discussed under Finding 1.3, highlights how avoiding discussions of racism, when examining racism clearly would have supported a deeper understanding of colonialism, further marginalizes the voices of people of Color. In predominantly white spaces, such as those described by Esmonde (2014), this marginalization is problematic because the unique voice of color is completely absent. Avoiding discussions of racism allows white teachers and white students to maintain and enact their dominant race ideologies (Picower, 2009).

Avoiding discussions of race or racism in classrooms with students of Color also raises serious concerns, particularly when white teachers decide to omit the focus on race (Finding 1.3; Bartell, 2013). In such cases the unique voice of color and the lived experiences of students of Color can be further marginalized, representing a *microagression.* Microagressions are *subtle* verbal and non-verbal, cumulative, racially-based insults or assaults (Ledesma & Solorzano, 2013). Students of Color commonly experience microagressions in mathematics classrooms because the dominant mathematics curriculum prioritizes Eurocentric (i.e. white) knowledge, values and perspectives. The competencies of students of Color are under-assessed and under-valued in mathematics (Martin, 2009a), and students of Color experience a cumulative assault on their ways of knowing just by engaging in the dominant mathematics curriculum (Kohli, 2009). When the white teachers devalue their students of Color's interpretation of the mathematical analysis in TMSJ enactments and prioritize their own interpretations, which omit racism, (Finding 1.3; Bartell, 2013), they add to the cumulative, subtle assaults, which students of Color in their mathematics classes experience (Bartell, 2013; Ledesma & Solorzano, 2013). Even though such examples of these types of microagressions were rare in this analysis, the risk of microagressions in TMSJ enactments is high because the process of teachers' critical race consciousness engagement and development is both complex and understudied (McDonough, 2009). Microaggressions against students of Color are likely underrepresented in TMSJ reports because so many studies rely on self-study by the teachers themselves.

The challenge of normalizing conversations about race in mathematics classrooms is evident in TMSJ enactments in which students resisted teachers' efforts to explicitly name racism. Students who did not actively resist did not necessarily engage in courageous conversations about race, even when teachers initiated such conversations (Finding 1.2). These findings are not surprising because classrooms, in general, rarely serve as places that welcome critical dialogue about race and racism (Allen, 2004). Moreover, mathematics teachers and students, even those with liberal political views, often fail to acknowledge the highly racialized nature of the teaching and learning of mathematics (Martin, 2009b; Picower, 2009). Findings suggest that engaging students in courageous conversations about race through TMSJ enactments is possible but perhaps *only* when discussions of such politically taboo topics have been normalized (Finding 1.2). Several examples exist (e.g. Gutstein, 2003; Turner & Font Strawhun, 2013; Trexler, 2013), in which students themselves felt comfortable initiating conversations about race in mathematics classrooms. These examples provide evidence that normalizing conversations about race is possible in mathematics classrooms, but the work to normalize discussions about race may largely take place outside of the TMSJ enactments themselves.

More research is needed to understand how teachers can learn to normalize conversations of race in order to minimize microagressions and effectively center the unique voice of Color during TMSJ enactments. This work would demand more research on teachers' evolving critical race consciousness as they move from teacher education programs to mathematics classrooms and also on students' developing critical race consciousness. Additional guidance for white teachers enacting TMSJ may be especially important, considering that students of Color did not necessarily view TMSJ as serving their best interests (Finding 1.2). Research also suggests that few people of Color accept or adopt critical pedagogy efforts, like TMSJ (Allen, 2004). This is problematic since "a plan for humanization that is led by whites will always be fraught with problems due to the limited consciousness of whites, even if the plans arise from those who are well meaning" (Allen, 2004, p. 124). Although students' motivations for resisting TMSJ remain unclear, how and why people of Color, in particular, resist TMSJ deserves further consideration. Centering the unique voice of Color in mathematics education means acknowledging and working to understand people of Color's support for and resistance of TMSJ.

Promising practice: Encourage considerations of intersectionality and critiques of liberalism in all TMSJ enactments

Some TMSJ enactments justifiably highlighted other social factors that play a role in inequities or injustices. For example, Stocker (2012) naturally centered issues of gender and sexism in a TMSJ enactment focused on domestic violence; however, he prompted students to consider data relating domestic violence to factors such as race and class. Attention to race, however small, created a space for students to value and consider the unique voice of color and to examine issues at the intersection of race, gender and class. Intersectionality is important for students to consider as their critical race consciousness evolves (Wing, 2003). In TMSJ enactments that centered social issues other than racism, however, Stocker's (2012) attention to intersectionality was unique, suggesting a need to better understand how teachers and students might acknowledge the complex nature of social justice issues during TMSJ enactments.

Inclusion of critiques of liberalism in TMSJ enactments offered another way of minimizing microagressions and actively challenging racism. Critiques of liberalism provided opportunities for students to construct counterstories to challenge mainstream claims of objectively and neutrality, which perpetuate racism (Finding 2). Examples in the findings section (Finding 2.1) highlight how critiques of liberalism were common in TMSJ enactments that explicitly addressed racism, and these examples provide some guidance for centering the voice of Color and minimizing microagressions. Critiques of liberalism in enactments that did not explicitly address racism (e.g., Dean, 2013; Steele, 2013) may provide important additional insights. These examples offer hope of minimizing microagressions, even when white teachers' critical race consciousness is limited or when discussing race remains taboo. Including critiques of liberalism could be important for helping students challenge dominant racial ideologies, even if teachers and students do not name racism explicitly during TMSJ enactment. In the example from Steele (2013) (Finding 2.1), students of Color might naturally extend counterstories to create their own alternative stories about employment opportunities that account for racism, as long as they do not feel disempowered or marginalized during the TMSJ enactment.

Not all TMSJ enactments analyzed in this study included a critique of liberalism, and a number of reasons explained why critiques of liberalism were omitted (Finding 2.2). Some of the reasons (e.g., teacher did not prioritize challenging school and societal structures; teachers held liberal views) are rooted in teachers' and students' unexamined assumptions. Research on teacher education shows how white prospective teachers often resist critiques of liberal perspectives and find ways to maintain their dominant race ideologies (Picower, 2009). Logically, we might expect white students to react similarly during TMSJ enactments, and the findings show evidence of white students' resistance to critiquing liberalism. For example, in an exploration of world wealth inequality the teacher related wealth and power, but students resisted this connection. As a result, discussions about debt reinforced (rather than challenged) judgments about people who accrue debt as morally inferior (Esmonde, 2014). White students' view of their own experiences as de facto "normal" resulted in mathematical interpretations that reinforced deficit perspectives of people of Color and people with low socioeconomic status (e.g., Esmonde, 2014; Staples, 2013). Although TMSJ enactments hold promise for centering the voice of Color in predominantly white spaces, the risk that white teachers and white students will maintain racial stereotypes exists (Esmonde, 2014), making the critique of liberalism even more important.

Critiques of liberalism were also absent in TMSJ enactments with teachers and students of Color. Evidence suggesting students of Color (Brantlinger, 2013) and teachers of Color (Gonzalez, 2009) might offer similar resistance to critiquing liberalism may seem counterintuitive; however, internalized racism helps to explain why some students and teachers of Color also maintained and enacted dominant racial ideologies. Research illustrates how teachers and students of Color often hold assumptions and deficit views of their own racial group (Huber, 2010; Picower, 2012). For example, Latinx youth consciously or unconsciously internalized racist beliefs about Latinx undocumented immigrants (Huber, 2010). Both teachers and students of Color are susceptible to internalized racism. This offers an explanation of why teachers of Colors upheld beliefs of meritocracy, particularly in light of their own personal success through education, even when they critiqued the education available to their students of Color (Gonzalez, 2009). Moreover, Brantlinger (2013) found students of Color continually offered and defended "hegemonic explanations for social inequality" (p. 1073) in response to his efforts to name racism and challenge liberalism. Students of Color's resistance to critiquing liberalism and their dismissal of counterstories may be linked to internalized racism. Nonetheless, drawing conclusions from liberal assumptions and deficit perspectives of people of Color leaves students of Color powerless to change the circumstances of their own lives and to work towards a more socially just world (Gutstein, 2003). Once again, these findings demonstrate the need for better understanding critical race consciousness engagement and development for teachers of Color, white teachers, students of Color and white students through TMSJ enactments.

Promising practice: Allot sufficient time for doing substantial and authentic mathematical work, understanding complex social issues, and taking action towards change

The mathematical work necessarily to center voices of Color and critique liberalism was substantial and authentic (Finding 3). Examining inequalities through mathematics can emphasize that, “most often, personal situations are not unique and not the result of individual failure; rather they are due to the failure of our society to ensure equality and justice for all” (Frankenstein, 1990, p. 343). Only by engaging in substantial and authentic mathematical work (i.e., articulating assumptions, weighing evidence, etc.) can students come to question liberal assumptions and construct counterstories accounting for race, gender, and class exploitation (Gutstein, 2003). This finding is important because it suggests that the mathematical work and the social justice work must necessarily compliment each other in order to assuage certain challenges in TMSJ, such as balancing the focus on mathematical goals and social justice goals (Bartell, 2013) and developing students’ critical race consciousness (Brantlinger, 2013; Esmonde, 2014).

Guiding students to use mathematics to understand complex social issues presented challenges (Finding 3.1), and teachers made certain compromises when students struggled or when managing time constraints (Finding 3.4). In balancing mathematics and social justice goals, Gutstein (2003) found students initially made superficial connections between their mathematical work and the social justice issues, but by the end of his two years working with students, they overwhelming showed evidence of sophisticated understanding of both the mathematical concepts and social justice issues. Because Gutstein (2003) provides the only example of students engaging with TMSJ across multiple years, future research might explore how students’ ability to work with complex and advanced mathematical concepts and to use the mathematics to analyze social justice issues evolves over time. In addition to engaging students in TMSJ over time, interdisciplinary projects hold promise for allowing students to make more meaning connections between challenging mathematics and complex social justice issues. These connections were more common at the elementary level, where teachers are responsible for teaching multiple content areas, but findings also point to some examples at the secondary level that can serve as models (Finding 3.4). Another possibility for managing time is to choose one social justice issue, which is particularly relevant to students, for more a more in-depth exploration, rather than attempting to cover multiple social justice issues (Stocker, 2012). The collaborations necessary for interdisciplinary or in-depth TMSJ project likely require much effort on the part of teachers. Little is known about the ways that teachers learn to collaborate with other likeminded social justice mathematics teachers or about how teacher educators might support this type of work, but some reports suggest these types of collaborations can be particularly important (e.g., Wright, 2016).

A practical need to understand and use mathematics also holds promise for helping students to navigate advanced and challenging mathematical work (Finding 3.2). The example of students communicating findings from their TMSJ enactment to school board members to advocate for real change (Turner & Font Strawhum, 2013) shared many common characteristics with other analyzed TMSJ enactments: students engaged with sophisticated research methods (e.g., Terry, 2010), used authentic data (e.g., Dean, 2013), did mathematical analyses motivated by student interest (e.g., Aguirre et al., 2013) and found opportunities to make real changes towards a more socially just world (e.g., Stocker, 2012). Moreover, in cases when students collected their own data (e.g., Terry, 2010; Turner & Font Strawhun, 2013; Turner et al., 2009), students drew on their knowledge of the community as well as the mathematical knowledge they gained through the TMSJ enactment to make conclusions about social justice issues (Turner et al., 2009). These findings suggest that some level of student investment in the social justice issue at hand may also play an important role in how students navigate the complex mathematical work required to meaningfully address social justice issues and support claims.

When allowing students' questions to drive the mathematics, managing connections to the dominant mathematics curriculum in TMSJ can become especially challenging, and teachers may inevitably struggle to balance social justice goals with mathematical goals (Bartell, 2013). Access to the dominant mathematics curriculum is important because lack of mathematics proficiency blocks students of Color from various opportunities because of the gatekeeper nature of mathematics (Moses & Cobb Jr., 2001). TMSJ does not serve the interests of students of Color if TMSJ enactments limit their access to the dominant mathematics curriculum. Supporting students to both access the dominant mathematics curriculum and to engage meaningfully with TMSJ enactments likely requires sophisticated teaching, but some scholars argue that rather than considering these tensions as problems in need of "healing" through better teaching practices, we should critique the paradoxes inherent in the school system (Pais et al., 2012). Although I strongly agree with this sentiment, mathematics education researchers should also value students of Color's input by further examining the relationship between students' engagement in TMSJ enactments and their access to the dominant mathematics curriculum, particularly at the secondary level (Finding 3.4). More research is necessary to help teachers navigate the paradoxical space of schooling that both perpetuates racism and promises hope for social justice.

Conclusion

This analysis revealed several promising practices that can guide intentionally ant-racist TMSJ enactments and also inform future research aimed at racially just mathematics education. Because this analysis relied on information provided by the authors of articles and chapters, which naturally provided incomplete accounts of TMSJ enactments, and used a particular theoretical lens, direct observations and analysis of data through additional research and different lenses will be necessary to investigate the findings discussed here. This necessary synthesis, however, provides a strong basis for what the field of mathematics education currently understands about an increasingly popular approach to mathematics teaching, and the limitations and potential of TMSJ in practice. Because differences in racial identities among mathematics teachers and students exist even in classes without TMSJ enactments (Nieto & McDonough, 2011), this analysis has larger implications for mathematics teaching and learning by contributing ways of considering whether students of Color's mathematical experiences challenge, perpetuate, or exacerbate racism. Future research, with an eye towards dismantling racism in mathematics education, holds promise for helping educators and students realize goals for a more racially and social just world.

APPENDIX

Appendix: Final Template for Analysis

1 Context of study

1.1 Grade level
- 1.1.1 PK-5
- 1.1.2 6-8
- 1.1.3 9-12
- 1.1.4 Postsecondary

1.2 School or classroom type
- 1.2.1 Public school
  - 1.2.1.1 Traditional
  - 1.2.1.2 Alternative
  - 1.2.1.3 Social justice mission
  - 1.2.1.4 Unspecified
- 1.2.2 Private school
- 1.2.3 Afterschool or summer program
- 1.2.4 Unspecified

1.3 Race of teacher participant(s)
- 1.3.1 White
- 1.3.2 Black
- 1.3.3 Latinx
- 1.3.4 Asian or Asian American
- 1.3.5 Undetermined

1.4 Race of students
- 1.4.1 White
- 1.4.2 Black
- 1.4.3 Latinx
- 1.4.4 Asian or Asian American
- 1.4.5 Native American
- 1.4.6 Diverse (race unspecified)
- 1.4.7 Unspecified

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2 TMSJ lesson or project topics

2.1 Central mathematics topic(s)
- 2.1.1 Statistics or data analysis
- 2.1.2 Proportional reasoning
- 2.1.3 Geometry or measurement
- 2.1.4 Number sense or computation
- 2.1.5 Linear relationships
- 2.1.6 Exponential relationships
- 2.1.7 Calculus

2.2 Central social justice topic(s)
- 2.2.1 Racism or racial profiling
- 2.2.2 Education
- 2.2.3 Inequality (e.g., wealth, power)
- 2.2.4 Local issues

2.2.5 Economics or consumerism
2.2.6 Labor issues
2.2.7 Women's issues
2.2.8 Health; food/water access
2.2.9 Incarceration
2.2.10 Government issues
2.2.11 Immigration

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3 Attention to race and racism

3.1 Explicitly acknowledged race or racism in TMSJ enactments
3.1.1 Teacher initiates/sustains discussion of race/racism
3.1.2 Students initiate/sustain discussion of race/racism
3.1.3 Race/racism was the central social justice topic
3.1.4 Race/racism was peripheral to mathematics or other social justice topic(s)
3.1.5 Race/racism was considered alongside other social justice topic(s) – intersectionality

3.2 Race or racism not acknowledged explicitly in TMSJ enactments
3.2.1 Intentional avoidance of discussions about race or racism
3.2.2 Influence of race or racism implied
3.2.3 No evidence of implied attention to race/racism nor intentional avoidance

3.3 Attention to context and anti-essentialism
3.3.1 Anti-essentialism - Race/racism or broader social justice issues was contextualized and/or related to students' experiences; multiple perspectives encouraged
3.3.2 Race/racism or other social justice issue was considered in a decontextualized way (e.g., as a variable; essentialism)

3.4 Critique of liberalism present in TMSJ enactment
3.4.1 Challenged meritocracy or individualism
3.4.2 Challenged colorblindness, neutrality, or objectivity
3.4.3 Teacher challenged liberalism
3.4.4 Students challenged liberalism
3.4.5 Counterstory (or personal experience, community knowledge, etc.) connected explicitly to mathematical evidence

3.5 Critique of liberalism not present in TMSJ enactment
3.5.1 Teacher expressed liberal views
3.5.2 Students expressed liberal views/resisted teacher's critiques of liberalism
3.5.3 Insufficient time for critique of liberalism
3.5.4 Teaching goals did not include critique of liberalism
3.5.5 Mathematical evidence used to support liberal claims

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4 Interest convergence

4.1 Teacher's stated motivation for TMSJ
4.1.1 Make mathematics meaningful, relevant, or more interesting to students (and teacher)
4.1.2 Foster student agency, ownership of, or positive relationship with mathematics
4.1.3 Develop critical consciousness using mathematics

4.1.4 Help students use mathematics as a tool for social action or change; agency or ownership of social issues

4.1.5 Increase mathematics achievement and academic opportunities

4.2 Cognitive demand of mathematics work

4.2.1 Higher-order thinking and problem solving

4.2.1.1 Learned new mathematics content

4.2.1.2 Used authentic mathematics practices

4.2.2 Lower-order thinking

4.2.2.1 Mostly procedural calculations

4.2.2.2 Review of previously-learned material

4.2.3 Students struggled with mathematics work

4.3 Alignment of content to dominant curriculum

4.3.1 Content was grade-level appropriate

4.3.2 Content was advanced for grade-level

4.3.3 Content was remedial for grade-level or not included in dominant curriculum at all

4.3.4 Teacher purposefully selected mathematics content

4.3.5 Teacher allowed mathematics content to arise naturally from social justice questions

4.4 Teacher's negotiation of tensions

4.4.1 Sacrificed mathematical accuracy or higher-order thinking to make work feasible

4.4.2 Made superficial connections between mathematics and social justice issue

4.4.3 Used previously collected data

4.4.4 Connected to relevant and familiar community issues or other content areas/classes

4.4.5 Other ways

4.5 Students of Color resisted TMSJ enactments

4.6 Students of Color supported TMSJ enactments

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5 **Unique voice of Color**

5.1 Students raised social justice questions for TMSJ enactments

5.1.1 Prior to enactment

5.1.2 During enactment

5.2 Teachers chose social justice questions/topics for TMSJ enactments

5.2.1 Teacher solicited student input on topic choice prior to enactment; or teacher based topic choice on knowledge of students

5.2.2 Teacher solicited student input and interpretations during enactment

5.2.3 No evidence that teacher solicited student input

5.3 Students took action steps

5.3.1 Communicated to an authentic audience

5.3.2 Joined existing social activism

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CHAPTER 3: GEOMETRY, GROCERY STORES, AND GARDENS: LEARNING MATHEMATICS AND SOCIAL JUSTICE IN A PROJECT-BASED MATHEMATICS CLASSROOM

With growing attention to issues of equity and social justice in mathematics education, school mathematics classrooms increasingly are becoming hybrid spaces. Scholars and educators generally envision hybrid classrooms as ones that "allow or encourage out-of-school experiences and identities to become part of content-based activity" (Langer-Osuna, 2015, p. 54). Introducing hybridity by integrating students' cultural, linguistic, or community-based knowledge, resources, and experiences into mathematics instruction holds promise for addressing equity issues because such teaching supports the learning of students who are historically marginalized in mathematics[1] (Aguirre et al., 2012; Ladson-Billings, 2009; Langer-Osuna, 2015; Lipka et al., 2005; Turner, Gutiérrez, Simic-Muller, & Díez-Palomar, 2009). Under the broad umbrella of "equity" (Gutiérrez, 2013), however, hybrid classrooms can take diverse forms and draw on different pedagogical structures. To name a few, these structures might include: interventions to support more equitable access and interactions in small groups (i.e., complex instruction; Boaler & Staples, 2008; Esmonde, 2009a; Wood, 2013); projects that involve authentic, real-world tasks and broad knowledge bases (i.e., project-based learning; Jurow, 2005; Langer-Osuna, 2011, 2015); investigations of social justice issues through mathematics (i.e., teaching mathematics for social justice; Esmonde, 2014; Gutstein, 2003; Turner et al., 2009); or the integration of face-to-

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[1] For the remainder of the paper, I use "students who are historically marginalized" to refer to groups of students who have been historically and systematically marginalized in mathematics and mathematics education in the U.S. context. This includes students from historically and systematically marginalized racial and/or ethnic groups, students with disabilities, students whose first language is not English, students from low socioeconomic backgrounds, LGBTQ students, and girls. I recognize that using this term has limitations (e.g., does not recognize different sources and forms of marginalization), but I adopt this term for the sake of clarity and readability. I name specific groups of students when possible and in specific contexts.

face instruction with personalized, computer-based learning (i.e., blended learning; Balentyne & Varga, 2016; Means, Toyama, Murphy, & Baki, 2013).

In studies of equitable mathematics teaching and learning, mathematics education researchers increasingly have attended to how students who are historically marginalized develop identities as learners and doers of mathematics, how students' various identities and knowledge bases (e.g., racial, cultural) are positioned as compatible or incompatible with doing and learning mathematics, and how broader systems of power play out in important ways to influence identity development and mathematics engagement (Gutiérrez, 2013; Nasir, Hand, & Taylor, 2008). These studies, however, have largely focused on students' experiences with one specific pedagogical structure within hybrid mathematics classrooms. In other words, individual studies tend to focus on only one of the pedagogical structures listed at the end of the first paragraph. These enactments of a single pedagogical structure meet the needs of many students who are historically marginalized (e.g., Boaler & Staples, 2008; Gutstein, 2003; Langer-Osuna, 2015; Wood, 2013), but studies also shed light on tensions and limitations that arise within these different pedagogical structures. For example, teachers may select authentic real-world problems for project-based learning or social justice projects that they believe are relevant and important, but real-world problems are complex (Langer-Osuna, 2015; Leonard, Brooks, Barnes-Johnson, & Berry, 2010). Students may not be able engage fully, or they may engage in ways that are problematic (e.g., reinforce stereotypes; continue to marginalize groups of students) (Esmonde, 2014; Harper, accepted [Chapter 2]; Jurow, 2005; Langer-Osuna, 2011). Because equity issues in mathematics education are multifaceted (Gutiérrez, 2012; Martin, 2003), realizing mathematics teaching for equitable learning demands further (re)imagining new models for hybrid classrooms.

This article documents an innovative approach towards equitable and hybrid mathematics classrooms. In a 9th grade geometry classroom, hybridity occurs as out-of-school experiences and identities become part of content-based activity and, additionally, as the pedagogical enactment itself reflects a hybrid of various equitable teaching approaches. Specifically, this teacher wove together strategies for equitable collaborative learning and teaching mathematics for social justice with technology-driven, project-based learning with the goal of attending to different dimensions of identity and power. Ideally, this approach to hybridity would preserve the features that make each distinct pedagogical approach effective for achieving equity goals (e.g., positive mathematics identity development, shifting classroom power dynamics), and would form a coherent instructional approach that may alleviate some tensions that arise through implementation of only one of the various pedagogical approaches to hybrid classrooms. Because students can take up well-intentioned pedagogical efforts in unintended ways (Brantlinger, 2013; Esmonde, 2014; Lubienski, 2000), however, the goal of this study was to investigate students' experiences and identity development with this innovative hybrid approach. More specifically, I asked, how do students experience the intended instructional emphasis on identity and power within an innovative approach to equity-minded, hybrid mathematics teaching? The present article builds on the growing body of research that investigates dimensions of identity and power in students' experiences in hybrid classrooms (Gutiérrez, 2013; e.g., Boaler & Staples, 2008; Gutstein, 2003; Langer-Osuana, 2015; Wood, 2013). I aim to extend recent efforts to use the figured worlds construct to understand how students' construct their hybrid experiences (e.g., Barton & Tan, 2010; Esmonde, 2014; Langer-Osuna, 2015) to consider the relationship between hybridity in pedagogical enactments and students' negotiation of identity and power.

Framing Learning, Identity, and Power in and through Figured Worlds

I draw on the *figured worlds* construct (Holland, Lachicotte, Jr., Skinner, & Cain, 1998) in order to investigate how students negotiate, take up, shift or resist identity and power within a hybrid classroom and hybrid pedagogical space. The theoretical framing of figured worlds is particularly appropriate for this study because it allows me (and the reader) to navigate the multiple hybrid spaces at play in the focal classroom – the various instructional approaches and the range of knowledge, resources, and experiences that become part of mathematics activity through authentic, real-world and/or social justice projects. Figured worlds create an opportunity to explore connections between personal and academic identities in classroom spaces (Langer-Osuna, 2015), to bring together sociocultural and critical theories for more sociopolitical framings of identity and power (Gutiérrez, 2013), and to illuminate multiple types of learning (e.g., mathematics learning, social justice learning, learning about authentic, real-world situations) (Esmonde, 2014; Jurow, 2005).

A figured world is a “socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (Holland et al., 1998, p. 52). Teachers and students construct figured worlds as they assign significance and meaning to people, actions, and ideas. Meaning is constructed as particular actors, actions, or other forces relate to each other in ways that resemble a narrative or *storyline.* Storylines provide a standard plot, or a taken-for-granted sequence of events, by which “the meaning of characters, acts and events in everyday life [are] figured against” (Holland et al., 1998, p. 54). In other words, storylines help determine how we “figure” out someone or something that happens in the “world.”

Consider, for example, the following storyline that has been observed in a project-based mathematics classroom: Students work autonomously in groups to complete the objectives of a project. One student in each group takes charge to initiate and facilitate the collaborative work. If the student who takes the lead is male, he is viewed as 'smart' by his peers; if the lead student is female, she is labeled 'bossy' for similar actions (Langer-Osuna, 2011). In students' experiences with small group work, the identities of 'smart' or 'bossy' that accompany the action of taking the lead are enacted by students and assigned by their peers based on specific expectations laid out in the standard storyline. This storyline draws on constructed meanings from various figured worlds; the group work figured worlds in the classroom interact with broader gender figured worlds to help students and the teacher make sense of actions, relationships, and identities.

Through extended construction of and participation in figured worlds, students and their teacher come to see themselves as certain types of people, embody the perspectives of the figured worlds, and act according to standard storylines (Jurow, 2005). In mathematics classrooms, this means students develop a "self-understanding…about their relationships to the subject of mathematics" (Horn, 2008, p. 204) that influences their actions and interactions with the discipline of mathematics and with their teacher and peers (Boaler & Greeno, 2000; Esmonde & Langer-Osuna, 2013; Langer-Osuna, 2015). Figured worlds and their storylines, however, are not fixed or predetermined. In the example storyline above, a 'smart' female leader or a leading partnership is also a possibility, but identities and actions outside the standard storyline may be interpreted as surprising or unusual. Through continued rejection or negotiation of standard storylines, figured worlds are collectively (re)constructed. In other words, *learning* occurs (Esmonde, 2014). This shifting of standard storylines is possible because multiple figured worlds come together in classrooms and particularly in hybrid classrooms where personal figured worlds can serve as bridges to school-based figured worlds (Esmonde, 2014; Langer-Osuna, 2015). Thus, this extension of the figured worlds construct to theorize learning is valid because schools aim to help students construct various figured worlds, namely, of mathematics, of equity and social justice, and of real-world situations framed by projects (Esmonde, 2014).

Learning as the collective construction of figured words is compatible with a situated and sociocultural perspective of learning (Greeno & Project, 1997; Lave & Wenger, 1991; Wenger, 1999). Learning occurs through collective engagement in practices, which are situated within specific contexts. As individuals engage in these practices together, they co-construct the practices and knowledge central to the discipline, and these practices and knowledge are also informed by the particular social, cultural and historical contexts in which learning occurs. The specific practices involved can include particular discourses (i.e., talk, gestures, etc.), interactions, and participations. As individuals engage in these practices, they develop an identity as someone who uses discourses and interactions central to the discipline. Learning, then, is the process of becoming a certain kind of person (developing a particular identity) in the world (Horn, 2008), namely someone who successfully (as defined by the community) does mathematics.

Learning as the collective construction of figured worlds is also compatible with sociopolitical perspectives on identity and power, which are particularly relevant in light of the equity-minded pedagogical hybrid described here. Sociopolitical perspectives on identity reject fixed views of identity and recognize the use of static cultural markers perpetuates deficit or overly simplistic framings of students who are historically marginalized. Instead, identity is "something you do, not something you are" (Gutiérrez, 2013, p. 45); thus, identity is fluid and flexible and enacted differently in different contexts and at different moments. Even so, researchers adopting this perspective must also pay attention to how power operates in a particular setting and influences which identities are salient in given contexts and at given moments (Gutiérrez, 2013). Within the figured worlds construct, this means that power, privilege and status affect aspects of identity and serve to organize figured worlds and their storylines. *Positional identity* develops from "one's position relative to socially identified others, one's sense of social place, and entitlement" (Holland et al., 1998, p. 125). Everyday interactions within figured worlds position individuals relative to one another. In other words, identities, as performativity, are socially, culturally, and politically situated, making them partly the control of an individual and partly under the control of other individuals and broader power structures that collectively give meaning and significance to actions and interactions (Gutiérrez, 2013). In a mathematics classroom figured world, understandings about students' relationships to the subject of mathematics are enacted by individuals and "are assigned to them through their position and encounters in the social world" (Horn, 2008, p. 204), and this mathematics identity is important because success in mathematics confers certain status in society more broadly (Gutiérrez, 2013). Different figured worlds present distinct opportunities for developing varied positional identities because people are afforded different positions in those worlds and because people can resist positions afforded them, with varying degrees of agency, within different worlds (Holland et al., 1998). Thus, adopting sociopolitical perspectives within the figured worlds framework means attending not only to how students are positioned in doing mathematics, how they position themselves in doing mathematics, and what meanings they ascribe to mathematics, but also to influences from broader power structures and from student agency and voice.

Methodology and Method

The research reported in this article relies on ethnography to frame the study of equity-minded teaching and student learning in a mathematics classroom. Ethnography is a particularly suitable methodology for understanding processes (i.e., teaching and learning) as they happen and for understanding classrooms from students' perspectives (Anderson-Levitt, 2006). I adopted a critical and transformative approach to ethnography, meaning that I viewed research as justice- and change-oriented and as collaborative with participants (Creswell, 2014). Thus, I continually questioned my own assumptions as a white, adult female seeking to interpret the experiences of a racially diverse group of adolescents. For example, I talked informally with students about my emerging interpretations of data and to clarify statements they had made during class or interviews, and I recorded notes from these conversations in field notes. Rather than assuming to speak for students, I strove (and strive in this article) to speak alongside them (Anderson-Levitt, 2006). Moreover, aiming for change and justice through research, my role extended beyond interpreting and describing what I observed in the classroom. Instead, I acted as a participant-observer. This role is common, and perhaps unavoidable, in ethnography (Emerson, Fretz, & Shaw, 2011), but I actively sought to work alongside participants to make the classroom a more just place. I intentionally engaged in regular conversations with both the teacher and students to explore alternatives to and multiple interpretations of observed interactions and practice. Moreover, I took actions during observations to support efforts towards equitable teaching and learning (Skovsmose & Borba, 2004). For example, I helped students solve problems or use technology when they were struggling; I assisted the teacher in finding resources for lessons; I adjusted my own research plans based on input from the teacher and students; and I anonymously relayed feedback from the students to their teacher.

Victory High School and Victory New Tech

This study took place across the 2015-16 academic year in a 9th grade Geometry classroom at a New Tech school in the Midwestern United States. Victory New Tech (New

Tech) is a STEM-themed magnet school within Victory High School (Victory) in Midland City, a small city (i.e., population approximately 115,000). New Tech opened in 2014-15 and initially enrolled approximately 200 7th-8th graders. At the time of the study, the school enrolled approximately 400 7th-10th graders in its second year of operation with a plan to expand to include 500 7th-11th grades the following year. In 2015-16, the total combined enrollment at Victory and New Tech was 1,620 students.

The restructuring of Victory was part of a district-wide effort to consolidate middle and high schools due to decreasing overall enrollments and growing budgetary concerns. Victory, a comprehensive 9-12 school, was restructured to include 7th and 8th grade by establishing the New Tech STEM magnet program using the school-within-a-school model. New Tech's mission is to incorporate rigorous academic content, guided by state standards, into integrated, multi-disciplinary classes with a focus on technology-driven, project-based learning. Project-based learning engages students in exploring and solving authentic, real-world tasks that require collaboration, creativity, critical thinking, and knowledge or skills across a range of disciplines (according to New Tech's website). New Tech used grant funding to provide each student a laptop computer and to remodel a wing of Victory to establish dedicated space for New Tech classrooms. The schedule was also restructured to include two-hour periods for co-taught, multi-disciplinary classes (e.g., 8th grade Algebra and Earth Science – known as EarthMath – co-taught by a mathematics teacher and a science teacher). During the restructuring, Victory revived a previously adopted magnet focus to emphasize the visual performing arts; however, Victory maintained a more traditional school structure with 50-minute periods for single-disciplinary classes.

New Tech had no minimum academic requirements for enrollment, but based on conversations with teachers and students, both Victory and New Tech students perceived New Tech students to have higher academic status than students at Victory. New Tech and Victory students took their core courses (i.e., math, science, English language arts, social studies) separately, but students from both schools enrolled in the same performing arts classes (e.g., band), language classes, and other electives. Some New Tech teachers also taught classes within Victory, but they often maintained a focus on project-based learning even in the 50-minute, single disciplinary class structure. As a result of students' introduction to project-based learning, some Victory students elected to enroll in New Tech midyear during the study.

New Tech and Victory students live in the same community and attended the same elementary and middle schools. If New Tech had not opened in 2014, New Tech students would most likely have enrolled in Victory upon entering 9th grade. Based on conversations with administrators and teachers, Victory and New Tech students represented similar demographics. In 2015-16, Victory and New Tech's combined enrollment was 43% Black, 24% White, 18% Latinx[2], 9% Asian/Asian American, and 6% bi- or multi-racial. Moreover, 400-700 refugees resettle in Midland City each year, and the school demographic data alone do not reflect the ethnic and linguistic diversity at Victory and New Tech. The median household income of Midland City in 2015 was $35,600, which was 22% lower than the median household income for the county, and 63% of students qualified for free or reduced lunch. Overall, the schools were thriving academically; in 2015-16, Victory and New Tech students met overall state proficiency improvement targets.

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[2] I use Latinx to refer, generally, to groups of people with cultural ties Latin America, regardless of race. I chose Latinx over Latino/a in order to problematize the gender binary. When referring to a specific person's cultural identity, I use Latino or Latino, respectively, based on the individual's gender identity.

Mrs. Stone's New Tech geometry class

This study took place in one of New Tech's 9th grade Geometry classes taught by Mrs. Olivia Stone. Mrs. Stone is a white woman in her mid-twenties and was in her fourth year of teaching at the time of the study. She began teaching at Victory in 2011 as a student teacher during the yearlong internship required by her five-year teacher preparation program, and in 2012, she accepted a job at Victory where she primarily taught Algebra. During the inaugural year of New Tech, Mrs. Stone co-taught EarthMath, and in 2015-16, she taught 50-minute Geometry classes for both New Tech and Victory and one Algebra class for Victory. New Tech teachers made the decision not to integrate 9th grade Geometry and Biology because of concerns that integrating 8th grade Algebra and Earth Science did not allow teachers and students to adequately address the content standards for these high priority subjects. Instead, they restructured the 9th grade schedule to include 50-minute, standalone Geometry classes and integrated Biology and Health/Physical Education (i.e., BioHealth).

The selected focal class was a yearlong New Tech Geometry class with an enrollment of 18 students at the beginning of the academic year and 14 students after the midyear (i.e., 2nd semester) schedule changes. Sixteen students consented to participate in the research. Table 3.1 provides information about each student participant's race/ethnicity, gender, and perceived academic status. Enrollment was smaller than the enrollments in Mrs. Stone's other Geometry classes because of scheduling conflicts with electives, which met for only one semester. At midyear, four students transferred out of the focal class into different Geometry classes taught by Mrs. Stone, and one student joined the focal class after transferring from another school. Eleven students both consented to the research and were part of the focal class for the entire academic year, but I continued to talk with and observe the other student participants during events that combined multiple classes (e.g., lunch, presentations for the final project). Scheduling conflicts also resulted in an unusually high percentage of White male students in the focal class (Table 3.1). Even though enrollment was unusually small and somewhat unique in terms of race/ethnicity makeup by gender, I selected this class for two reasons. First, all original 18 students were New Tech students enrolled in 8th grade EarthMath taught by Mrs. Stone in the school's inaugural year. I prioritized this particular criterion because mathematical identities develop both within single classes and across multiple classes and years (Horn, 2008). I hoped that students' shared 8th grade experience with Mrs. Stone's equity-minded approach to project-based learning might allow me to explore mathematics identity development during the specific focal class but also to imagine possibilities for mathematical identity development when equity-minded, project-based learning is sustained across the secondary mathematics curriculum. Second, the class met immediately before lunch, and conducting teacher and student interviews during lunch ensured a higher level of participation in the research.

Table 3.1

Demographic information and academic status for student participants.

Student*	Race/ethnicity, Gender	Perceived Academic Status in Math	Other Information
Antonio	White Male	Medium Low	
Ashley	White Female	Medium Low	Transferred out 2nd semester
Blake	White Male	Medium	
Carley	Black** Female	High	
Charlie	Black** Female	Medium High	Transferred out 2nd semester
Dante	Black** Male	Low	
George* **	White Male	Low	
Jane	Black** Female	Medium Low	
Kendra	Black** Female	High	Transferred out 2nd semester
Mikayla	Black** Female	Medium	Transferred out 2nd semester
Monique* **	Black** Female	Low	
Nemo* **	Black** Female	Medium	

(Table 3.1 cont'd)

Rosy* **	Korean American** Female	High	Highest academic status female
Simba	Black** Female	High	
Tino* **	Latino Male	High	Family from Argentina of European Descendent
Warren	White Male	High	Transferred in 2nd semester

**All names are pseudonyms. Most pseudonyms were selected by the students.*
***Student identified and presented as listed race/ethnicity but is bi- or multi-racial.*
****Students were selected as focal students at the beginning of the year in collaboration with Mrs. Stone. I focused on these students for observations and individual interviews because, collectively, they represented a range of intersections of race, gender, and status.*

Table 3.1

Mrs. Stone's commitment to equity and social justice in her mathematics teaching grew out of experiences in her teacher preparation program, and she and I began collaborating to further develop and study her equity-minded teaching efforts in March 2013. In addition, Mrs. Stone participated in more formal professional development with support from the Knowles Science Teaching Foundation. In our collaboration and her professional development, Mrs. Stone focused on two specific pedagogical approaches: (1) complex instruction (CI) and (2) teaching mathematics for social justice (TMSJ). CI is a particular approach to cooperative learning, in which teachers employ strategies to ensure equitable access and equitable interactions as students work together in small groups (Cohen, Lotan, Scarloss, & Arellano, 1999), and TMSJ involves teaching that engages students in mathematical investigations of social justice issues and encourages use of mathematics to inform action towards a more socially just world (Gutstein, 2003). Mrs. Stone integrated these two approaches to varying extents across the seven project-based learning projects students completed during the academic year (see Appendix A for descriptions of projects).

Mrs. Stone focused specifically on integrating CI and TMSJ into the project-based learning context at New Tech because of the complimentary nature of CI and TMSJ for realizing more comprehensive goals for equity and social justice in mathematics education. In particular, CI and TMSJ place different emphases on identity and power. CI strategies promote recognition of mathematical abilities that are usually marginalized, setting the stage for traditionally marginalized students to identify as competent (i.e., develop a positive mathematics identity) (Boaler, 2006, 2008). Additional features of CI shift the power dynamics of the classroom, so that all students have a voice and so that authority is delegated from teacher to students (Boaler, 2006, 2008). CI, however, focuses almost exclusively on students' mathematical identity development within a single classroom, with little consideration of students' development of critical consciousness related to racial, gendered, cultural, etc. identities and to social issues and structures (Boaler, 2008; Esmonde, 2009a). In contrast, traditionally marginalized students develop more positive mathematical identities through TMSJ by coming to see mathematics as important in their lives and compatible with their other (racial, gendered, cultural, etc.) identities (e.g., Gutstein, 2003). Examples of students using mathematical arguments to affect change in their local communities (e.g., Tate, 1995; Turner & Font Strawhun, 2013) also illustrate the potential for TMSJ to extend the focus on power beyond the immediate classroom by taking up issues of social transformation and developing students' critical consciousness. Thus, TMSJ compliments CI with greater emphasis on out-of-school factors that can positively shape students' experiences with mathematics.

Although CI and TMSJ have similar goals for increasing students' mathematics achievement and access to high quality mathematics teaching and learning, attention to the grade-level specific mathematics curriculum varies between the two approaches. TMSJ often involves substantial and authentic mathematical work, but the mathematics content does not necessarily relate to the grade-level specific content, particularly at the secondary level (Harper, accepted [Chapter 2]). Thus, TMSJ's capacity for supporting achievement in and access to the required content of school mathematics remains uncertain (Brantlinger, 2011; Gutstein, 2003). In contrast, CI's focus on access to rigorous, grade-level mathematics has been linked to increases on more traditional school-based measures of mathematics achievement (Boaler & Staples, 2008; Cohen et al., 1999; Horn, 2008). Thus, CI compliments TMSJ with a greater focus on grade-level specific mathematics learning.

Data sources

I observed Mrs. Stone's Geometry class from October 2015 through June 2016. Across the academic year, I visited the class 3-5 times per week for a total of 93 observations. During observations, I did not write detailed, in-the-field-notes because I took the role of participant observer. Instead, I wrote jottings, or brief key words or phrases about events and impressions (e.g., "Fast food has healthy options"; "CI: participation quiz - all participated"; Emerson et al., 2011), and took photos of naturally occurring mathematical work generated by individual students, groups of students, or the whole class. I also talked regularly and informally with the teacher before, during, and after class, and I added notes about lesson planning and the teacher's impressions of student engagement and the effectiveness of specific pedagogical strategies from these conversations to jottings. Immediately upon leaving the field, I worked from jottings and photos to record more detailed field notes, which included photo artifacts. I recorded as much as I could remember about activities, interactions, and the content of talk. My jottings and subsequent field notes primarily attended to a focus group, which I selected at the beginning of each project for video recording. Focus groups were selected to maximize the number of focus students participating in the groups (Table 3.1). I also jotted down notes about interactions, activities, or talk of students outside the focus groups or focus students when those notes helped me remember my overall impressions of how the class was engaging in activities, interacting with each other and with mathematics, or taking up topics of conversation (e.g., Non-focus group: talked about poverty but did not finish mathematics task). In collaboration with the teacher, I also pre-selected a subset of lessons for video recording, aiming to strategically capture a diverse range of equity-minded teaching practices for later detailed analysis (i.e., CI, TMSJ, and both CI and TMSJ). I recorded a total of 33 lessons across six projects (I did not have sufficient parent and student consent for video during the first project). I also made three audio recordings of impromptu equity-minded teaching efforts that seemed different from those already captured on video (e.g., conversation about standardized testing after students completed the test), and the teacher shared copies of student assignments and artifacts of student work with me, upon request, when I had not been able to capture these during observations and they seemed necessary for me to understand how students engaged with the activities when elaborating on jottings in field notes.

Following each project, I interviewed a subset of student participants to gain insight into students' personal and mathematics identities and to understand students' expectations for and interpretations of learning and doing mathematics. I selected one or two focus students from the selected focus group for individual interviews, and I did individual interviews with most of the girls and Black students in the class at the end of the year (for a different analysis). I conducted fourteen individual interviews across the school year focused on impressions of peer interactions, mathematics content, social justice topics, and equity-minded pedagogical efforts (e.g., Do you think centers of triangles helped you understand food deserts? How so or why not?; Mrs. Stone used some strategies to encourage you to work with your group, like checkpoints and group questions, how well do you think those strategies worked?; How would you describe yourself as a mathematics student?). Moreover, I conducted group interviews with a subset of students after three projects to gain a better sense of whether or not the impressions described in individual interviews were similar to or different from the experiences of other students in the class. I included students from both within and outside the selected focus group because group interviews brought to light interpretations and expectations that did not arise during individual interviews as students built on each other's responses (see Appendix A for an overview of data by project).

Analysis for this paper focused on a subset of data generated during three projects (Table 3.2). I selected these three projects for further analysis because each project shared the common social justice theme of exploring the existence and impact of food deserts in the local community and because the teacher employed a range of equity-minded approaches across these projects. The extended nature of the social justice topic and the equity-minded teaching approaches was important because existing literature suggests engaging with social justice issues across settings, activities, and time my allow students to more effectively take up a place within the social justice figured world, but there are no such cases in a school-based context (Jurow, 2005; Jurow & Shea, 2015). The focus on food deserts was inspired by a Midland City public health initiative, kicked off during the mayor's 2015 State of the City address, which promoted nutrition and physical activity.

Table 3.2

Overview of three selected projects and data sources for each project.

Project	Field Notes & Artifacts	Videos & Audio	Individual Interviews	Group Interviews
Mini-project 2a* 1st semester	4 field notes 0 artifacts	4 video	2: Nemo; Rosy	1: Antonio, Jane, Ashley, Blake, Carley, Simba
What is a food desert & do I live in one? Where is a fair location for a new grocery store in Midland City? *Students used various resources to define 'food desert' and discussed social justice issues*				

(Table 3.2, cont'd)

<table>
<tr><td colspan="5">surrounding health and access to food. They calculated the distance and time to travel from their home to the nearest grocery store, convenience store, and fast food restaurant and considered where they could purchase healthy and affordable foods. Then, students used the distance formula to calculate the shortest distance from their home to the nearest full-service grocery store to decide if they lived in a food desert. They decided that the area surrounding Victory, where most of their homes were located, was not a food desert, so they used the midpoint formula to determine if placing a grocery store half way between their home and Victory would make sense. Finally, students wrote letters to the mayor explaining their research and recommendations for improving health and food access in Midland City.
Length: 5 days (Oct 21-27, 2015)</td></tr>
<tr><td>Project 4
1st semester</td><td>9 field notes
21 artifacts</td><td>9 video</td><td>2: George; Rosy</td><td>1: Ashley, Blake, Carley, Charlie, Dante, George, Jane, Kendra, Monique, Nemo, Rosy, Tino</td></tr>
<tr><td colspan="5">What are the broader causes & consequences of food deserts in cities? Where is a fair location for a grocery store (revisited)?
Students watched a video created by other youth in a different city talking about the social justice issues surrounding food deserts. Then, they used the Food Access Research Atlas (USDA, 2017) to determine where food deserts where located across Midland City and did broader research on the causes and consequences of food deserts. Next, they explored different measures of center of triangles (i.e., orthocenter, circumcenter, centroid, and incenter) and applied these different measures to determine a grocery store location in Midland City that could make the biggest impact on residents' lives. Finally, they created a presentation summarizing their research and recommendations to share at New Tech's public open house.
Length: 11 days (Jan 6-21, 2016)</td></tr>
<tr><td>Project 7
2nd semester</td><td>18 field notes
17 artifacts</td><td>6 video
2 audio</td><td>5: Dante; Nemo George; Rosy; Monique</td><td>2: Carley, Simba; Antonio, Blake, Carley, Dante, George, Rosy</td></tr>
<tr><td colspan="5">How would you design a community garden at the school to address the causes and consequences of food deserts?
Students worked on the project across three of their classes: geometry, English, and biology. In geometry, students made two-dimensional layouts (to scale), calculated the cost of building materials, and built three-dimensional models (to scale) of their proposed gardens. The primary mathematical focus was on calculating area and volume of various shapes and understanding the relationship between area and volume. In English, geometry pairs teamed up with another pair (of algebra students) to research and write a formal proposal, and in biology, students learned about plant biology and nutrition to make decisions about what, where and how to plant. Teachers introduced the project as one possible way of addressing the causes and consequences of limited access to high quality and affordable food, which students had explored in two previous geometry projects, and the project culminated in formal presentations for the school improvement committee to request funding for building a community garden at the school.
Length: 27 days (Apr 26-June 2, 2016)</td></tr>
</table>

**See Appendix A for overview of all projects and data sources*

Table 3.2

Analysis

The operationalized research question for this study was: How do students collectively construct figured worlds to negotiate, take up, shift, or resist emphasis on identity and power across three projects focused on exploring social justice questions about access to healthy food in the local community? As Esmonde (2014) did, I defined "*learning* at the classroom level as the collective construction of figured worlds" rather than at the individual student level (p. 356).

As data was generated, I created content logs in Microsoft Excel and Word, organized by date and project. In these logs, I described the major activities included in field notes and/or video for each observation, listed the specific pedagogical structures (i.e., TMSJ, CI, both TMSJ and CI, neither TMSJ nor CI) based on my initial observation and discussions with the teacher about her plans, and the major topics discussed in each interview. In addition, I wrote four analytic memos from January-April, 2016, by reviewing the content logs and field notes, to record initial impressions and questions and to refine further data generation (Emerson et al., 2011). I also consulted the content logs regularly when deciding which class sessions to video record so as to capture video of varied pedagogical structures across the 2015-16 year, and I referred to content logs, field notes, and analytic memos when preparing for interviews. Based on these initial content logs and analytic memos, I selected the subset of data used for this paper (Table 3.2) for more detailed analysis, and due to the different natures of the data, I used slightly different methods for analyzing field notes and interviews than I did for analyzing video.

I analyzed field notes and transcriptions of interviews in Dedoose 7.5.16. I began by creating codes based on the strong theoretical basis of CI and TMSJ and for power and identity (e.g., high status) (Yin, 2009), and I added and refined codes based on emergent themes through iterative rounds of analysis until codes were exhaustive (Emerson et al., 2011). Primary codes included: (1) who was involved/discussed (e.g., Rosy, Nemo); (2) how students were described/positioned (e.g., good at mathematics); (3) which pedagogical and participation structures were used/discussed (e.g., small group work, entry even for project, technology used); and (4) which topics were involved/discussed (e.g., social justice topic, mathematics topic, cultural/community/home experiences) (see Appendix B for more detailed descriptions of coding scheme). Adopting methods from Esmonde (2014), I generated these codes by focusing on the topics discussed in field notes (based on my interpretations during observations) and by students (based on their interpretations as they recalled their experiences during interviews) in my analysis to discover who or what was given agency and the kinds of actions students were engaged in. Because of the focus on content of talk or notes, the units of analysis for field notes and interviews were based on distinctive topics or actors.

In Studiocode, I began analyzing video by segmenting each recording into distinct classroom participation structures. Using the theoretical basis for exhaustive participation structures developed by Schoenfeld, Floden, and the Algebra Teaching Study and Mathematics Assessment Project (2014), I coded the elapsed time for the following: (1) whole class activities, including launch, teacher exposition, and whole class discussion; (2) small group work; (3) student presentations, indicating whether the conversation involved only the teacher and presenter or the whole class; and (4) individual work. These codes served as a way to broadly categorize how the ever-present figured world of the immediate physical context (i.e., the mathematics classroom figured world) was given agency by the teacher and the students because I could recognize patterns in the broad actions that students and the teacher engaged in as part of their participation in the mathematics classroom.

To identify additional realms of interpretations intersecting with the immediate physical world, I listened to student and teacher talk for evidence of one or more figured worlds, using classroom participation structure segments as a unit for analysis. I focused on broad topics of conversation because, through talk, students and the teacher can give agency to actors, actions, ideas, etc. outside of the immediate physical context (Esmonde, 2014). By looking for confirming and disconfirming evidence of codes for topics (Erickson, 1986) and through several rounds of coding for figured worlds, I was able to group codes into the two figured worlds (in addition to the mathematics classroom figured world) discussed in the findings.

Next, I used additional rounds of analysis to identify the storylines that were collectively constructed within each figured world. Initially, I used both the general figured worlds codes (e.g., collaboration, food desert) and the codes for the topics that were involved/discussed during interviews or field notes as a guide because these codes were more detailed than the figured worlds codes (Appendix B). Once again, I coded talk in the videos, but at a more detailed level. For example, I coded not only that students talked about food desert, but I also coded for what students said about food deserts. I also coded for actions and gestures that helped me understand how students were interpreting actions, actors, ideas, etc. within the figured worlds. Focusing on both talk and actions allowed me to provide more detail about "key events and relationships in the figured worlds" (Esmonde, 2014, p. 357) for both the immediate physical figured world of the mathematics classroom and two other imagined figured worlds (Jurow, 2005). Looking for confirming and disconfirming evidence of codes in Appendix B among the emergent themes for storylines helped me distill the storylines down to a set of narrative statements to describe the collectively constructed standard plots for actors, actions, ideas, etc. in the three figured worlds. (See Findings section for these storylines and example excerpts from data.) Once I had refined the storylines, I did one final round of coding to make sure that the storylines were exhaustive

(Esmonde, 2014).

Finally, I considered how figured worlds and the storylines within them related to each other and to the constructs of identity and power. In particular, I looked for patterns in how the different figured worlds and their storylines where invoked (i.e., when they were invoked together; frequency of presence); how storylines changed (or not) across the three projects (i.e., when students invoked one storyline in one context and a related, yet unique, storyline in a different context), how students positioned themselves and their peers (through their interactions and talk), similarly and differently, across storylines and projects (i.e., identity), and how power played a role in the construction of storylines and relationships.

Findings

Across the three projects, Mrs. Stone's students primarily enacted and invoked three figured worlds:

1. A mathematics classroom figured world
2. A food desert figured world
3. A figured world of authenticity (that merges school-based and out-of-school-based experiences)

All three of these figured worlds were structured into each project, but Mrs. Stone and her students negotiated and eventually shifted the storylines within each figured world across the three projects. Below, I present the storylines that the teacher and students collectively constructed within each figured world and illustrate each storyline with excerpts from the data. In the next section, I discuss how shifts to the storylines reflected the ways students negotiated, took up, or resisted identity and power within figured worlds.

Mathematics Classroom Figured World

Within the context of a project-based learning magnet school, the mathematics classroom was figured, intentionally, as a collaborative world. Students sat at tables in groups of four to encourage frequent cooperation with their peers, and Mrs. Stone regularly designed activities within projects to foster collaboration. Even when assignments required an individual product, students were allowed and encouraged to consult with their peers. During whole class discussions, students sometimes moved their chairs to form a circle at the front of the classroom to support collaborative discussion, and I used a similar configuration for group interviews. The mathematics classroom figured world described here was constructed about and through collaboration, mostly in small groups, but sometimes during whole class activity and group interviews.

Students were familiar with the mathematics classroom as a collaborative figured world from their experience as 8th graders with Mrs. Stone as their teacher, but during initial interviews they described their prior mathematics classroom figured world as more teacher-centered and focused on individual work. Thus, they had more experience with storylines that centered teacher-student interactions rather than collaborative, peer interactions. As a result, during each project, particularly those at the beginning of the school year, students and the teacher collectively (re)constructed what it meant to do mathematics in a collaborative space. Table 3.3 shows how classroom participation structures (and thus storylines and figured worlds) varied across projects. Although small group activity was most common across the year, during Mini-project 2a, students spent most of their time engaged in whole class activity and doing individual work. In particular, from Mini-project 2a to Project 4, the decrease in teacher exposition and the increase in small group work are striking. In this section, I share selected excerpts from Mini-project 2a and Project 4 to illustrate how the mathematics classroom storylines provided the standard plots for collaboration in the mathematics classroom figured world; storylines remained consistent from Project 4 to Project 7.

Table 3.3

Percentage of time devoted to each classroom participation structure by project.

Classroom Participation Structure	Mini-Project 2a	Project 4	Project 7	All projects
Whole Class	47.37%	16.78%	18.87%	24.0%
Launch	15.93%	7.75%	10.68%	10.37%
Exposition	20.96%	0.61%	0%	4.83%
Discussion	10.48%	8.42%	8.19%	8.80%
Small Group	3.57%	58.08%	56.49%	45.84%
Individual	48.19%	24.36%	0%	22.39%
Presentation	0%	0%	24.10%	7.04%
Teacher-presenter			24.10%	7.04%
Whole class				
Other*	0.87%	0.78%	0.54%	0.73%
Total Time:	3 hr 17 min	7 hr 29 min	4 hr 27 min	15 hr 13 min

**The video camera ran before and after class, when students were setting up or packing up. These instances are included in the total time, so the percentages are included here.*

Table 3.3

Mathematics classroom storylines in Mini-project 2a. There were three storylines within the mathematics classroom figured world during Mini-project 2a (Do I live in a food desert?; distance formula). I present those here, and describe how selected excerpts illustrate each storyline. Because the mathematics classroom figured world was immediately and physically present, identification of these storylines relied heavily on both content of talk and actions, gestures, etc., and this is reflected in the selected excerpts.

Mathematics classroom storyline 1.1**: **The teacher guides students procedurally through using the mathematical and technological tools necessary for the project.

Excerpt 1 (Observation: Oct 22, 2015)

Mrs. Stone: Have you guys never used Google Maps to find directions?

Nemo: No.

Excerpt 2 (Observation: Oct 22, 2015)

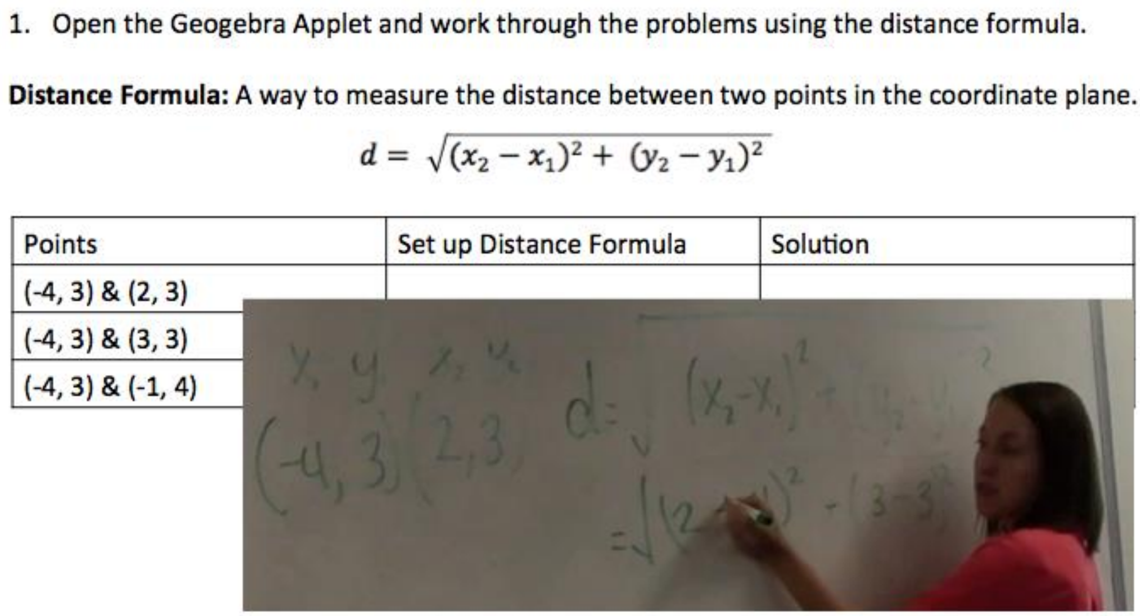
Mrs. Stone: There's a Geogebra applet, and you're going to play with the distance formula. [*Intervening comments redacted.*] You're going to open up this applet, and you're going to change the sliders to these points. And you're going to set up the distance formula. [*Mrs. Stone shows and explains how to use the applet.*] What the distance formula is…I have the formula written on [the worksheet], but it is a fancy way of saying, "I need to know how far this [*points to two coordinates*] is in a coordinate plane." [*Mrs. Stone shows how to set up the first problem on the worksheet in the applet.*]

Jane: I don't understand this.

Mrs. Stone: What don't you understand?

Jane: Everything.

Excerpts 1 and 2 both illustrate how Mrs. Stone's attempts to launch the activities led to her procedurally guiding students to use technological and mathematical tools. At the beginning of class, Mrs. Stone asked students to calculate the distance and time to travel from their home to the nearest grocery store, convenience store, and fast food restaurant by public transportation, by car, and by foot. As she continued explaining the activity, she realized that students were unfamiliar with Google Maps (Excerpt 1), and she proceeded to walk students through an example, calculating the time and distance from Victory to the nearest grocery store by car, foot, and public transit. After students had worked individually to complete the Google Maps activity, Mrs. Stone introduced the distance formula so that students could compare the distances by car, public transit, and foot to the shortest distance from their home to the nearest grocery store. In Excerpt 2, Mrs. Stone attempted to explain how to use the technology and to give meaning to the distance formula, but when students expressed confusion, she calculated the distance for the first pair of coordinates at the board (Figure 3.1). She continued teacher exposition for the remainder of class, showing students how to calculate square roots using their calculators, and she modified the assignment for the following day to give the students more practice using the distance formula after providing another example of calculating distance between two coordinate points.



1. Open the Geogebra Applet and work through the problems using the distance formula.

Distance Formula: A way to measure the distance between two points in the coordinate plane.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Points	Set up Distance Formula	Solution
(-4, 3) & (2, 3)		
(-4, 3) & (3, 3)		
(-4, 3) & (-1, 4)		

Figure 3.1. Introducing the distance formula. This figure shows the first part of the worksheet and Mrs. Stone calculating the distance between the first pair of coordinates.

Mathematics classroom storyline 2.1**: **Students rely on the teacher to complete tasks.

Excerpt 3 (Observation: Oct 26, 2015)

Nemo: Mrs. Stone, can you help me first? Before anyone else.

Dante: I need help. I wasn't here [yesterday when we learned how to complete this activity.] (*This comment was quiet and barely audible on the video. It is unlikely that Mrs. Stone was able to hear Dante's request for help.)*

Nemo: She's [Mrs. Stone] helping me first. You was [here yesterday.]

Dante: No I wasn't.

[*Mrs. Stone comes over and kneels next to Nemo (Figure 3.2)*.]

Mrs. Stone (to Nemo): Ok, we've got to insert our image… [*Intervening comments redacted.*]

[*6 minutes pass after Mrs. Stone leaves the group while Nemo, Rosy, and Nemo work individually.*]

Dante: Mrs. Stone. [*Raises hand*.]

Excerpt 3 illustrates how students worked individually, with little cooperation within their assigned groups (see seating arrangement in Figure 3.2). Before this excerpt, Mrs. Stone launched the task for the day: *use the distance formula to decide whether or not you live in a food desert*. The task itself encouraged students to work individually because Mrs. Stone required each student to submit their work and because the task was individualized based on students' home addresses, but the group seating arrangement was intended to encourage students to help each other with the procedural aspects of the task. Excerpt 3 illustrates how the students only worked individually or with help directly from Mrs. Stone. Both Nemo and Dante expressed a need for help, and Mrs. Stone reminded Nemo how to capture an image in Google Maps and import it into Geogebra to determine coordinates for her home and the nearest grocery store – the same task that Dante needed help with because he missed Mrs. Stone's demonstration in the previous class. Mrs. Stone worked only with Nemo before leaving the group. Then, Rosy, Nemo, and Dante worked individually at their computers for six minutes[3] before Dante called Mrs. Stone over again to help him import his map into Geogebra. During the six minutes, Dante did not seek help, nor did Rosy or Nemo offer help, with the procedural aspect of using technology to start the task. I observed similar interactions anytime students struggled to use mathematical or technological procedures while working individually.

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[3] In my analysis, I could observe Rosy working on the task, and based on a later question, Nemo clearly had made progress on the task. I was unable to tell what Dante was doing on his computer during the six minutes before he asked Mrs. Stone for help again, but he did not seemed to have made progress on the task. I often observed Dante (and other students) play games on their computers when the teacher was not available to help.

Figure 3.2. Working individually and with Mrs. Stone. This figure illustrates the beginning of Excerpt 3 when Mrs. Stone helped Nemo but not Dante.

Mathematics classroom storyline 3.1**: **The teacher designs but does not always reinforce features of small group tasks that require collaboration and every group member to participate.

Excerpt 4 (Observation: Oct 26, 2015*)*

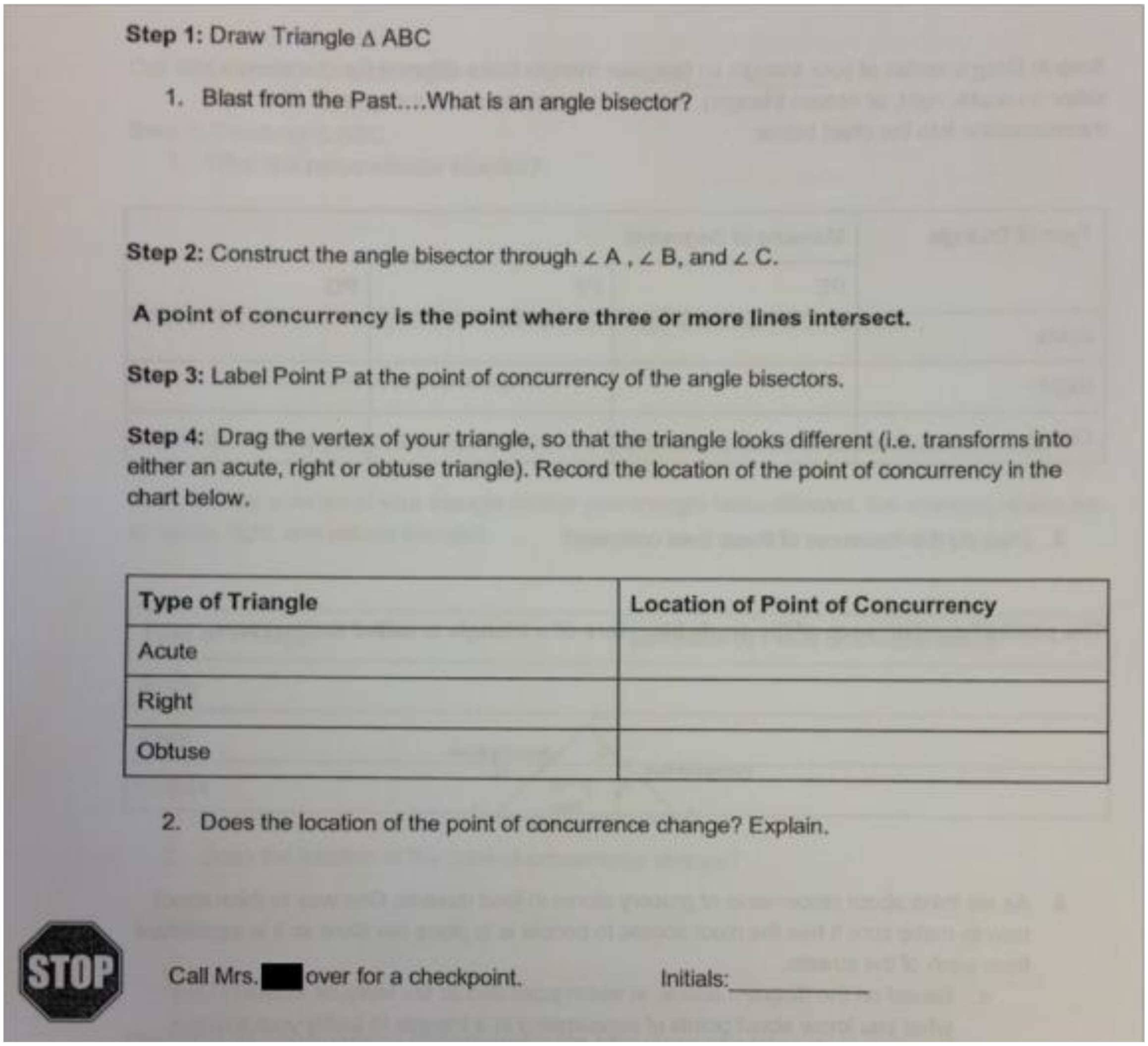
Rosy: We're done.

Mrs. Stone: Looks good. Everyone can explain it? [*Rosy, Nemo, and Dante nod.]* Dante can explain it? [*Dante nods.*] Make sure because I think I'm going to call on you.

Although tasks designed for small group collaboration were rare in Mini-project 2a (Table 3.3), Excerpt 4 shows how Mrs. Stone drew on strategies from complex instruction (i.e., reinforcing that the group is accountable for each individual student's learning) to require collaboration and encourage every group member to participate. This excerpt came at the end of a small group activity: *students worked with their group to create and solve their own distance formula problem*. Mrs. Stone told students that any group member should be prepared to explain the group's problem to the whole class, and she reminded Rosy, Dante, and Nemo of this in Excerpt 4. Mrs. Stone told Dante that she would ask him to explain to the class, likely because she observed that only Nemo and Rosy had worked together to create and solve the problem and/or because Dante was absent the previous day when students practiced using the distance formula. After Mrs. Stone left the group, Dante leaned in towards the whiteboard where Nemo and Rosy had written the problem, but consistent with Storyline 2.1, Dante did not ask for help, nor did Nemo or Rosy offer to help, with explaining the problem. At the end of the activity, Mrs. Stone announced to the class that she decided not to have students explain their problems to the whole class because she had heard everyone explaining as she monitored the groups. Thus, Dante was never required to explain Nemo and Rosy's problem, and the collaborative features of the task were not reinforced.

Mathematics classroom storylines in Project 4. The three storylines that students and the teacher enacted and invoked in Mini-project 2a shifted during Project 4 (Where would a grocery store help?; centers of triangles). Thus, I present three new storylines for the mathematics classroom figured world, but I link each one, respectively, to the previous storyline. For example, Storyline 1.2 in this section is related to Storyline 1.1 in the previous section. Moreover, I underline the part of the storyline that shifted from Mini-project 2a to Project 4. As previously, I illustrate each storyline with excerpts that include both content of talk and actions, gestures, etc. Although I include only excerpts from Project 4, analysis suggested that students and the teacher enacted and invoked these same storylines during Project 7.[4]

[4] Table 3.3 shows how students spent similarly proportional amounts of time engaged in small group work and whole class activity across Project 4 and Project 7 (Proposing a community garden; scale, area, and volume). The differences in time devoted to individual work versus presentation stemmed from differences in the structure of assignments. Project 4 included final products that students submitted individually (e.g., a paragraph about the benefits of placing a grocery store in a specific area of Midland City) and as a group (e.g., a final, cumulative presentation that they shared at an afterschool open house). In Project 7, all final products were group products, and students shared presentations during instructional time. For examples of students' interactions with mathematics and their peers during Project 7 see Harper (under review [Chapter 4]).



Step 1: Draw Triangle Δ ABC

1. Blast from the Past….What is an angle bisector?

Step 2: Construct the angle bisector through ∠ A , ∠ B, and ∠ C.

A point of concurrency is the point where three or more lines intersect.

Step 3: Label Point P at the point of concurrency of the angle bisectors.

Step 4: Drag the vertex of your triangle, so that the triangle looks different (i.e. transforms into either an acute, right or obtuse triangle). Record the location of the point of concurrency in the chart below.

Type of Triangle	Location of Point of Concurrency
Acute	
Right	
Obtuse	

2. Does the location of the point of concurrence change? Explain.

STOP Call Mrs. [redacted] over for a checkpoint. Initials:____________

Figure 3.3. Beginning of exploration of centers of triangles activity. This figure shows the first steps students needed to complete to discover properties of the incenter.

Mathematics classroom storyline 1.2**: **<u>Students work autonomously to figure out how to use the</u> mathematical and technological tools necessary for the project.

Excerpt 5 (Observation: Jan 11, 2016)

Rosy (to Blake): We can just do it together on my computer. Look how cool this is! [*Drags a vertex of a triangle with three angle bisectors that she constructed in Geogebra. (See Step 4 in Figure 3.3).*]

Blake: Oh!

[*Intervening comments redacted as Rosy and Blake continue to drag vertices to make different types of triangles.*]

Rosy (to Blake): There's nothing you can do to make it go outside of the triangle.

Excerpt 6 (Observation: Jan 11, 2016)

Dante (to George): Wait, go back to that thing [in Geogebra]. [Mrs. Stone] said [in the video] you have to click on "perpendicular bisector". [*Points to something on George's computer in Geogebra.*] Click on that.

As Table 3.3 showed, Mrs. Stone spent very little time engaged in teacher exposition during Project 4. Instead, students spent the majority of their time working in small groups. Excerpts 5 and 6 illustrate how students were able to work independently of the teacher to figure out both the mathematics and how to use the technological tools necessary to complete the larger project. Mrs. Stone introduced students to the mathematics content of the project (i.e., center of triangles) by asking them to work collaboratively to complete an exploration in Geogebra. This exploration required students to construct triangles with the various points of concurrency and to manipulate those triangles to discover the properties of center of triangles (Figure 3.3). In Excerpt 5, Blake was struggling to construct his triangle, but Rosy had already completed Steps 1-3 (Figure 3.3). She told Blake to look at her computer for Step 4, in which they realized that the incenter is always located inside the triangle. Figure 3.4 shows how Rosy and Blake worked together: Rosy did the work on her computer as Blake watched. Unlike Mini-project 2a, when Mrs. Stone provided students with the distance formula and the meaning of the formula and planned for them to use a pre-existing Geogebra applet to reinforce the meaning (Excerpt 2), in Project 4, students made their own constructions in Geogebra and their own discoveries about the properties of points of concurrency.

Excerpt 6 shows how students were able to work more autonomously with the mathematics because they did not need to wait for Mrs. Stone to be physically present to guide them through the procedural aspects of using technology in an unfamiliar way. Mrs. Stone created a series of videos, which explained and showed how to make constructions in Geogebra, and students could access those videos as necessary. Throughout the task, Dante watched the appropriate videos on his own computer and explained to George how to make the constructions in Geogebra on his computer. Figure 3.4 shows George looking at Dante's computer as they watched the video, but the figure does not show how Dante would subsequently look onto George's computer as George did the construction with Dante's guidance. For Steps 1-4, after each step, Dante also did the constructions on his own computer while George explained to him (without the videos) what to do, but as they moved forward, they realized it was more time efficient to do the constructions only once. During over 30 minutes of small group work on January 11, they worked continuously on the task, rewatched the teacher videos together as needed, and were able to complete most of the constructions without direct help from Mrs. Stone.

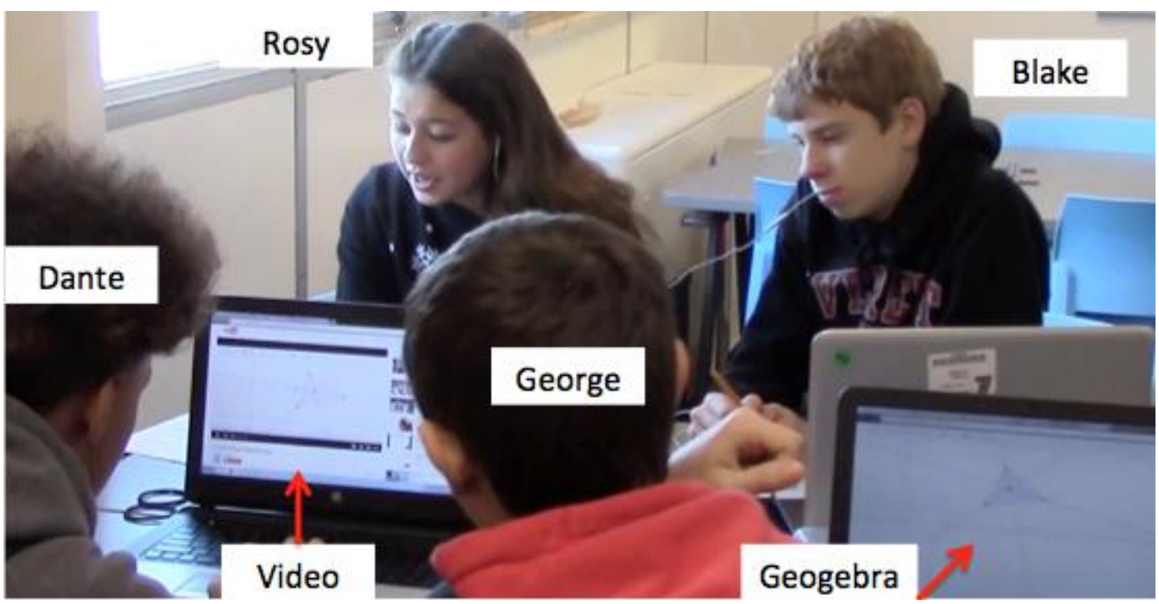


Figure 3.4. Group of four students working as two pairs. Blake looks on as Rosy works on her computer. Dante and George watch videos together on Dante's computer, and then they make constructions in Geogebra together on George's computer.

Mathematics classroom storyline 2.2**: **Students rely on <u>their peers and</u> the teacher to complete tasks.

Excerpt 7 (Observation: Jan 11, 2016)

George: Inside, inside, inside. [*George and Dante write on the table (Step 4 in Figure 3.3)*.]

Dante (to Rosy): Hey, what answer did you write here? [*Points to #2 under Step 4 in Figure 3.3*.]

Rosy: I said, “No, they’re all inside.”

Excerpt 8 (Observation: Jan 14, 2016)

Rosy (*looks at table in Figure 3.5*): Visual picture of an altitude [*Does a search for an image of “altitude” on her phone.*]

Blake: Good job on using your technology, guys!

Rosy (*shows her phone to the group*): Ok. So look for something that looks like this. [*Looks at cards with diagrams of triangles.*] They all look the same!

George: Not all of them. [*Points to one diagram.*] This one has a right angle.

[*Intervening comments redacted as Rosy, George, Dante, and Blake continue to look for the visual representations of each segment.*]

Dante: Here. [*Hands a the visual representation of “median”*.] The median is the point in the middle.

Rosy: Oh, yeah. Smart! [*Looks at card.*] Are you sure?

Dante: Yeah. It’s the right one.

As Excerpt 3 illustrated, during Mini-project 2a, students relied only on Mrs. Stone when they needed help completing a task. In contrast, during Project 4, as Excerpt 7 shows, students more often turned to their peers to ask for help. Dante and George had relied on each other, the provided videos, and Mrs. Stone (a couple of times) to complete the constructions in Steps 1-4 (Figure 3.3) in Geogebra (Excerpt 6). Together, they realized that the incenter is always inside the triangle (evidenced by George's statement in Excerpt 7), but Dante is not sure what to write in response to question 2 (under Step 4 in Figure 3.3). Rather than calling Mrs. Stone over for help, he asks Rosy what she wrote, and she shares her response with him. Excerpt 8 also shows how students relied on each other, as a whole group, to complete a cooperative task. After students had completed the exploration in Geogebra, Mrs. Stone assigned a participation quiz – a complex instruction strategy where the teacher evaluates groups on how they participate collaboratively (Esmonde, 2009b; Featherstone, Crespo, Jilk, Parks, & Wood, 2011) – in which students had to sort cards with different properties using the table shown in Figure 3.5. Groups were assessed on their ability to: (1) get started quickly; (2) provide justification when they sorted the cards; (3); ask their group mates why they sorted the cards a particular way; and (4) make the materials accessible to all. Initially, Rosy had all of the materials, but after Blake reminded her to make the materials accessible to all, she distributed cards to everyone (Figure 3.5). Excerpt 8 and Figure 3.5 illustrate, after having the materials accessible, George and Dante were able to provide mathematical justifications that there were differences in the visual images and that one of the diagrams must be the median, respectively. The group correctly sorted the cards without soliciting any help from Mrs. Stone.

Segment name:	Altitude	Angle Bisector	Median	Perpendicular Bisector
Visual				
Definition				
Special name of point of concurrency				
Special Characteristic				
Other characteristics				

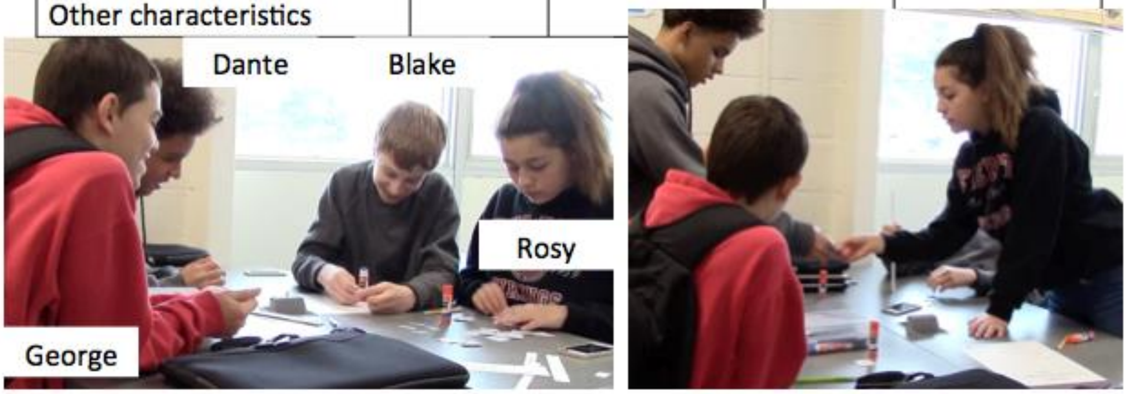


Figure 3.5. Students work on sorting cards during participation quiz. This figure shows how initially Rosy had most of the materials, and Dante, George, and Blake had to lean in to have access to the cards (*left).* After Rosy distributed the cards at Blake's request, each student in the group was able to contribute to sorting (*right).*

Mathematics classroom storyline 3.2**: **The teacher designs <u>and reinforces</u> features of small group tasks that require collaboration and every group member to participate.

Excerpt 9 (Observation: Jan, 11, 2016)

Rosy (to Dante, George, and Blake, after reading Step 2 in Figure 3.3): Do you guys all have the same question of, "What is a point of concurrency? And where to put it?"

Dante: Yeah. [*Continues working with George.*]

[*Rosy raises her hand.*]

Excerpt 10 (Observation: Jan 11, 2016)

Rosy (to George and Dante): Did you guys reach stop yet? [see Figure 3.3]

George: No

Rosy: Ok, just let us [me and Blake] know.

When Mrs. Stone launched the Geogebra exploration, she introduced two complex instruction strategies designed to encourage collaboration.: (1) students can only ask the teacher a question if they ask everyone in the group first and everyone has the same question (Excerpt 9); and (2) students must stop at checkpoints (stop sign in Figure 3.3) to make sure the group is together and to check in with the teacher before moving to the next part of the task (Excerpt 10) (Featherstone et al., 2011). The teacher reinforced these features of the task, and students participated. Unlike features described in Excerpt 8 (e.g., making sure all the materials are accessible to everyone), however, collaborative features of tasks did not always have the desired outcome. In Excerpt 9, Rosy's question and Dante's response suggest that Rosy simply wanted the group to agree they had the same question before calling Mrs. Stone over. The group did not engage in discussing the question about the mathematical concept. Similarly, in Excerpt 10, because they have been working separately as two pairs, Rosy checks with George and Dante once she and Blake reach the checkpoint. Instead of working together as a group of four to help George and Dante reach the checkpoint (as the feature intends), Rosy and Blake watch an unrelated video on Blake's computer while they wait for George and Dante to catch up to the checkpoint.

Food Desert Figured World

Although Victory is not located within a food desert, most students lived in a food desert (according to USDA, 2017). Students had extensive experience with buying and consuming food in Midland City, but they were new to interpreting parts of the city and/or the area surrounding their homes as a food desert. Collectively constructing the food desert figured world required students to imagine their out-of-school experiences and the experiences of others who live in food deserts. Thus, identifying storylines relied heavily on the content of student talk during class and interviews, and this is reflected in the selected excerpts. Across the three projects, students collectively constructed four storylines within the food desert figured world. Unlike the storylines within the mathematics classroom figured world, the shifting of storylines in the food desert figured world was not clearly contained within specific projects. Instead, students invoked storylines from previous project(s) as they refined, extended, and negotiated the food desert figured world during Project 4 and Project 7. In this section, I provide excerpts from across projects to illustrate each storyline and elaborate on each excerpt to illustrate how the storyline was invoked across projects.

Food desert storyline 1: People in urban areas who have limited access to healthy and affordable foods live in a food desert.

Excerpt 11 (Observation: Oct 21, 2015)

Mrs. Stone (reading Monique's definition to class): Food desert is an urban area where it's difficult to buy high quality and affordable food. I like that definition.

Excerpt 12 (Observation: Jun 2, 2016)

Simba (during presentation): A food desert is when there isn't a full-service grocery store within a mile from your home.

Excerpt 11 illustrates how, from the beginning of Mini-project 2a, students agreed that limited access to healthy and affordable foods makes an area a food desert. Monique's definition came from Mini-project 2a. After students made some initial conjectures about the meaning of "food desert" (e.g., Rosy guessed the meaning to be areas without food based on the individual words "food" and "desert"), Mrs. Stone asked students to do a Google search to write their own definitions for "food desert," which tried to incorporate a mathematical way to define food deserts. As students explored and discussed social justice issues surrounding food deserts across projects (e.g., relationship between low-income areas and food deserts, health risks associated with living in a food desert), they agreed that people who lived in food deserts had difficulty buying quality and affordable food, a situation that was problematic. As I discuss in the next storyline, however, they disagreed about *what* qualified as limited access to healthy and affordable food. They tended to prefer Monique's definition of "food desert," with more ambiguity about what made buying high quality and affordable food difficult. In particular, they resisted Mrs. Stone's definition of a food desert as an urban area without a full-service grocery store within a mile radius throughout Mini-project 2a and throughout most of Project 4 (discussed in the next storyline). Excerpt 12 illustrates that by the time students created presentations in Project 4 and 7, they had adopted using "one mile" and "full-service grocery store" to define a food desert. Excerpt 12 shows how Simba described a food desert during presentation in Project 7, but the slide that the group displayed during the presentation was from the one they created in Project 4.

Food desert storyline 2: People who live more than one mile from a grocery store can still get healthy and affordable food.

As mentioned previously, students resisted Mrs. Stone's claim that living farther than one mile from a grocery store made getting healthy and affordable food difficult. Based on their own out-of-school experiences, they argued that grocery stores were not the only places with affordable and healthy foods (food desert storyline 2a) and that people could get food from grocery stores farther than a mile from their homes (food desert storyline 2b). Students used these arguments to reject interpreting areas of Midland City, particularly those areas immediately around their homes, as food deserts during Mini-project 2a and Project 4. It was unclear whether or not, and to what extent, food desert storyline 2 persisted across Project 7 because teachers asked student to propose a way of addressing problems of food deserts through a community garden rather than through adding a grocery store. Because of the limited talk in Project 7 about grocery stores, I include only excerpts from Mini-project 2a and Project 4 to illustrate this storyline.

Food desert storyline 2a: People can get healthy and affordable foods at convenience stores and fast food restaurants.

Excerpt 13 (Observation: Oct 22, 2015)

Nemo: [At] Wendy's, you get 4 for $4…that's cheap!

Excerpt 14 (Group interview: Jan 22, 2016)

Jane: A McDonald's is not really a place to actually go and get groceries to bring home. You need a grocery store.

Carley: But McDonald's does have kind of healthy food, like salads and stuff like that.

Tino: That's not healthy. You see what they put on it?

Rosy: [McDonald's] does have some healthy options, and I live around the corner from a [Midland City convenience store and dairy producer], and you can get milk there. And that's a healthy option, but I think the reason why I live in a food desert is because it's not like a real grocery store where you can get all different types of healthy foods.

Excerpt 15 (Observation: Jan 7, 2016)

Jane: There's a McDonald's right over here. [*Points to map on computer.*] And a Kroger [grocery store] right here. And there's a Subway. And a [regional coffee shop]. They're all walking distance. Like I could walk.

Excerpts 13-15 illustrate how students emphasized the affordability and accessibility of food at fast food restaurants and convenience stores as places with healthy foods, as a way to resist interpreting their community as a food desert. In Excerpt 13, Nemo noted how affordable food is at fast food restaurants, and in Excerpt 14, Carely argued that you could get healthy foods, like salads, there. This interpretation of fast food restaurants persisted throughout Mini-project 2a, but Excerpt 14 shows how some students were beginning to question the storyline about fast food restaurants by the end of Project 4. By the group interview on January 22, students had finished a project related to healthy meal planning in their BioHealth class. Mrs. Stone made references to the BioHealth project throughout Project 4, but the students never directly referenced this project during in-class conversations or interviews. Their experiences with the BioHealth project, combined with their own personal experiences eating at fast food restaurants (Tino's comment, Excerpt 14), may have been sources of motivation for some students to question the availability of healthy food options at those restaurants and to recognize the need for grocery stores. Nonetheless, most students continued to insist that fast food restaurants and, especially, convenience stores carried healthy food options (Carley's and Rosy's comments, Excerpt 14), and the storyline did not collectively shift. Moreover, Excerpt 15 demonstrates how even students who recognized the importance of grocery stores (Jane's comment, Excerpt 14), persistently rejected framing the area around their homes as a food desert, and instead, they stressed their personal experiences with an abundance and diversity of places to buy food.

Food desert storyline 2b: People who live more than one mile from a grocery store can still get healthy and affordable foods from grocery stores.

Excerpt 16 (Observation: Oct 21, 2015)

> Kendra: I don't think [limited access to a grocery store] would be linked to obesity because if you're not going there [grocery store], you could have someone else go there and bring [healthy food] to you. Like, you could pay them.

Excerpt 17 (Group interview: Jan 22, 2016)

> Rosy: I don't think it's as bad as they [*unclear who she meant by* 'they'; *maybe the teachers or websites she read*] make it seem, because if you have a car and just because you have to drive a little ways doesn't mean you're going to die.

Excerpts 16 and 17 illustrate how students never took up the storyline that the teacher attempted to promote about people in Midland City needing more grocery stores. Both Mini-project 2a and Project 4 required students to chose a location for a new grocery store in Midland City to help alleviate limited access to quality and affordable food. In Mini-project 2a, the teacher determined the location: at the midpoint between each student's home and Victory, and in Project 4, students chose their own location based on their maps of food deserts in Midland City (USDA, 2017) and centers of triangles. Although students completed both projects as instructed, they insisted people farther than a mile from a grocery store could access healthy and affordable foods. Based on their personal experiences, students recognized that people could either drive to a grocery store (Excerpt 17) or ask someone else to go shopping for them if they could not drive (Excerpt 16). Thus, students did not view the number of grocery stores currently available in Midland City as problematic.

Food desert storyline 3: Some students from Victory and some people in Midland City live in a food desert, and that is a problem because of the negative health consequences.

Excerpt 18 (Observation: Jan 7, 2015)

Ashley: I am [my home is] in a food desert. [*surprised tone*] I guess.

Jane: I'm not in a food desert.

Monique: I am.

Jane: But see. Look! All around me is green [a food desert according to USDA (2017)].

[*Jane, Monique, and Ashley show each other their computer screens and point out where the food deserts are near their homes.*]

Ashley: All around me is [a food desert].

Excerpt 19 (Observation: Jun 2, 2016)

George (during presentation): According to kidshealth.org, 1 in 3 kids in America are obese. This is a big problem. According to [a survey we did of 150 New Tech students], 54% never eat the fruits and vegetables given at lunch. 27[%] don't even know the benefits of fruits and vegetables. 71% said that they eat fast food 1-2 times in a week.

Excerpt 20 (Group interview: Jun 2, 2016)

Dante: Why do we just focus on [the area around Victory] having like a food desert? What about people that live 2 miles or more away from [Victory] and don't have a store or nothing near them. I think we need to help everybody instead of just helping [the community near Victory].

Mrs. Stone acknowledged that students had decided after Mini-project 2a that their neighborhood (south side of Midland City) was not a food desert, but for Project 4 she invited students to revisit the idea of food deserts in other areas of Midland City. Students used a searchable map of food deserts in the United States (USDA, 2017) to find their home, to explore the area around Victory, and to look at all of Midland City to decide where food deserts were located. Excerpt 18 illustrates how some students were surprised to learn that the area surrounding their home was classified as a food desert, but they generally trusted the data reported on the USDA (2017) map. At first, Ashley seemed surprised, but later, her tone suggested that she believed that the area around her home was a food desert. In the group of three, only Jane did not live in a food desert, and, nonetheless, she seemed surprised, but trusted, that areas near her home were food deserts. At the end of Project 4, as students were working on their presentations, I asked them whether or not they were convinced that some students at Victory lived in a food desert, and everyone told me that they were (Field Notes: Jan 21, 2016). This was also reflected in Rosy's comment in Excerpt 14.

Excerpts 19 and 20 show how students not only took up the idea that some students at Victory and some people in Midland City live in food deserts but they also took up the idea that food deserts are problematic. Across projects 4 and 7, students had multiple opportunities to do collaborative research on food deserts. In mathematics class during Project 4, Mrs. Stone engaged students in an activity (Southern Poverty Law Center, 2017) to identify the causes and consequences of food deserts. Health consequences were a prominent focus of students' research and discussions, and a focus on obesity as a possible consequence of food deserts is reflected in Excerpt 19. In this excerpt, George also referenced a survey that his group did as part of their proposal (for the community garden) in their English class for Project 7. George used data from this survey to suggest childhood obesity could be a potential issue among students at Victory that the community garden would address. Throughout Project 7, Mrs. Stone made references to aspects of the project that students were completing in their English and BioHealth classes, and the students explicitly invoked their English and BioHealth experiences in conversations during mathematics class, during presentations (this was required), and during interviews (see Excerpt 23 for another example). Excerpt 20 illustrates students' growing concerns about the negative impacts of food deserts. In the presentations, students focused on the potentially negative health consequences of having limited access to healthy foods, and they proposed nutritional education, as well as food access, for the community garden (detailed in the next storyline). Although Mrs. Stone had asked students to think broadly about food deserts in Midland City during Project 4, Project 7 asked them to focus locally on students and families at Victory and the immediate community. Nonetheless, some students, such as Dante (Excerpt 20), recognized food deserts as a broader problem for the city.

Food desert storyline 4: A community garden can help address the negative health consequences of food deserts but only if there is a nutritional education component.

Excerpt 21 (Group interview: Jun 2, 2016)

Carley**:** In biology, we learned all the different things that vegetables do for you. Like what all the different colors do for your body. And everyone is just kind of focusing on food deserts [i.e. access to food], but we need to focus on eating healthy, too.

Excerpt 22 (Individual interview: May 27, 2016)

> Rosy: One idea my group had is to make recipes [for each of the vegetables in the community garden]. That would be good, because when you're eating healthy, that doesn't always mean straight eating vegetables and fruits. You know what I mean? My dad can make a chicken and broccoli fettuccine and it still had vegetables in it. I think that's really important to include like a recipe so you're still eating your vegetables and it's not just straight vegetables.

Excerpts 21 and 22 illustrate how students focused on nutritional education as a major component of the proposed community garden in Project 7. In their final presentations, students shared ideas about how to distribute the produce they would grow in the garden. Most suggested donating it to people living in food deserts in Midland City, including Victory students and families, but as Excerpt 21 shows students recognized that providing more access to fruits and vegetables would be insufficient to address the impact of food deserts. Overwhelmingly, students focused on the importance of using the community garden to provide nutritional education for students and the broader community in order to address the negative health consequences associated with living in a food desert. Students drew on their school-based experiences, such as learning about the benefits of different vegetables in BioHealth (Excerpt 21), and their out-of-school experiences, such as cooking at home (Excerpt 22), to propose ideas for nutritional education in the garden.

Figured World of Authenticity

Within the context of project-based learning, school content and activities were figured, intentionally, as authentic to the out-of-school world. Students were familiar with the classroom as authentic to the out-of-school world from their experiences as New Tech students in 8th grade, and their comments and actions in the mathematics classroom clearly reflected an expectation of authenticity. This figured world of authenticity created a hybrid space where students merged their out-of-school-based experiences with their school-based ones. Although there was only one storyline within this figured world, I provide three sets of excerpts to illustrate the subtlety within the storyline. Excerpts are drawn from all three projects.

Authenticity figure world: School projects and the mathematics involved (should) address authentic, real-world situations.

Excerpt 23 (Observation: Oct 21, 2015)

Nemo: Is this true? [*Tone suggested skepticism.*]

Mrs. Stone: Yes, actually. The mayor is… [*talks about a citywide initiative to promote nutrition and physical activity.*]

Excerpt 24 (Group interview: Jun 2, 2016)

Blake: Yeah, [Project 7] could be anything. It doesn't need to be a garden. That's the problem with this project. We had to do a garden and write a proposal, blah blah blah. I think they should just say, "Help the community. Here's some cool ways to do it." Then, we go off and do it how we want. I would learn more probably. The only thing again this is that they have things they [have to] teach us.

Excerpt 23 and 24 illustrate the general expectation that projects should relate to authentic, real-world situations. When Mrs. Stone launched Mini-project 2a, she asked students to read a letter about the project, explaining how the mayor asked for more information about access to quality and affordable food in Midland City for a citywide initiative to promote nutrition and physical activity. Skeptical, Nemo asked Mrs. Stone (loudly enough for everyone to hear) if the details in the letter were real. Mrs. Stone responded (for everyone to hear) that the citywide initiative was real, but she admitted that the mayor had not contacted her asking for more information from the New Tech students. Mrs. Stone, however, explained that Nemo's question had inspired her to choose some of the letters (the final product for the project) and actually mail them to the mayor. Similarly, Blake discussed how, without the constraints of a school project, he might have chosen a different approach to addressing impacts of food deserts in the community than the approach of building a community garden selected by the teachers.

Excerpt 25 (Observation: Oct 23, 2015)

Carley: We're not going to do all this [use the distance formula] to find a distance. That's what GPS is for.

Mrs. Stone: We talked about this yesterday when we looked at Google Maps. But remember [food deserts are based on the shortest distance.]

Excerpt 26 (Group interview: Jan 22, 2016)

Tino: Well, a food desert has to do with health class and how to get yourself near a grocery store, this and that. Then, you want to put triangles in that, it's pointless.

Excerpts 25 and 26 show how students expected the mathematical work involved in projects to authentically match the methods involved in addressing the situations in the out-of-school contexts. In Mini-project 2a and Project 4, in particular, students highlighted times when they felt the mathematics involved in the project was inauthentic. In Excerpt 25, during the launch of the distance formula activity, Carley objected (to Mrs. Stone and the whole class) that she would not actually use the distance formula if she needed to calculate the distance from her home to the grocery store. Mrs. Stone reminded her that Google Maps (or GPS) would not give her the shortest distance required by the food desert definition; however, students continued to object to using the distance formula in this way throughout the project. Similarly, in Excerpt 26, Tino expressed his concerns that the connections between mathematics, specifically center of triangles, and food deserts were contrived in mathematics class, and, instead, the topic would be more authentic to BioHealth class. Although Mrs. Stone made comments throughout Project 4 to connect the mathematics topic to the context of grocery store access, the students only made these connections when required to by a particular assignment (e.g., questions during the Geogebra exploration; final presentations).

Excerpt 27 (Observation: Jan 21, 2016)

George: This [slide] is [about] the impact [of placing a grocery store in a specific location within a food desert]. What would happen?

Dante: How far would [the grocery store] be away though?

George: A mile. It's gotta be within a mile of you [to no longer be considered a food desert].

Dante: So it'd be better cause people could walk to a grocery store.

Excerpt 28 (Individual interview: May 23, 2016)

Monique: I like the gardening [project the most] because I liked learning plants because I would do that with my grandpa. I'd help him with his garden that he has.

Harper: So do you think that he uses the same kind of math that you're doing [at school] when he works in his garden?

Monique: Yeah because he has to measure them [the garden beds] and then how deep he has to plant [the seeds or plants] and how far apart they have to be.

Excerpts 27 and 28 illustrate ways in which students were able to connect the mathematics involved in projects to their out-of-school experiences in authentic ways. In Project 4, analysis suggested that students did not make any spontaneous connections between centers of triangles and access to a grocery store, but in Excerpt 27, Dante made a spontaneous connection between his out-of-school experience of being able to walk distances within a mile and the requirement that he and George place a grocery store within a mile to alleviate the food desert in the selected area. During Project 7, I found that students frequently made spontaneous connections between the mathematics they were using to design a garden and their out-of-school experiences, which influenced their design choices, but I did not observe any spontaneous connections between the mathematics of gardening and the broader social justice issue of food deserts. Excerpt 27 reflects the ways that students saw the mathematical work of Project 7 as authentic for gardening but more indirectly related to addressing the issues of food deserts.

Discussion: Negotiations of Identity and Power across Figured Worlds

Within a context that integrated various equity-minded instructional approaches, CI, TMSJ, and project-based learning provided students different opportunities to negotiate identities and power across the three projects. Remember, I frame identity as performative, fluid, and flexible, such that different identities can be more salient in different contexts and at different moments. In this section, I discuss possibilities for interpreting students' negotiation of identity and power within each of the three figured worlds in light of the storylines described above and based on what we know from existing theory and research about each pedagogical approach.

Identity and Power in the Mathematics Classroom Figured World

In the mathematics classroom figured world, students' mathematics identities were most salient, specifically in regards to students' relationships to mathematics (Boaler & Greeno, 2000; Horn, 2008). Table 3.1 listed each student's overall academic status in mathematics for the 2015-16 year based on my analysis of interviews in which students explained how they positioned themselves and believed others saw them as mathematics learners and based on conversations with the teacher about her perceptions of status and about students' scores on assessments. Mathematics identity, however, is fluid, and in my analysis of classroom interactions students enacted different mathematics identities in different moments and contexts. Other researchers have observed this phenomenon (e.g., Wood, 2013) but the analysis here extends these findings by illustrating how different pedagogical strategies were associated with different storylines within the same classroom. Each storyline presented different opportunities for the enactment of different mathematics identities.

Mini-project 2a reinforced storylines in which mathematics learning is an individual endeavor. In such classrooms, the teacher is viewed as the mathematical authority and the "owner" of mathematics knowledge. Such storylines are typical in teacher-led classrooms dominated by teacher exposition and individual work (Boaler & Greeno, 2000), as was the case in Mini-project 2a (Table 3.3). In Mathematics Classroom Storylines 1.1 and 2.1, mathematical power resided with Mrs. Stone as she provided and explained the technology and the distance formula and guided students through using both procedurally. Mrs. Stone held the most authority to decide what was mathematically correct, and students had opportunities to be positioned as good at mathematics in limited ways. Namely, good mathematics students could correctly solve problems without help from others or from Mrs. Stone. In Excerpt 3 and Figure 3.2, Rosy (high status; Table 3.1) positioned herself as good at mathematics by being able to start the assignment without help from Mrs. Stone. In contrast, both Nemo (medium status; Table 3.1) and Dante (low status; Table 3.1) waited for the teacher's help before starting the assignment, enacting "not good at mathematics" identities. Dante and Nemo further distinguished their mathematics identities in Excerpt 4. When Nemo contributed to the mathematical work alongside Rosy, she enacted an identity of someone good at mathematics, but Dante never had an opportunity to demonstrate his ability to correctly explain the problem because the collaborative features of the task were not reinforced (Mathematics Classroom Storyline 3.1).

In contrast, Project 4 reinforced storylines in which mathematics learning is a collaborative endeavor. In such classrooms, mathematics authority and "ownership" of mathematics knowledge is shared among students and the teacher (Boaler & Greeno, 2000). Although the teacher still holds elevated authority to determine what is mathematically correct, mathematics knowledge is collectively constructed through small group and whole class activities as in Project 4 (Table 3.3). By working autonomously (Mathematics Classroom Storyline 1.2) students had more opportunities to enact mathematics identities as good at math because the features of the task supported them to work without direct help from the teacher. In Excerpt 6, Dante and George, two students with low status (Table 3.3), were able rely on each other (Mathematic Classroom Storyline 2.2) to engage in the mathematics work with only limited direct help from Mrs. Stone, enacting identities as students who are good at mathematics. Moreover, the reinforced features of the collaborative tasks (Mathematics Classroom Storyline 3.2) created more diverse ways for students to demonstrate the ability to do mathematics. For example, being good at mathematics came to include being able to explain mathematical thinking and provide justification. In Excerpt 10, Dante and George correctly and meaningfully contributed to their mathematical reasoning when working with Rosy and Blake. Although Dante and George had numerous opportunities to enact identities as good mathematics students throughout Project 4, differences in status persisted. In particular, Rosy maintained a higher academic status than her other group members. In Mini-project 2a, Mrs. Stone was positioned as the mathematical authority, but in Project 4, Rosy enacted that identity and was positioned as an authority and "owner" of mathematics knowledge by her peers. For example, in Excerpt 7, Dante asked Rosy for help, and in Excerpt 5, Rosy did the bulk of the intellectual work for Blake.

Persistent differences in positional mathematics identities are problematic because being capable in mathematics is associated with broader social status and 'smartness' (Gutiérrez, 2013), and differences in status can limit students' access to mathematics learning. As identity and power intersect, group members (and the teacher) listen when students perceived to have high status talk, validating their competence and allowing them to dominate group interactions. In contrast, group members (and the teacher) often overlook the contributions of those perceived to have low status (Cohen, 1994; Esmonde, 2009a, 2009b). For example, in Excerpt 3, having more mathematical status than Dante may have given Nemo more authority to get help from

Mrs. Stone, and unbalanced power dynamics may have also contributed to the group overlooking the need to ask for or offer help (Excerpts 3 and 4). In Project 4, Mrs. Stone reinforced features of collaborative tasks designed to disrupt these inequitable power dynamics (Mathematics Classroom Storyline 3.2). For example, in Excerpt 8, these features encouraged Rosy to share ownership of the materials so that Dante and George could enact mathematics identities as students good at mathematics. This strategy resulted in Rosy explicitly positioning Dante as smart. Other researchers have found such complex instruction strategies to be effective at encouraging more equitable group interactions in mathematics (e.g., Boaler, 2008; Boaler & Staples, 2008), but Excerpts 9 and 10 illustrate how students' might only superficially take up these features designed to disrupt power differences. Superficial up take can be problematic when students do not discuss their mathematical thinking as intended (Excerpt 9) or when they stop working on the task all together (Excerpt 10). Although superficial up take may more likely occur in classrooms where these features are inconsistent (used and reinforced in Project 4 but not Mini-project 2a) or when students are new to complex instruction, students' up take, even superficially, of these features also might play an important role in the overall increase in collaboration described in the shifts to storylines from Mini-project 2a to Project 4.

Of course, other influences might explain some of the interactions in the excerpts. In particular, students' personal identities likely impacted how students positioned themselves and others in regards to mathematics and group interactions. For example, friend groups likely influenced students' willingness to help each other (Esmonde & Langer-Osuna, 2013; Harper, under review [Chatper 4]). Rosy, Nemo, and Dante were not part of the same friend groups (Mini-project 2a). In contrast, Dante and Austin were friends (both on the football team), and Rosy and Blake were a romantic couple (Project 4). Broader narratives and stereotypes about different racial groups and mathematics (e.g., Asians and Asian Americans are good at mathematics; Blacks are bad at mathematics; Na'ilah Suad Nasir, Snyder, Shah, & Ross, 2013) may have helped perpetuate status differences among students. For example, in Harper (under review [Chapter 4]), I discuss an additional storyline in which Black girls, specifically, framed being able to help others do mathematics as essential to being good at mathematics in Mrs. Stone's class. This storyline influenced Black girls, in particular, because they were operating within broader racial and gendered storylines about their mathematics ability. Helping peers outside of their immediate friend groups posed a risk to perpetuating those broader storylines if they were not able to explain mathematics correctly or well.

Identity and Power in the Food Desert Figured World

Although most of the students in the class lived in a food desert, all students were new to interpreting areas around their homes and throughout Midland City as food deserts. Like the affluent students learning about social justice in mathematics classrooms described by Esmonde (2014), students had to "come to inhabit" the world described in the social justice projects (Esmonde, 2014, p. 351). Unlike the affluent students, however, most students in this study physically inhabited the world described in the projects. This difference is important because it allowed students both to learn *about* a food desert figured world in school and *within* a food desert figured world through their out-of-school experiences. Drawing on their immersion in the food desert figured world created opportunities for deeper learning about the world within the school context in a way that is not possible when the figured world must be entirely imagined by students (Jurow, 2005). As a result, students' identities from their out-of-school worlds were essential for the collective construction of the food desert figured world.

Students’ firsthand experiences with the food desert figured world might explain why they so readily took up the idea that some people in urban areas have limited access to healthy and affordable foods (Food Desert Storyline 1; Excerpt 11). Also based on their personal experiences, students resisted the definition promoted by Mrs. Stone. Because of Mrs. Stone’s authority and “ownership” of the official definition of food deserts, which was necessary for the mathematical work of the projects, students used and eventually took up the school-based food desert definition (i.e., urban area farther than a mile from a full-service grocery store). Excerpt 12 shows how students used and interpreted the school-based definition in presentations. Although it is possible that some students took up this definition only superficially within the school-based context, Excerpt 20 suggests that at least some students took up describing food deserts in terms of miles in contexts when it was not required by Mrs. Stone. Nonetheless, students’ persistent resistance to the school-based definition is important to consider. Other researchers have noted students who are historically marginalized’s resistance to the integration of social justice topics in mathematics classrooms, particularly when topics are selected by teachers as relevant for students (e.g., Brantlinger, 2013; Leonard et al., 2010). A certain level of resistance might be expected when students are introduced to new ideas (e.g., different teaching approaches; a new framing for a familiar issue), but that resistance might fade as students negotiate and reconstruct the new ideas and come to inhabit a new figured world. This case of TMSJ is unique because of opportunities for students to reconstruct the food dessert figured world across settings, activities, and time, something which other researcher suggest can make social justice actions increasingly consequential (Jurow & Shea, 2015).

Because the social justice projects required students to establish an identity in a new figured world (i.e., the food desert figured world), “it is important to consider the influence of the other worlds [students] simultaneously inhabit" (Barton & Tan, 2010, p. 193) in thinking about how they negotiated this world across settings, activities, and time. One of the most salient dimensions of student identities in their construction of the food desert figured world was their identity as experienced consumers of food in Midland City. Based on their own experiences, students insisted that, even if their home was farther than a mile from a grocery store, they could access healthy and affordable food (Food Desert Storyline 2). Grocery stores were not the only places they could buy affordable and healthy foods (Food Desert Storyline 2a), and people could get food from grocery stores farther than a mile from their homes, either with a car or with the help of someone else (Food Desert Storyline 2b). This resistance to interpreting areas around their homes as food deserts is understandable given that students recognized that "desert" implied a total absence or lack of something. Thus, the wording, "food desert" itself implies a deficit framing of the areas surrounding students' homes, which did not align with students' experiences with accessing a diversity and abundance of food near their homes (Excerpt 15; Food Desert Storyline 2). Moreover, as students did additional research on food deserts in Project 4, they learned about the relationship between poverty and food deserts. Based on interviews in which I asked students to describe their socioeconomic status, however, students did not position themselves and their families as poor. Most of the students qualified for free lunch, and in Mini-project 2a, Nemo made a reference to using public assistance for food, but during interviews, students told me their families were middle class (or higher). Students inhabited a home-based figured world that they constructed as abundant, particularly in regards to food, and this home-based figured world was incompatible with the food desert figured world promoted in school (e.g., Excerpt 18) during Mini-project 2a and Project 4.

Students largely rejected framing the areas around their homes as food deserts, and instead, they took up a focus on nutrition and nutritional education rather than the emphasis on access to full-service grocery stores as they reconstructed the food desert figured world in school (Food Desert Storyline 4). Focusing on individual choices and nutrition likely made students more willing to accept that some students and people in Midland City lived in food deserts (Food Desert Storyline 3). This storyline was more compatible with storylines from their out-of-school experiences, in which they and other students regularly ate and enjoyed unhealthy food options, but students could adopt this framing of food deserts without accepting a personal framing of themselves or their communities as deficit (Excerpt 19). This focus on nutrition initially stemmed and was later reinforced by experiences in their BioHealth class. During Project 4, students simultaneously completed a project focused on nutrition and meal planning in BioHealth, and during Project 7, teachers collaborated to incorporate the project into BioHealth (plant biology; nutrition), geometry, and English (writing grant proposals). Extending the construction of the food desert figured world to other settings (e.g., BioHealth) and different activities in those other settings (e.g., research in English class) allowed students to have more authority over what they emphasized within the projects because food deserts where strictly defined to facilitate certain mathematics content in geometry class. As students redefined and reconstructed the food desert figured world, they also took on "to a certain degree the concerns and responsibilities of the characters in this imagined world", something that makes virtually constructing out-of-school figured worlds in school setting more effective (Jurow, 2005, p. 60). In storyline 4, students positioned imagined others as living in food deserts and needing help (Excerpts 19 and 20), while they positioned themselves and their families as already having access to food and being able to help.

Mrs. Stone intended for the introduction of the food desert topic to act as a mirror, giving students opportunities to see important issues in their lives reflected in mathematics class (Gutiérrez, 2012). To some extent, this was successful because students took up their out-of-school experiences (e.g., cooking at home) in meaningful ways to construct and reconstruct the food desert figured world in geometry class and across settings and activities in BioHealth and English. Students, however, largely positioned the food desert projects as windows, or opportunities to view a broader world (Gutiérrez, 2012). Although both mirrors and windows in the mathematics curriculum are important, the balance within the food desert figured world was disproportionately shifted towards viewing the situation of others (e.g., windows). While this negotiation of the food desert figured world eased students' resistance to the social justice topic and allowed them to assert their authority over the project, the shift in storylines also came at a cost. Namely, the focus on nutrition overshadowed the emphasis on broader social, cultural, and economic causes and consequences, in addition to the health consequences, of food deserts, which Mrs. Stone introduced and students researched in Project 4. The emphasis on individual choice and nutrition inherently deemphasized the broader systems of power that create inequitable access to affordable and healthy foods in the first place. Moreover, students challenged and rejected deficit framings of themselves as people living in a food desert, but they continued to perpetuate this deficit framing of others living in food deserts as people who need outside help. The possibility that TMSJ might perpetuate deficit views of historically and systematically marginalized communities is not new (Harper, accepted [Chapter 2]), but this case draws attention to the need for both mirrors and windows and a persistent focus on broader systems of power, privilege, and oppression within TMSJ.

Identity and Power in the Authenticity Figured World

The figured world of authenticity created a hybrid space where students could merge their out-of-school experiences with school-based experiences, but only in cases when their school-based experiences were authentic to their out-of-school experiences. Excerpt 23 illustrated how students had constructed a storyline, within the project-based context, that their school-based activities should address authentic, real-world situations. Students expected that not only the topic of projects but also the ways in which they were asked to use mathematics would remain true to the authentic, real-world situations. Maintaining such authentic connections between social justice topics and mathematics, particularly as teachers attempt to integrate new content from the secondary mathematics curriculum, presents significant challenges (Bartell, 2013; Brantlinger, 2013; Harper, accepted [Chapter 2]), and students recognized that some of the connections between food deserts and the mathematics involved in Mini-project 2a and Project 4 were contrived. Students questioned and critiqued the use of certain mathematics content to complete tasks within the projects (Excerpts 25 and 26), but they recognized that the constraints of school and the required curriculum limited what they and their teachers were able to do during projects (Excerpt 24).

This critique of the connections between social justice topics and mathematics is important to consider for two reasons. First, it raises questions about what it means for students to see themselves and/or real-world issues in mathematics at the secondary level. Excerpts 27 and 28 showed how students were able to make some authentic connections between the mathematics involved in the projects, but only in limited ways. Most of the connections between mathematics and food deserts were made during required assignments. Research in science education (Thompson, 2014), however, suggests that privileging students' critique of the discipline over the discipline itself may create opportunities to leverage out-of-school narratives while also engaging students in disciplinary discourse. Thus, students may have had opportunities to see themselves in mathematics, even as they were critiquing the connections between the content and the social justice topic. Second, this critique raises questions about the role of mathematics in interdisciplinary projects, more generally. When students constructed storylines within the food desert figured world, they spontaneously drew on experiences from their BioHealth and English classes, or they referenced activities in their geometry class that did not integrate geometry content (e.g., research on causes and consequences of food deserts). Science and English classes may provide more natural spaces for students to construct a figured world of authenticity that merges their out-of-school and school-based experiences through project-based learning at the secondary level. Although examples of interdisciplinary social justice projects exist, they are mostly at the elementary and middle school levels (Harper, accepted [Chapter 2]). Given the status of school mathematics in society and the power of mathematics to determine students' academic trajectories, further research is necessary to identify a range of general topics and social justice topics that meaningfully integrate school mathematics and other disciplines as students learn about figured worlds within the school-based context.

Conclusion

Based on the possible interpretations of identity and power discussed above, I have shown that integrating multiple equity-minded instructional approaches also comes with tensions; however, I want to conclude by highlighting some of the ways these instructional approaches complimented each other within a hybrid classroom context. In particular, I focus on the integration of TMSJ and CI and the integration of TMSJ and project-based learning. I end by raising some questions for future research and suggesting possible implications for mathematics teacher education.

Theories of critical pedagogy, more generally, imagine a problem-posing model of education, one in which students raise their own questions about social injustice and work, alongside their teachers, to address those questions using the most appropriate disciplinary content (Freire, 1993). Although such examples exist in the literature on TMSJ (e.g., Aguirre, Mayfield-Ingram, & Martin, 2013), they are rare within the classroom-based context, particularly at the secondary level (Harper, accepted [Chapter 2]). In most cases of TMSJ, teachers maintain some level of authority, particularly over the mathematics, and teachers may engage in more teacher exposition than usual in order to help students navigate both the challenging mathematics and the complexity of social justice issues (e.g., Gutstein, 2003). At first, Mrs. Stone managed some complexities of TMSJ by maintaining authority within the mathematics classroom figured world (Mini-project 2a) through teacher exposition, but across Projects 4 and 7 mathematical authority shifted more to students through Mrs. Stone's use of CI strategies. Using a pedagogical approach, like CI, that encourages students to work more independently (from the teacher) and collaboratively with each other could be one way of managing the challenges students face as they learn about new mathematics content and new social justice topics simultaneously.

Teachers also face significant challenges balancing the mathematics and social justice goals in TMSJ at the secondary level (Harper, accepted [Chapter 2]). Teachers might take up students' interpretations of social justice topics in only limited ways during TMSJ, perhaps to ensure students use particular mathematics content as Mrs. Stone did. Within the food desert figured world, Mrs. Stone maintained authority by insisting on a particular definition of food desert (Mini-project 2a and Project 4) and focus for projects (i.e., grocery stores and gardening) as a way of also ensuring students used geometry content required by the school curriculum. In such cases, when the required school curriculum takes priority, a focus on mathematics might overshadow the social justice issues as teachers enact TMSJ (e.g., Bartell, 2013). In this study, however, interdisciplinary, project-based learning helped balance the focus on learning about mathematic and learning about social justice. Because students were familiar with the project-based learning approach, Mrs. Stone was able to devote time to research and writing within the mathematics classroom, with little resistance from students (e.g., "Where's the math?", Brantlinger, 2013; Trexler, 2013), and in Project 7, through teacher collaboration, students had opportunities to explore social justice topics more extensively from different disciplinary perspectives. This case of a collaborative and interdisciplinary social justice project is promising for teachers who wish to integrate mathematics and social justice at the high school level but are concerned about balancing learning about both mathematics and social justice topics.

CI, TMSJ, and project-based learning each come with their own sets of challenges and tensions teachers must face when enacting only one pedagogical approach. Despite the complexity, this study suggests that attempting to integrate these sophisticated pedagogical approaches comes with some advantages in terms of supporting students who are historically marginalized to take up identities as capable learners and doers in school mathematics. The present analysis, however, is insufficient for making claims about the extent to which these mathematics identities might persist, particularly in light of how teacher-dependent CI strategies are and how superficially some students took up aspects of collaboration and social justice. This suggests a need for future research focused on students' superficial (i.e., for the sake of the teacher or a grade) up take of pedagogical strategies (e.g., CI checkpoints) and topics (e.g., social justice issues). Particularly in contexts where teachers are designing hybrid classrooms to integrate particular out-of-school practices (e.g., collaboration in the workforce; social justice activism) that they believe are relevant or important to students (Langer-Osuna, 2015), what are the implications when students who are marginalized in mathematics take up these practices in superficial ways (i.e., only within the school context and for the sake of the teacher or a grade)? Even if students' superficial uptake of these practices results in desired outcomes, are inequitable power relations (e.g., teacher from a privileged background; students who are historically marginalized) reinforced, and at what cost? These questions will be especially important as researchers and educators consider how to balance opportunities for both windows and mirrors (Gutiérrez, 2012) in the secondary mathematics curriculum in ways that do not perpetuate deficit discourses about historically and systematically marginalized groups. Finally, this case suggests some implications for mathematics teacher education. The pedagogical approaches described here are complex, and teachers may find it challenging to imagine enacting one of these approaches across an academic year. As this study shows, however, features of these approaches can still be effective, even when all three are not used for every unit or project (for the frequency of pedagogical approaches across all projects see Appendix A). Mathematics teachers educators face the challenge of preparing teachers to enact a range of equity-minded pedagogies to design hybrid classroom spaces, but more importantly, teacher educators and teachers together must explore how to strategically use combinations of different pedagogical approaches in ways that most effectively support mathematics learning in particular contexts and in particular moments.

APPENDICES

Appendix A: Overview of All Projects and Data Sources

<table>
<tr><td colspan="5">Table 3.4

Overview of all projects and data sources.</td></tr>
<tr><th>Project</th><th>Field Notes & Artifacts</th><th>Videos & audio</th><th>Individual Interviews</th><th>Group Interviews</th></tr>
<tr><td>Project 1</td><td>8 field notes
11 artifacts</td><td>0</td><td>1: Kendra</td><td>0</td></tr>
<tr><td colspan="5">Art & Geometric transformation
Students worked in groups to create an original piece of artwork. The artwork had to include each of the geometric transformations students had learned, with each student in the group responsible for creating and explaining one of each transformation.
Length: 8 days (Oct 6-16, 2015)
Pedagogical approaches used: CI, project-based learning</td></tr>
<tr><td>Project 2</td><td>7 field notes
13 artifacts</td><td>4 videos</td><td>2: George, Monique</td><td>0</td></tr>
<tr><td colspan="5">Scavenger hunt & relationships between lines and angles (e.g., parallel lines, angle pairs)
Students worked in groups to create a scavenger hunt using the Aurasma application (www.aurasma.com). They had to integrate what they had learned about the relationships between lines and angles into the scavenger hunt.
Length: 16 days (Oct 19-20; Oct 28-Nov 18, 2015)
Pedagogical approaches used: CI, project-based learning
NOTE: The teacher introduced Mini-project 2a as a way for students to learn some of the necessary mathematics content for Project 2. Students abandoned Project 2 early because they decided it was not benefiting them. They learned the remaining content through more traditional lessons.</td></tr>
<tr><td>Mini-project 2a</td><td>4 field notes
0 artifacts</td><td>4 videos</td><td>2: Nemo; Rosy</td><td>1: Antonio, Jane, Ashley, Blake, Carley, Simba</td></tr>
<tr><td colspan="5">Food deserts & distance and midpoint formulas
Students used the distance formula to calculate the shortest distance from their home to the nearest full-service grocery store to decide if they lived in a food desert. They decided that the area surrounding Victory, where most of their homes were located, was not a food desert, so they used the midpoint formula to determine if placing a grocery store half way between their home and Victory would make sense.
Length: 5 days (Oct 21-27, 2015)
Pedagogical approaches used: TMSJ, project-based learning</td></tr>
<tr><td>Project 3</td><td>9 field notes
13 artifacts</td><td>1 video</td><td>0</td><td>0</td></tr>
<tr><td colspan="5">History of proof & triangle congruence and similarity
Students learned how to prove triangle congruence and similarity, and then they wrote letters with a mathematical proof to people who use mathematics in their jobs.
Length: 18 days (Nov 19-Dec 19, 2015)
Pedagogical approaches used: CI, project-based learning</td></tr>
</table>

(Table 3.4, cont'd)

<table>
<tr><td>Project 4</td><td>9 field notes
21 artifacts</td><td>9 video</td><td>2: George; Rosy</td><td>1: Ashley, Blake, Carley, Charlie, Dante, George, Jane, Kendra, Monique, Nemo, Rosy, Tino</td></tr>
<tr><td colspan="5">Food deserts & centers of triangles
Students used the Food Access Research Atlas (USDA, 2017) to determine where food deserts where located across Midland City and did broader research on the causes and consequences of food deserts. Next, they explored different measures of center of triangles (i.e., orthocenter, circumcenter, centroid, and incenter) and applied these different measures to determine a grocery store location in Midland City that could make the biggest impact on residents' lives.
Length: 11 days (Jan 6-21, 2016)
Pedagogical approaches used: CI, TMSJ, project-based learning</td></tr>
<tr><td>Project 5
2nd semester begins</td><td>12 field notes
36 artifacts</td><td>4 videos</td><td>0</td><td>0</td></tr>
<tr><td colspan="5">Circles (no project)
Due to time constraints, Mrs. Stone decided not to do a project for the circles content. Instead, students did a series of collaborative, problem-based tasks. The final task required students to take actual measurements on the baseball field to find the solution.
Length: 19 days (Feb 1-Mar 4, 2016)
Pedagogical approaches used: CI</td></tr>
<tr><td>Project 6</td><td>11 field notes
16 artifacts</td><td>1 video</td><td>1: Tino (at his request)</td><td>0</td></tr>
<tr><td colspan="5">Computer programming & trigonometry and Pythagorean theorem
Students worked in pairs to use SNAP! (programming language) to create video games. They incorporated what they learned about trigonometric relationships into their games, and they got feedback from game designers and university students on their games.
Length: 20 days (Mar 7-Apr 1, 2016)
Pedagogical approaches used: Project-based learning</td></tr>
<tr><td>Mini-project 6a</td><td>5 field notes
8 artifacts</td><td>4 videos</td><td>0</td><td>0</td></tr>
<tr><td colspan="5">Disability rights & inverse trigonometry
Students worked in pairs to determine whether or not wheelchair ramps at the school were compliant with the regulations. Students wrote letters to the principal making recommendations for school improvements.
Length: 5 days (Apr 18-25)
Pedagogical approaches used: TMSJ, project-based learning</td></tr>
</table>

(Table 3.4, cont'd)

Project 7 2nd semester	18 field notes 17 artifacts	6 video 2 audio	5: Dante; Nemo; George; Rosy; Monique	2: Carley, Simba; Antonio, Blake, Carley, Dante, George, Rosy
Community gardens and nutrition & relationships between area and volume *Students worked on the project across their geometry, English, and biology classes. In geometry, students made two-dimensional layouts (to scale), calculated the cost of building materials, and built three-dimensional models (to scale) to propose a community garden.* ***Length: 27 days*** *(Apr 26-June 2, 2016)* ***Pedagogical approaches used**: CI, TMSJ, project-based learning*				

Table 3.4

Appendix B: Coding Scheme and Sample Excerpts

Table 3.5

Coding scheme and sample excerpts.

Code	Definition	Sample Excerpt
Who	Who was involve or discussed This code is only used for specific students, the teacher, or the researcher. Subcodes were the names of students, the teacher, or researcher.	(Field notes: Jan 11, 2016) *George and Dante were working on the task, but Rosy and Blake were watching videos off task.* CODES: George, Dante, Rosy, Blake
Positioning	How students described/positioned themselves or others **How students are working with math** • Can do with help (e.g., asking questions) • Can do without help (e.g., explaining thinking) • Cannot do **How students describe their or others' relationship with math** • Good at math • Improving or kind of good at math • Not good at math **How students describe their or others' student identities** • Good student (e.g., hard worker, quick learner, enjoys school) • Ok student (e.g., slow learner, high stress) • Struggling student (e.g., failing, does not enjoy school) **How group members interact** • Work collaboratively (e.g., all contribute) • Student helps student • Student invites student to participate • Teacher invites student to participate • Work individually on parts of group task • Work individually on individual task • Work collaboratively on individual task	(Interview: May 31, 2016) *Harper: Great. How is that [preferring to work one-on-one with the teacher] factoring with this asking questions piece?* *Simba: I don't know. I don't understand math until I ask a lot of questions and then when she answer them I kind of get it.* CODES: How students are working with math – can do with help – asking questions

(Table 3.5, cont'd)

	How student work with social justice topics • Connected to math • Express deficit view • Express interest in topic **How students describe their or others' personal identities** • Personality (e.g., kind, loner) • Race • Gender • Class	
Pedagogical or Participation Structures	Which pedagogical and participation structures were used or discussed Subcodes included: **Complex Instruction Features** • Group accountability strategies (e.g., group question) • Individual accountability strategies (e.g., individual products) • Positive interdependence strategies (e.g., quizzed on "materials accessible to all") • Group Roles (e.g., facilitator) **Technology Use** • How students use (e.g., collaboratively, struggling) • Use for what (e.g., mathematics work, off task activity) **Participation Structures** (e.g., whole class, small group)	(Field notes: Jan 14, 2016) *Students have some trouble with vertices being labeled differently on the worksheet and in Geogebra* *Teacher tells Carley to just label the A on the worksheet as a G so it'll be less confusing when she drags the triangle* CODES: Technology use – how students use – struggling; Use for what – mathematics task
Topics	Which topics were involved or discussed Subcodes included: **Math topics** • Topics in projects (e.g., circles, distance formula) • Perception of math (e.g., boring, relevant) **Social justice topics** • Related to project (e.g., food desert) • Spontaneous topic (e.g., immigration) **Collaboration** • Value collaboration	(Field notes: Jan 6, 2016) *Nemo and teacher talking about infants. Nemo volunteered to take care of her newborn baby sister last night. Complained that she woke up crying at 6am.*

(Table 3.5, cont'd)

	• Complaint about collaboration **Out-of-math topics** • Community-based experience • Family experience • Friendship • Hobbies • School-based (e.g., football, BioHealth) • Social constructs (e.g., ability, class, gender, race)	CODES: Out-of-math-topics – family experience

Table 3.5

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CHAPTER 4: BLACK GIRLS' CONSTRUCTION OF "HANDS ON" MATHEMATICS AS HUMANIZING

On a sunny day at the end of April, Mrs. Stone's (all names are pseudonyms) 9th grade geometry students headed outside to measure space for a community garden at Victory High School (Victory). Mrs. Stone equipped each assigned pair with a meter stick for the self-selected "measurer" and a clipboard for the self-designated "sketcher." Students immediately grouped together and began working, seemingly based on the measurer and sketcher roles, but as I looked more closely from behind the camera, I realized that was not the case. Instead, students had huddled together by gender (gender and racial/ethnic identities are self-identified).

Inside the classroom, I had noticed mixed-gender pairs had self-selected roles along gender lines; all of the boys were measurers, and all of the girls were sketchers. (There were only three same-gender pairs – two pairs of boys and one pair of girls). Once outside, students divided into two large groups, prioritizing gender over agreed upon roles. All the boys, even the two sketchers, strategized and collaborated to measure the irregular space for the garden, and the girls, including the one measurer, worked together to create accurate two-dimensional representations. This gender division also grouped students by race because of unique demographics of this class resulting from scheduling conflicts. All but two of the boys are White, and all of the girls, except one, are Black.

Mrs. Stone made several attempts to disrupt the gendered and racial division. She encouraged the lone girl measurer to collaborate with the boys, and she advised the two boy sketchers to consult with the girls on how to accurately record a two dimensional sketch. She also urged the sketchers to provide additional ideas for dividing the space into measurable areas and prompted the measurers to help match the measurements to the drawings. Rosy, the only

Asian American student and only non-Black girl, made the most effort to collaborate with the measurers, but students largely gravitated towards working with those who shared their racial and gender identities.

In my 93 hours of observing in Mrs. Stone's geometry classroom, never before, nor again, did I see such stark racial and gendered division in how students collaborated. As I continued observing and talking with students and as I analyzed field notes, interviews, and videos, however, I came to realize that this instance was important because it made apparent (to me – a White, adult female) the subtle racial and gendered differences in how students were making meaning of school mathematics in the collaborative, project-based learning context (for more details about research methods see Appendix). In this paper, I use this scene to set the stage for a consideration of how Black girls, in particular, negotiated a classroom culture rooted in collaborative, project-based learning to construct "hands on" mathematics as humanizing.

A Context for "Actually Doing Something Real"

Mrs. Stone's geometry class was situated within a STEM-themed magnet program – Victory New Tech (New Tech) – within Victory, a high school in a small urban district in the Midwestern United States. Victory and New Tech students shared similar demographics. Combined Victory and New Tech enrollment during the study (2015-16) was 43% Black, 24% White, 18% Latinx, 9% Asian/Asian American, and 6% bi- or multi-racial, and the median household income for the district was $35,600 (22% lower than the county's median household income). Although racial/ethnic division along gender lines in the geometry class was unusual, the overall racial/ethnic composition of the class reflected the school demographics (31.25% White, 56.25% Black, 6.25% Asian American, 6.25% Latino). Mrs. Stone is a white woman, who was in her fourth year of teaching in 2015-16. She has taught at Victory throughout her career and began teaching for New Tech during the magnet program's inaugural year (2014-15). All of the 9th grade geometry students in New Tech also had Mrs. Stone as their teacher for 8th grade algebra. Mrs. Stone is committed to ensuring equity and social justice in her mathematics teaching, and she and I have collaborated towards that goal since 2013. My time in Mrs. Stone's classroom for this study focused on understanding how students negotiated, took up, or resisted Mrs. Stone's equity-minded teaching efforts.

According to the school website, project-based learning was designed to engage students in exploring and solving authentic, real-world tasks that require collaboration, creativity, and knowledge across a range of disciplines. An interdisciplinary approach to authentic tasks in the school context holds potential for realizing some key tenets of humanizing pedagogy, namely considering the needs of the whole student (i.e., not just the mathematics student) and valuing students' varied resources as they take steps to contribute to real-world problems. Humanization, however, also demands promotion of students' well-being beyond academic considerations (e.g., social, emotional) and reflection on sociohistorical, sociopolitical, and sociocultural contexts in the individual and collective journey toward critical consciousness and social action (del Carmen Salazar, 2013). In other words, project-based learning is not inherently humanizing but can support humanizing pedagogical principles and practices (for a full description of ten principles and practices of humanizing pedagogy see del Carmen Salazar, 2013, p. 137-141).

Preliminary analyses across the school year suggest that Mrs. Stone leveraged the parameters of project-based learning at New Tech to "recreate and reinvent teaching methods and materials…to expand the possibilities to humanize [mathematics] education" (Bartolomé, 1994, p. 177). She valued project-based learning for its emphasis on students' "experiencing the math and figuring it out [for themselves]" and "actually doing something real," but she also recognized the need to supplement project-based learning with other teaching approaches to support students' holistic development and encourage more equitable distributions of power within the mathematics classroom (e.g., Boaler 2008; Gutstein 2003). In particular, Mrs. Stone employed strategies from complex instruction to promote development of students' academic, intellectual, and social abilities through collaborative mathematics (i.e., "Students will achieve through their academic, intellectual, social abilities," del Carmen Salazar, 2013, p. 140). Using complex instruction encourages students to "respect each other's differences, to listen to others who have a different opinion, perspective or experience and to act in equitable ways" (Boaler, 2008, p. 172). Across projects, Mrs. Stone also integrated school mathematics and project topics that were meaningful and relevant to students' lives and encouraged them to draw on their cultural- and community-based resources in authentic ways (i.e., "Content is meaningful and relevant to students' lives" and "students' sociocultural resources are valued and extended," del Carmen Salazar, 2013, p. 139). In this paper, I focus on the Community Garden Project, which was the final in a series of three projects across the year focused on social justice questions about access to high quality and affordable food in the local community. This social justice emphasis reflects Mrs. Stone's efforts to engage students in critically evaluating and problematizing meaningful and relevant topics from their lives (i.e., "Critical consciousness is imperative for students and educators", del Carmen Salazar, 2013, p. 138-139).

The Community Garden Project

The community garden project lasted 27 school days and culminated with each group presenting, to the school improvement committee, their proposal to build, plant, use, and maintain the community garden starting in the next school year (Mrs. Stone planned to teach the students' Algebra II class in 2016-17). Students worked on the project across three of their classes: geometry, English, and biology. In geometry, students made two-dimensional layouts (to scale), planned for and calculated the cost of building materials, and built three-dimensional models (to scale) of their proposed gardens. The primary mathematical focus was on calculating area and volume of various shapes and understanding the relationship between area and volume. In their English class, geometry pairs teamed up with another pair (of algebra students) to research and write a formal proposal, and in biology, students learned about plant biology and nutrition so that they could make decisions about what, where, and how to plant. Teachers introduced the project as one possible way of addressing the causes and consequences of limited access to high quality and affordable food, a social justice issue that students had explored in two previous geometry projects (for details about the three social justice projects that explored access to high quality and affordable foods see Harper (in preparation [Chapter 3]). Students took up the social justice issue in various ways; proposals included plans to use the garden for nutritional education, to provide food to students and community members, and to teach others about urban gardening.

Highlighting "Hands On": "I Could Do It [Because] We Just Measured It"

Because every student told me geometry was their favorite class, I aimed to explore, alongside students, what they identified as humanizing about their experiences. A few students described mathematics as their favorite subject, but most were tentative to express their love for mathematics itself (but no one told me they hated mathematics). Instead, most students emphasized their mutually respectful relationship with Mrs. Stone and the specific teaching approach that Mrs. Stone used. Monique's sentiments were commonly expressed by other students, "I used to love doing math but now that it has gotten harder…it's just tricky to keep up with all the math that we've been doing," but "I just like Mrs. Stone because she is a really kind teacher. I had her last year, and I'm glad I had her this year again." Carley also had concerns about the increasing difficulty of mathematics, but she explained, "[Geometry is my favorite class] because the other ones are just not…don't work as well with how I learn." Many of my follow up conversations with students and much of my analysis for this paper focused on trying to understand what exactly students identified as critical to their positive experiences in this particular geometry class, even if they claimed not to particularly enjoy mathematics itself.

"Hands on" mathematics emerged as an important factor shaping students' mathematics experiences early in my analysis as students repeatedly emphasized "hands on" mathematics as critical for making mathematics more accessible and relevant. For example, Nemo shared, "When we did the baseball [problem] it was easier for me to do the math [calculating area of irregular shapes], and I couldn't do it in my head. But I could do it [because] we just measured it. We measured the inside of [the baseball field]." Blake agreed that "hands on" experiences supported mathematics learning, saying, "I think actually this group [of students] all really enjoys hands on, and I think those ["hands on" projects], we learned the most. I'm speaking for myself, but making art and making a game…made me understand [the math] so much easier. And I like video games, and I like art…maybe not everybody liked those, but anything hands on…worked really well for me." In other words, "hands on" experiences allowed students to draw on cultural and community resources and interests while participating in school mathematics, effectively making learning mathematics a more humane experience.

My observation from the opening vignette helped me realized that, in trying to understand students' construction of "hands on" as humanizing, I was overlooking one important principle of humanizing pedagogy: "the reality of the learner is crucial." Although written for educators striving for humanizing pedagogy, the description of this principle seemed important in my work as a researcher aiming for humanizing research on teaching and learning.

> [Researchers] who enact humanizing [research] commit to explore the varied macro- and micro-level elements that affect teaching and learning by interrogating multiple forms of oppression in students' lives…Moreover, [researchers] actively inquire into students' identities inside and outside of school to further understand the diversity and multiple identities of their [student participants] and the cultural differences that affect teaching and learning (del Carmen Salazar, 2013, p. 139).

With a renewed commitment to explore the varied macro- and micro-level elements affecting teaching and learning, I reframed subsequent interviews, observations, and analysis in an attempt to more deeply understand "multiple forms of oppression" and "students' identities inside and outside of school" (for more details about research methods see Appendix). In particular, I focused on the unique experience of being both Black and a girl in this geometry class. I relied on the relationships I had developed with the girls in the class throughout the year and aspects of our shared identities or backgrounds (e.g., being female, growing up in poverty in a biracial household) to open conversations about race, class, and gender, but as a White, adult in a position of power, I also recognized that it would be challenging for me to truly understand the students' experiences. When interpreting video observation and statements from interviews, I turned both to the girls, directly, for clarification or to confirm interpretations and to the theoretical and empirical work of Black female scholars in mathematics education to make sense of findings.

Black Girlhood

In this paper, I theorize race and gender as socially constructed, performed in a particular context, and influenced by broader systems of power (e.g., Damarin and Erchick, 2010; Gholson & Martin, 2014). In other words, I aimed to let the Black girls' "voices and actions form the basis of what [I] call 'Black girlhood'" in the context of doing and learning mathematics

(Gholson & Martin, 2014, p. 19). For example, in the opening vignette, the Black girls were performing their identities as they adopted the sketcher role and resisted the teacher's push to collaborate more actively with the boys. They self-constructed their Black-girl-mathematics identities as being receivers/organizers/translators of information and being collaborators with those who shared their role and racial and gender identities. I do not mean to suggest that they never created and gave information or that they never collaborated across racial and gender lines, but I mean only to highlight a performance of Black girlhood in a very particular moment (Gholson & Martin, 2014). This illustration is important because, although the performance happens in a very specific moment, performances and interpretations of identities are also shaped by broader systems of culture and power. In the context of the vignette, decisions about which role to adopt and which collaborators to favor were shaped by broader experiences with oppression (e.g., stereotypes that position women as less capable in mathematics and African Americans as less academically capable; Spencer, Steele, & Quinn, 1999; Steele, 2007) and power (e.g., peer support within groups of Black women, Joseph, Hailu, & Boston 2017). In my analysis, I aimed to interpret narratives and actions in specific moments in light of broader sociopolitical and sociocultural influences to understand the unique construction of "hands on" mathematics as humanizing for Black girls in this geometry class.

Black Girls' Construction of "Hands On" Mathematics as Humanizing

Two key elements that fostered Black girls' construction of "hands on" mathematics as humanizing were: (1) variation in the format of mathematical products; and (2) support from collaborative partnerships. For clarity, I have chosen to focus on two students, Monique and Carley, and their reflections on and experiences during the Community Garden Project. These two key elements were identified and confirmed as critical by all of the Black girls in the class, and analysis showed that these elements played out across various projects during the year.

"Not Doing the Same Thing Over and Over Again"

Black girls in the class appreciated opportunities to work with mathematics in various formats and to create a range of mathematical products. Carley explained that, "some paperwork, computers, and everything" worked well for her in terms of Mrs. Stone's teaching, "So we're not doing the same thing over and over again." In other words, the Black girls valued opportunities to perform their Black-girl-mathematics identities by building physical models, creating computer-based presentations, doing mathematical work on paper or computer, and writing reports for authentic audiences. Although they did not disagree openly when their classmates vocally complained about projects that mostly involved "[writing] on a piece of paper or [typing] something" (Blake), during interviews and informal conversations with me, the Black girls disagreed with the sentiment that "the [only] difference between New Tech and regular school…is just the paper is on computer" (Tino). They saw "hands on" mathematics as involving more than physically building or manipulating objects.

Because of the extended nature of the Community Garden Project, students produced a range of mathematical products: two-dimensional blueprints, three-dimensional models, budgets, and computer-based presentations. Many of these products involved working on paper (e.g., drawing blueprint) or on the computer (e.g., researching cost of materials for budget), and the Black girls recognized these aspects of the projects as "hands on" and engaging. Through their appreciation for and willingness to engage in multiple formats of mathematical work, the Black girls constructed "hands on" mathematics as humanizing in two ways: (1) their sociocultural resources were valued and extend, and (2) they developed mainstream knowledge and discourses (del Carmen Salazar, 2013).

Extending varied resources to mainstream mathematics products. Including work on paper or the computer in their construction of "hands on" mathematics projects presented advantages for mathematics learning and identity development, which were particularly evident in Monique's interactions with her partner, Antonio (White male), during the Community Garden Project. Despite telling me at the beginning of the year that she loved mathematics, Monique typically interacted with her collaborators by allowing them to take the lead. She engaged with the mathematical work in projects under the direction of her groupmates, and prior to the Community Garden Project, I had never seen her facilitate work with her peers. This reluctance to assume a leadership role, combined with frequent absences, positioned Monique as one of the students with low mathematical status in the class. In the Community Garden Project, however, Monique took the lead and demonstrated mathematical authority throughout the project.

Monique's willingness to take the lead was likely motivated by her unique interest in the topic of gardening. She told me, "I liked the gardening [project] because I liked learning plants because I would do that with my grandpa. I'd help him with his garden that he has." The content and curricular resources in the Community Garden Project reflected Monique's family-based experiences with gardening (del Carmen Salazar, 2013). Drawing on resources that Antonio did not have, Monique felt confident in her ability to engage with some of the mathematical work because it was authentic to the mathematics her grandpa used. "He has to measure…how deep he has to plant them [the seeds] and how far they have to be." Monique's willingness to do "hands on" work on paper (not the way her grandpa would do it) was important because it allowed her to build on her sociocultural resources and extend them to school mathematics (del Carmen Salazar, 2013). Antonio had elected to work exclusively on measuring the garden space (perhaps assuming that his contribution to the blueprint was done after measuring the physical space), giving Monique ownership and authority over the tangible and mainstream mathematical work (i.e., the sketch) for this part of the project. Students had three days to transform their sketches into blueprints (to scale) for their proposed gardens, and Monique used this time to work diligently on the "hands on" work (done on paper) for this part of the project. To do so, Monique had to make sense of Antonio's measurements, make mathematical decisions about scale, and determine areas for the design of the two-dimensional blueprint. As the deadline grew closer, she instructed Antonio on how to help her calculate scaled dimensions. Antonio expressed more interest in the project once he and Monique were ready to build their three-dimensional model from clay; however, the model was dictated by Monique's prior decisions about the design and scale of the blueprint. Thus, Monique continued as the mathematical authority by directing Antonio as the pair transitioned to a different mathematical topic and worked towards a differently formatted mathematical product.

Although Monique's experiences were unique given her mathematical status and familiarity with gardening, her experiences with drawing on outside resources were similar in many ways to the other Black girls in the class. Ownership over the original blueprint for the community garden positioned most of the Black girls as leaders and experts across various mathematical formats and content, and the one pair of Black girls shared the workload more evenly throughout the project than other pairs did. The variations in mathematical formats and products supported the Black girls' efforts to draw on their out-of-mathematics-classroom resources, even when they did not have experience with gardening, to make decisions about the community garden design and budget. For example, when deciding what vegetables to plant and where to plant them (in the blueprint and model), Carley referenced what she learned in biology class about plants and nutrition, and Nemo made decisions based on what she and her family liked to eat. Restricting "hands on" mathematics to physically building or manipulating objects, just like exclusively pen-and-paper-based mathematical work, limits the sociocultural resources that students bring to doing and learning mathematics. Instead, a more humanizing approach to "hands on" mathematics includes opportunities for students to work with a range of mathematical formats and products designed to encourage more varied resources – from out-of-school and in-school but out-of-mathematics experiences – in order to develop mainstream mathematics knowledge and discourses.

"Work with Our Group to Understand [the Math] Better"

When reflecting on "hands on" mathematics, in general, the Black girls expressed mixed feelings about working collaboratively. They appreciated the support that collaboration could offer but worried about being positioned as the mathematical authority among their peers. For example, Carley noted that she "liked how we [the students] had to work with our group to understand [the math] better. And use our groups," but when reflecting on being assigned groups by Mrs. Stone, Carley lamented, "They [the teachers] think that certain people bring other things [strengths] to the table, so then they [the group members] collaborate all of the different things. And they [the teachers] probably think it [assigning groups based on different strengths] works really well, but it doesn't work well at all if you ask me." Other Black girls in the class had similarly mixed reactions to working within assigned groups. For example, Monique reflected on how well she collaborated with many of the students in class because, "I knew [my classmates] since last year…and they're nice people;" whereas Nemo told me she preferred to work alone because, “I don’t have any friends in this class.” Often, the Black girls resisted assigned groups by changing seats or asking Mrs. Stone to reassign groups.

Although students generally described, and I observed, the “hands on” mathematics space as “a safe learning environment where risk-taking and active engagement” were valued, the trusting and caring relationships necessary to advance the pursuit of humanization (del Carmen Salazar, 2013, p. 140) were strongest among friend groups and between individual students and Mrs. Stone. Resistance arose when Mrs. Stone asked students to collaborate with or to help classmates outside their friend groups (i.e., outside their immediate trusting and caring circle). Mrs. Stone encouraged students to rely on their support networks, but she also pushed students to value opportunities to work with peers who brought different perspectives and strengths. In other words, Mrs. Stone sought to “guard against deficit views” that students held about their own classmates (del Carmen Salazar, 2013, p. 141). Thus, the Black girls constructed the collaborative aspect of “hands on” mathematics as both supportive when trusting and caring relationships (with the Black friends and Mrs. Stone) advanced the pursuit of humanization and problematic when Mrs. Stone tried to promote the development of students’ academic, intellectual, and social abilities by extending collaborative circles (del Carmen Salazar, 2013).

Limited circles of trusting and caring relationships for collaboration. Tensions arose between Mrs. Stone’s goals for supporting students to leverage caring and trusting relationships and her goals for encouraging students to value working with every other student when, for the Community Garden Project, Mrs. Stone paired Carley with Dante. Mrs. Stone hoped Carley and Dante would work well together. Carley was one of the highest achieving students in class and diligently completed assignments; Dante quickly picked up on mathematical concepts while working with his peers but struggled to finish tasks in a timely manner. Carley, however, questioned whether she could support Dante because she was unsure how to explain her mathematical thinking to him. For Carley, performing a good-at-mathematics identity in "hands on" mathematics meant being good at collaborating and explaining mathematical thinking. Thus, Carley expressed some doubt about her mathematical ability when tasked with supporting Dante. Likewise, I observed that the other Black girls in the class rarely (or reluctantly) assumed the role of mathematical authority when working in assigned (versus self-selected) groups.

Although Antonio insisted, "A lot of people like [being the boss], being the teacher or teaching other people what to do," Carley noted that what really helped her to feel successful in mathematics was an opportunity to ask questions and feel confident about what she was doing. "If I don't know what I'm doing, I just get all stressed out." Carley explained that she preferred to ask questions when working on mathematics rather than answer them; "It's easier to ask other people questions, but not easy to answer other people's questions." I observed that within the trusting and caring embrace of their Black-girl-friend-groups, the girls would ask each other questions, but when assigned to collaborate outside of that group, they relied heavily on Mrs. Stone for support when they or their groupmates had questions. As Carley explained, "When she [Mrs. Stone] talks and explains it, I understand some of it, but then I just have to ask questions so I understand what I'm doing, or else I cannot do the work because I don't know…I just can't." The other Black girls in the class expressed similar concerns and confirmed that they felt most supported asking and answering questions with classmates who were their friends (e.g., Carley, Simba) or working alone with support from Mrs. Stone (e.g., Nemo).

Carley, like most of the other Black girls, reluctantly assumed a leadership role and acted as a mathematical authority throughout the Community Garden Project. Monique's willingness to be a leader and mathematical authority (as described in the previous section) was unique, but it was also limited to the parts of the project most directly related to designing the garden (likely because of her unique familiarity and confidence with gardening). When learning unfamiliar mathematics content (calculating area of various polygons), Monique thrived when her collaborative group supported her to ask questions rather than answer them. Mrs. Stone created larger groups during the Community Garden Project for a two-day exploration of area. Because Antonio was absent, Mrs. Stone assigned Monique to a group of five (i.e., two pairs plus Monique), which included two of the highest achieving (non-Black) students in the class. These high achieving students supported Monique throughout the task, and Monique presented the group's mathematical thinking during the whole class discussion for the first time all year.

In mathematics especially, being Black and a girl represents a unique intersection of stereotype threats; Black girls must battle stereotypes that position girls as less capable in mathematics and position African Americans as less capable academically. When explaining mathematics or supporting someone else's mathematics learning, Black girls risk being judged based on these stereotypes, and a fear of confirming these negative stereotypes can stifle mathematics performance (e.g., Spencer, Steele, & Quinn, 1999; Steele, 2007). Stereotype threat may help explain the Black girls' reluctance to assume leadership roles and collaborate with their non-Black peers, and this finding suggests a need for students to evaluate and problematize sociocultural, sociohistorical, and sociopolitical influences within the classroom. Although Mrs. Stone encouraged students to critically evaluate and problematize meaningful and relevant topics in their lives from outside the classroom (for more discussion about this aspect of the Community Garden Project see Harper (in preparation, [Chapter 3]), more attention to developing critical consciousness about stereotype threat or other sociopolitical influences within the mathematics classroom may have helped both Mrs. Stone and the students widen the Black girls' circle of trusting and caring relationships for collaboration.

Conclusion

Recently, educators and scholars have pushed for recognizing and challenging the gendered and racialized topics that can make the school mathematics curriculum dehumanizing for many students. For example, the mathematical work of contextualized problems (e.g., "How many ways are there to pick a man and a woman who are not married to one another from a group on *n* married couples?") can relay gender normative assumptions – " the idea that there is one way to be male, or a boy, and another way to be female, or a girl" (Rubel, 2016, p. 436-437). Efforts to challenge assumptions about one way of being a girl or one way of being Black are important, but those assumptions can extend beyond the mathematics curriculum itself. Paying attention to differences in *how* students engage with mathematics and with their peers along intersections of gender and race is just as important as addressing the racialized and gendered topics in the curriculum. The case presented here is important because it draws attention to how seemingly neutral ways teachers may try to humanize mathematics for students, such as creating "hands on" experiences, become racialized and gendered based on students' identities in specific contexts and moments.

Collaborative, project-based learning has potential to be a fertile context for "hands on" mathematics as accessible and engaging for students who historically are marginalized in mathematics, but simply creating opportunities for students to work together on authentic and relevant (to them) mathematics tasks does not ensure a humanizing experience. Recognizing how students construct "hands on" based on intersections of race and gender (or other socially constructed identities) is important for making the mathematical work accessible throughout a collaborative project. Such recognition requires listening to students and making changes to instruction accordingly. As described above, the Black girls were vocal about not wanting the teacher to assign them to groups that did not include any of their friends. Mrs. Stone responded to their concerns in a few ways. She provided her rationale for assigned groups (i.e., grouping students with different strengths); she allowed some students, such as Nemo, to work more independently at times; and she encouraged groups to consult other groups when they were struggling. These were important steps towards helping students feel like their voice was valued, but these responses did not necessarily acknowledge or respond to the what the Black girls were not able to articulate explicitly about their mathematics experiences. An important part of learning to listen to students is learning to "read between the lines and recognize that…students' lived experiences may be very different" from teachers' (Gutiérrez, 2015, p. 272). The analysis described above provides some possibilities for hearing what students are not saying.

First, recognizing when mathematics experiences are going well for students can be challenging. In this case, the variations in mathematical work and products in the "hands on" projects worked well for the Black girls in the class, but the loudest message from students was that of discontent with the current approach to "hands on" work and products. Because Mrs. Stone's current instructional approach was working well for the Black girls, they were largely silent when their While male peers complained about the lack of "real" projects. Only through interviews with the Black girls did I learn how much they appreciated working with mathematics in diverse ways. This suggests that teachers and researchers alike should find ways to hear from all students, perhaps by directly asking them in small groups or individually, before making major changes, particularly if those changes lessen the diversity of ways that students can engage with mathematics, or before deciding whether or not a particular approach is working well.

Second, learning to read between the lines when students complain about or resist a particular instructional strategy is equally important but challenging. In their complaints about assigned groups, the Black girls did not name, explicitly, their preference for getting support from their peers rather than giving support to their peers. Only through careful analysis of interviews, field notes, and video did I begin to see the possibility that the Black girls may have resisted their assigned groups as a way of protecting a good-at-mathematics-identity. Educators and scholars who focus on strategies for equitable collaborative learning emphasize the importance of addressing status issues that can limit students' access to mathematics, but they largely focus on supporting students who are struggling and perceived as "not good at math." Negotiating effective collaborative partnerships among students necessitates recognizing and responding to students' different needs, including those students who may be learning to transition from "being helped" to "being the helper" among their peers. This raises questions for teachers and researchers about how to support those students who are historically marginalized in mathematics, such as Black girls, as they transition to the role of mathematical authority among their peers while also continuing to support those students who continue to struggle in mathematics. By listening to students and supporting them in humanizing their experiences in mathematics, we may also learn other ways in which historically marginalized students need different supports as they negotiate their socially constructed identities of race and gender alongside their identities as capable and confident learners and doers of mathematics.

APPENDIX

Appendix: Research Methods

To understand how the Black girls in Mrs. Stone's New Tech geometry class constructed "hands on" mathematics, I drew on a subset of data collected during a yearlong ethnography in 2015-16 (for details about the larger study design, methodology, methods, and data sources, see Harper, in preparation [Chapter 3]). Table 4.1 lists the primary and secondary data sources used for this specific analysis. Analysis focused on understanding the experiences of the Black girls in the class (Kendra, Monique, Nemo, Carley, Simba, Jane, and Charlie).

Table 4.1

Primary and secondary data sources.

Primary Data Sources		
Data Source	**When**	**Who or What**
Individual Interviews	Beginning of year End of year	Kendra, Monique, Nemo Carley,* Simba,* Monique, Nemo
Group Interviews**	Beginning of the year Midyear End of year	Jane, Carley, Simba Carley, Charlie, Jane, Kendra, Monique, Nemo Carley
Video (from the community garden project)	Apr 27	Students went outside to measure the area where they would propose to build the garden.
	May 3	Students work on completing their blueprints. Video focused on Monique, Antonio, & Dante.
	May 5 & May 6	Students do a 2-day area exploration in groups. Video focused on Monique, Nemo, Rosy, George, and Warren.
	May 25	Students are building 3D models of gardens. Video focused on Monique and Antonio.
	June 2	Students present their community garden proposals to the school improvement committee. All students present, except for Jane (absent).
Field Notes	17 days during community garden project	Notes focused on documenting content of talk and how students were interacting with mathematics and their peers.
Secondary Data Sources		
Data Source	**When**	**Who or What**
Individual Interviews	Beginning of year Midyear End of year	George, Rosy George, Rosy, Tino Dante, George, Rosy
Group Interviews**	Beginning of year Midyear End of year	Antonio, Ashley, Blake Ashley, Blake, Dante, George, Rosy, Tino Antonio, Blake, Dante, George, Rosy

(Table 4.1, cont'd)

Analysis of video & field notes	Projects prior to the community garden project	For more details, see Harper, in preparation [Chapter 3]

**When I scheduled end-of-year individual interviews, Carley and Simba requested to do their interviews together. I asked the same questions as in other individual interviews.*
***The Black girls participated in the group interviews alongside their non-Black and/or male peers, but primary analysis focused on the Black girls' contributions during these group interviews. For example, at the beginning of the year, Jane, Carley, and Simba were part of the same interview with Antonio, Ashley, and Blake.*

Table 4.1

Data analysis began with individual interviews conducted with the Black girls. From these interviews I aimed to get a sense of what Black girls described as working well for them or not working well for them in their experiences in geometry. Certain questions from the beginning-of-year interviews were helpful in this regard. Namely, those questions designed to learn about students' relationship with mathematics (e.g., Do you like math? Why or why not? Do you think it is useful outside of school?) and about their current and past experiences with mathematics (What kinds of things do you do on a typical day in math class? What do you like about those things? What don't you like? How does geometry class compare to your past math classes?) were particularly relevant. Because the observation described at the beginning of this chapter immediately raised questions for me about the role of gender in students' construction of their mathematics experiences, I designed end-of-year interviews specifically to focus on understanding students' mathematics and personal identities and their perceptions doing and learning mathematics in geometry. During the last class session before individual interviews, I asked all students to fill in a diagram about who they are as math student (Figure 4.1). During individual interviews, I asked students to elaborate on what they had written on the diagrams (i.e., Can you start by telling me a little bit about what you wrote here?) Before each interview, I also prepared a specific set of probing questions for each student based on their diagrams. Next, I asked students: If I were to ask you to change this map to be about who you are as a person, outside of geometry class, what would you add? What would you delete? Students had the option of adding to their diagram or crossing out parts of it, or they could make a completely separate diagram. After they finished, I asked them to elaborate on what they had written and asked probing questions. Then, I gave students a list of words that some people might use to describe themselves (e.g., female, Black, disabled, poor), and I asked them to add any words they thought were relevant to their identities. I followed up by asking if they thought any of those parts of their identities mattered in mathematics class, and if so how. Finally, I showed students a list of mathematics topics and other topics by project for the year and asked them to recall which projects they liked and which ones they did not like. I probed further by asking for specifics about what did or did not work well for them during a particular project.

Through iterative rounds of analysis in Dedoose 7.5.16, I coded each interview with Black girls for the content of talk until I had created an exhaustive set of codes. Primary code categories included: (1) perceptions of mathematics (e.g., boring, easy, enjoyable); (2) mathematics identity (e.g., good at math; improving, not good); (3) personal identity (good person; quiet or shy; Black; middle class; person with a disability); (4) student identity (e.g., good student, ok student; struggling student); (5) perceptions of collaboration (e.g., important; enjoyable; challenging); (6) perceptions of other class activities (e.g., like making presentations, do not like whole class discussions). Next, I applied the same codes to the beginning-of-year interviews with Kendra, Monique, and Nemo and to the Black girls' contributions during group interviews to confirm that codes were exhaustive for the Black girls who participated in interviews.

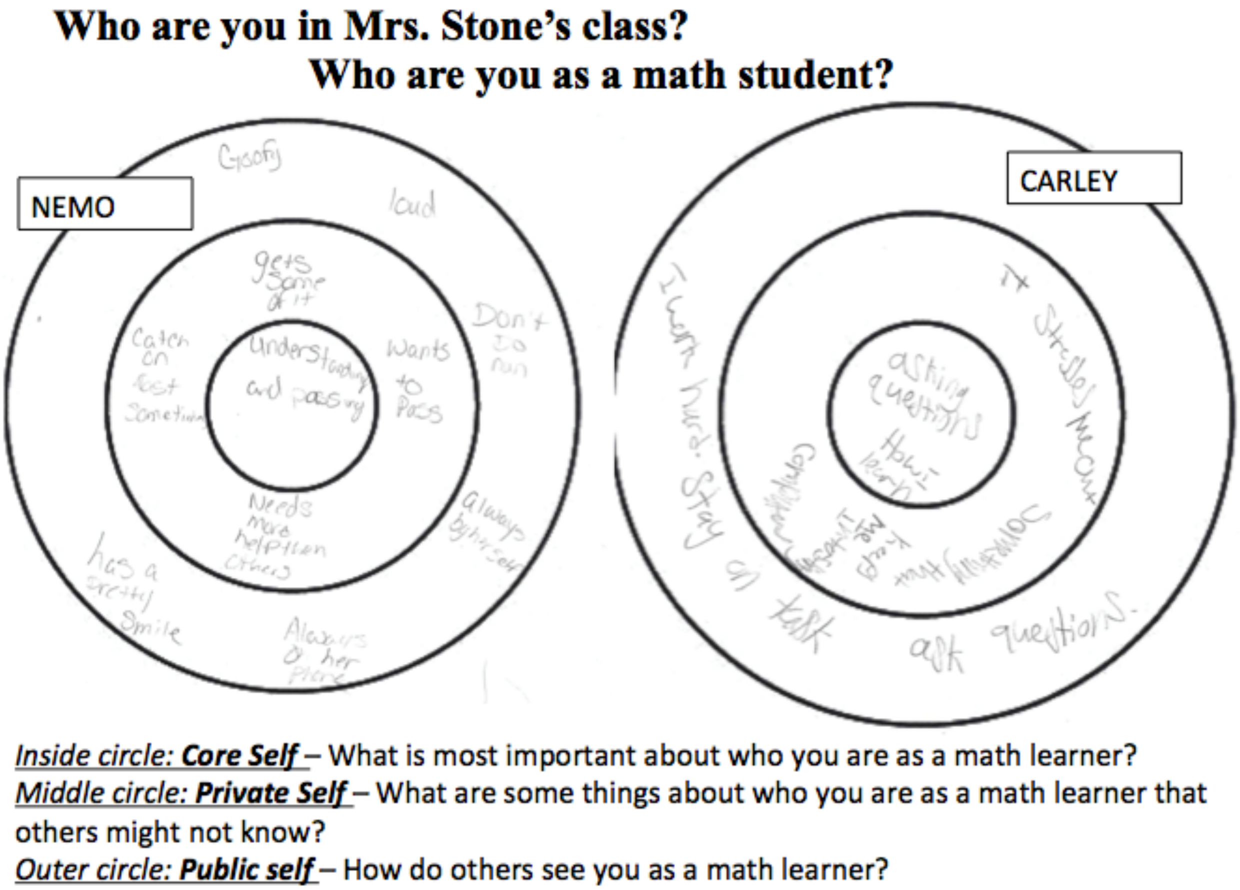

Figure 4.1. Mathematics identity diagrams. This figure shows the questions posed to students as they wrote about their mathematics identities using the diagram. Two sample diagrams are provided here. These diagrams were used during end-of-year individual interviews.

Once I had refined the definitions of the primary codes listed above, I applied the codes to interviews with other students. Primary codes were exhaustive for other students also, but when I needed to create a new subcode, I added a memo in Dedoose to alert me to differences in the way that Black girls had described their experiences and identities compared to their peers. Next, I looked for confirming and disconfirming evidence of the themes identified from interviews in the videos and field notes listed in Table 4.1. I had previously analyzed the videos and field to identify themes in students' interactions with their peers and with mathematics (for more details see Harper, in preparation [Chapter 3]). I compared themes from my previous analysis to themes from the analysis of interviews described here. I rewatched or reread data in order to confirm that themes from the analyses matched or did not match, and I added new codes to the video and field notes as necessary. From this analysis, I identified the additional storylines about "hands on" mathematics that are presented in this chapter.

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CHAPTER 5: CONCLUDING THOUGHTS

In this final chapter, I end by sharing concluding thoughts about the research presented within this dissertation. First, I reiterate the significance of the problem addressed by this dissertation. Then, I summarize Chapter 2 through Chapter 4, highlighting what each chapter contributes to the field of mathematics education's understanding of students' experiences with equity-minded mathematics teaching and synthesizing important ideas across the manuscripts. I conclude with some possibilities for future research as I move forward into an Assistant Professor position.

Significance of Problem Addressed by this Dissertation

The three empirical manuscripts contained within this dissertation explored the relationships between equity-minded mathematics teaching and students' learning and identity development. Namely, I focused on three instructional approaches, which were naturally occurring in the classroom described in Chapter 3 and Chapter 4: (1) teaching mathematics for social justice (TMSJ) – classroom-based investigations aimed at understanding social justice issues and advancing change towards social justice through mathematics (Gutstein, 2003); (2) complex instruction – cooperative learning in which the teacher uses specific strategies to ensure equitable access and equitable interactions in small groups (Cohen et al. 1999); and (3) project-based learning – an approach in which students collaborate on projects to explore and solve authentic, real-world tasks or problems using a range of disciplinary knowledge and skills (Langer-Osuna 2011). Although different in their structures and strategies, teaching mathematics for social justice and complex instruction share an equity-minded focus on supporting historically marginalized students to develop positive mathematics identity by challenging power structures that perpetuate inequity within mathematics and the mathematics classroom. Equity goals are not inherent in project-based learning, but the focus on collaboration and authentic, real-world tasks is compatible with both complex instruction and teaching mathematics for social justice.

Because students can take up well-intentioned reform efforts in unintended ways (e.g., Brantlinger, 2013; Lubienski, 2000), the extent to which equity goals are actually achieved through the enactments of equity-minded instruction (i.e., TMSJ, CI, and project-based learning) remains uncertain. In particular, for TMSJ, the bulk of scholarship focuses on the teaching and tasks in cases of TMSJ, but limited research attends to students' learning through and experiences with classroom-based social justice mathematics (Esmonde, 2014). In addition, studies investigate students' experiences within enactments of only one of the three equity-minded teaching approaches even though these pedagogies are rarely standalone.[1] The enactment of only one of these equity-minded teaching approaches is complex and raises tensions that teachers and students must navigate (e.g., Langer-Osuna, 2015; Leonard, Brooks, Barnes-Johnson, & Berry, 2010; Wood, 2013). Thus, within efforts to blend TMSJ, CI, and project-based learning into a coherent instructional experience for students, there is a need to understand and learn from students' experiences as teachers, researchers, and students work together to transform mathematics classrooms into more equitable spaces for those students who are historically margainlized in mathematics and in society.

Chapter Summaries and Contributions to the Field of Mathematics Education

In Chapter 2, I explored the possibilities and limitations of teaching mathematics for social justice (TMSJ) to address racially-based inequities and injustices, in mathematics

[1] TMSJ is not standalone because of the need to address matheamtical content not included in TMSJ lessons (Brantlinger, 2011; Gutstein, 2003). CI is rarely standalone because of the challenges of implementation without the support of department-wide collaboration (Horn, 2005, 2007).

education and in society more broadly. Such a consideration is important because mathematics classrooms, particularly those with students from historically and systematically marginalized racial and ethnic groups (Brantlinger, 2013), are increasingly becoming sites for investigating social (in)justice (Gutiérrez, 2013; Stinson, 2014). Research on teaching mathematics for social justice, however, remains limited to individual cases of TMSJ, mostly focused on teaching and tasks rather than students' learning and experiences (Esmonde, 2014). In this study, I used qualitative metasynthesis to analyze the body of existing literature on TMSJ and to synthesize findings across a range of qualitative reports of TMSJ in practice. Systematically integrating qualitative findings offers one way of gaining greater insight towards more evidence-based, claims (Thunder & Berry, 2016), in this case, to inform TMSJ practices that address racially-based educational and social inequities across various classroom contexts.

Chapter 2 reported on a metasynthesis of thirty-five qualitative reports of social justice mathematics enactments in diverse classroom contexts. Critical Race Theory (Delgado & Stefancic, 2012) served as a guiding framework for analyzing possibilities and limitations of these enactments to address racial inequities in mathematics education. This metasynthesis produced three major findings: (1) explicitly addressing race in TMSJ enactments provided opportunities for centering people of Colors' voices and experiences across classroom contexts; (2) critiquing liberal views through TMSJ provided opportunities to challenge overt and subtle forms of racism; and (3) most TMSJ enactments created opportunities for substantial and authentic mathematical work. Although these findings suggested possibilities for using TMSJ to challenge racism, the analysis highlighted a number of dilemmas that teacher must navigate in order to prevent TMSJ from further marginalized the unique of Color in mathematics. This study contributes to the field's understanding of evidence-based, promising practices that might help teachers address tensions to ensure anti-racist TMSJ enactments. These are discussed in more detail in the synthesis below.

In Chapter 3 and Chapter 4, I investigated students' learning experiences and identity development with an innovative, hybrid approach to mathematics teaching and learning in a 9th grade geometry class through a yearlong ethnographic interpretative study. The hybrid approach blended TMSJ and CI with project-based learning in a STEM-focused, open-enrollment magnet school with an ethnically and racially diverse student population. At the core of instructional hybridity were goals for equity. Namely, the teacher strove to create a classroom environment that encouraged out-of-school experiences and identities as part of mathematics activity (Langer-Osuna, 2015), towards supporting historically marginalized students to develop positive mathematics identity by challenging power structures that perpetuate inequity within mathematics and the mathematics classroom. The studies presented in Chapter 3 and Chapter 4 build on the growing body of research (Gutiérrez, 2013; e.g., Boaler & Staples, 2008; Gutstein, 2003; Langer-Osuana, 2015; Wood, 2013) that investigates dimensions of identity and power in students' experiences in equitable and hybrid classrooms while offering a new model for equity through hybridity in mathematics teaching and learning.

Chapter 3 described how students collectively negotiated the emphasis on identity and power across three project-based learning projects, which integrated CI strategies and focused on exploring social justice questions about access to quality and affordable food. Using figured worlds as a theoretical framing for identity and learning (Holland, Lachicotte, Skinner, & Cain, 1998), I identified the storylines – taken-for-granted ways that relationships and interactions among mathematics, social justice issues, students, and the teacher were organized – that showed how students shifted, took up, or resisted the instructional focus on identity and power.

Mathematics classroom storylines shifted from more teacher-led, individual approaches to mathematics in the first project (i.e., teacher as mathematical authority; limited ways of being 'good' at mathematics) to more student-centered, collaborative approaches to mathematics in the later projects (i.e., students as mathematical authorities; more diverse ways of being 'good' at mathematics). This shift was associated with an increased use of CI strategies by the teacher, which facilitated more student autonomy and more equitable collaboration. The shifts in the food desert (i.e., urban areas located farther than a mile from a full-service grocery store) storylines were less clearly demarcated by project, but generally, students used their authority as residents of the local community to resist the school-based framing of food deserts because it was not compatible with their personal identities and experiences. Eventually, students took up the focus on addressing negative consequences of food deserts in their city as they renegotiated the focus away from access to food (i.e., grocery stores) and recentered it on individual health and nutrition. Although the framing of the social justice issue was negotiated, partly, by students, the focus on individual choice potentially perpetuated deficit framings of groups of people living in food deserts because it ignored the systemic reasons for inequities in access to affordable and quality food. The study contributions to the field's understanding of using multiple equity-minded instructional approaches within the same classroom to create opportunities for students to see themselves in mathematics and to challenge traditional power structures in mathematics and society.

Chapter 4 focused specifically on the voice of Black girls and their construction of "hands on" mathematics as humanizing within the project-based learning context. Imagining and realizing a humanizing mathematics pedagogy must honor what students who are historically marginalized in mathematics, in this case, Black girls, identify as critical to their ability to succeed (Fránquiz & del Carmen Salazar, 2004). Analysis showed how Black girls collectively constructed a different meaning for “hands on” than their peers did. Namely, Black girls in the class described a broader range of activities as “hands on.” Although they valued opportunities for working with concrete objects in the physical world, they prioritized opportunities to work with a variety of formats for mathematical products and highlighted the need for support from their collaborative partnerships as key elements for their success and engagement in mathematics. These gendered and racialized constructions of “hands on” experiences in mathematics had implications for how students approached mathematical work as they collaborated during projects. In this study, Black girls, themselves, spoke to how seemingly ‘neutral’ mathematics classroom practices, such as “hands on” mathematics and collaboration, can be negotiated as humanizing on students’ own terms, and the possible interpretations I offer contribute to the field’s understanding of how mathematics practices are constructed at intersections of race and gender.

Synthesis across Chapters

In this section, I focus on what can be learned from synthesizing findings from Chapter 2 through Chapter 4 about TMSJ because that specific pedagogical approach was a common thread across this dissertation. In Chapter 2, I identified three promising practices, based on the metasynthesis of TMSJ literature, which might help teachers address dilemmas of integrating mathematics goals and social justice goals to ensure anti-racist TMSJ enactments. I organize this synthesis around those three promising practices, providing a brief explanation of the practice from Chapter 2 and then discussing what additional insights Chapter 3 and Chapter 4 contribute. Because Chapter 2 relied on reports from researchers and/or teachers, I pay particular attention in this synthesis to how findings from Chapter 3 and Chapter 4 amplify students’ voices in regards to TMSJ. In other words, I identify what we (teachers, teacher educators, and researcher) might learn from listening to students and what questions we might ask next.

Centering the unique voice of Color. Findings in Chapter 2 suggest that TMSJ enactments, which explicitly attend to race and racism, created opportunities for centering people of Colors' voices and experiences in mathematics classrooms, but embracing conversations about race in TMSJ can seem impossible unless conversations about politically taboo topics are normalized, in general. Like many of the TMSJ enactments analyzed in Chapter 2, analysis in Chapter 3 shows that the three TMSJ projects did not attend explicitly to race or racism in the TMSJ enactment nor did evidence suggest that discussing race/racism was intentionally avoided by the teacher or the students. Together Chapter 3 and Chapter 4 illustrate two ways the teacher tried to center the unique voice of Color in mathematics, even though race was not named explicitly. In Chapter 3, Mrs. Stone attempted to center students of Color's first-hand experiences with a social justice issue and to extend those experiences to content in the dominant mathematics curriculum. In Chapter 4, she worked to position Black girls as mathematical authorities among their peers. In each case, listening to students' voices and learning from their experiences revealed tensions that can arise when teachers make such efforts. In both cases, students resisted their (White) teachers' efforts. Listening to this resistance can shed light on why students might take up opportunities to center race or racism to varying degrees in TMSJ enactments, specifically, and why students might resist efforts to center the voice of Color in mathematics, in general.

Chapter 3 presented findings from a context in which the students were not resistant to TMSJ, in general, but instead, they resisted a specific framing of the social justice issue required by the teacher to necessitate specific mathematics content. Based on previous cases of TMSJ, this is not surprising. Students' can take up social justice issues (chosen by the teacher) in unexpected (to the teacher) ways (e.g., Leonard et al., 2010), especially in cases when the teacher selects the social justice topic. In this case, the students' resistance to the social justice topic may have stemmed from their recognition that "desert" implied a total absence or lack of something. Thus, the wording, "food desert" itself implied a deficit framing of the areas surrounding students' homes. Consequently, a struggle ensued between the collective construction of a school-based "food desert" necessary for the mathematics and the collective construction of an out-of-school-based "food desert" that aligned with students' experiences with accessing a diversity and abundance of food near their homes. In this example, the out-of-school-based "food desert" amplified students voice and the unique voice of Color – the perspective shared by the students of Color in the class. When the unique voice of Color must compete with another voice (in this case, the school-based voice of their White teacher), it is not surprising that the context does not welcome challenging conversations about race.

Some scholars recommend managing this dilemma by allowing students to select the social justice topics for exploration (e.g., Kokka, 2015), but this approach does little to address the challenge of integrating topics from the required mathematics curriculum into social justice projects (Bartell, 2013). Listening to students' experiences in this case suggests there is a place in TMSJ for teachers to purposefully select social justice topics – to align with the mathematics curriculum and also to expose students to social justice issues or perspectives on social justice issues that are unfamiliar to them. Chapter 3 illustrates how students can become passionate about a social justice topic selected by their teacher, which they did not initially recognize as relevant, when given opportunities to consider the issue from multiple perspectives. By only exploring social justice issues identified by students, teachers might miss opportunities to support students learning about unfamiliar (to students) issues that affect their community (and beyond) while also learning school mathematics. Co-creating a space for social justice investigations in mathematics could mean that both teachers and students identify topics for exploration. Thus, the question remains: How can (White) teachers purposefully select social justice topics to align with school mathematics curriculum and to challenge their own and their students' internalized assumptions and biases while honoring the unique voice of Color?

Chapter 4 provides additional insights to explain why students of Color might take up social justice topics, not just conversations about race or racism, to varying degrees. In negotiating their mathematics identity, Black girls were battling, even if unconsciously, past negative experiences with mathematics and/or gendered and racial stereotypes that positioned them as "bad at math" (Spencer, Steele, & Quinn, 1999; Steele, 2007). As Black girls shifted their relationships with mathematics, they, in part, came to define being good at mathematics by their ability to help others do mathematics. This new framing of mathematics ability supported more equitable interactions among group members in some cases (Harper, in preparation [Chapter 3]), and the Black girls agreed that they appreciated opportunities for support from their peers through collaboration (Harper, under review [Chapter 4]). When the teacher positioned them as the lead mathematical authority in a group (i.e., tried to center the voice of Color in mathematics), particularly among peers outside their friend groups, however, they worried about their ability to explain their mathematical thinking to their classmates. Likely feeling the need to protect their "good at mathematics" identities, they often resisted the teacher's requests that they support their peers to engage with new (to all students) mathematics content. Listening to students experiences in this case shows how learning mathematics can be challenging, and situating the mathematics within authentic, real-world contexts, such as social justice issues, places even more demands on students. As students (of Color) try to manage the challenge of learning new mathematics themselves while supporting their peers by explaining their thinking, they may resist being authorities on the social justice topic, the mathematics, or both in an attempt to manage complexity. Teachers must pay attention when students resist how they are asked to engage with mathematics and make an effort to read between the lines. Students of Color's resistance to TMSJ, or equity-minded teaching in general, likely indicates that students of Color need different supports as they negotiate their personal identities alongside their mathematics identities. The question remains: How can teachers honor students of Color's resistance to being authorities on mathematics and/or social justice topics while also supporting them to center their voices in mathematics?

Considering intersectionality and critiques of liberalism. Findings from Chapter 2 highlighted how critiques of liberalism were more common in TMSJ enactments that explicitly addressed racism than in those that did not. Moreover, considerations of intersectionality and critiques of liberalism were important across TMSJ enactments because there was a need to challenge assumptions and deficit views students of Color held about their own racial groups. Consistent with these findings, Chapter 3 provides a case where the teacher and students did not attend explicitly to racism in the TMSJ enactment and also minimally critiqued liberalism. Instead, students adopted a framing of the social justice topic that allowed them to maintain positive views of their own experiences but potentially perpetuated deficit views of communities of Color (i.e., liberalism). To frame food deserts without accepting a personal framing of themselves or their families as deficit, students shifted the focus away from food access towards individual health and nutrition. The emphasis on individual choice and nutrition inherently deemphasized the broader systems of power that create inequitable access to affordable and healthy foods in the first place. Moreover, students challenged and rejected deficit framings of themselves as people living in a food desert, but they continued to perpetuate this deficit framing of others living in food deserts as people who need outside help.

Findings in Chapter 4 also provide additional insights into the importance of considering intersectionality alongside critiques of liberalism in TMSJ enactments. During research on food deserts, students considered and discussed relationships between poverty and food deserts, which may have made them more inclined to disassociate themselves from living in a food desert. Based on interviews in which I asked students to describe their socioeconomic status, students did not position themselves and their families as poor. Although most of the students qualified for free lunch and Nemo made a reference to using public assistance for food, during interviews, students told me their families were middle class (or higher). Students likely associated living in a food desert with being poor – something that was not part of their constructed home/family figured worlds – and they distanced themselves from both food deserts and poverty.

Listening to students in this case reveals a tension between honoring students' interpretations of social justice issues (and their own experiences) and pushing them to consider other perspectives (including critiquing liberalism). If the students, themselves, do not identify a social justice issues as problematic in their own lives, they may be more likely to distance themselves from the issue (to maintain a positive perspective of their own life) and view the issue as a problem affecting others. Likewise, if students view a social justice issue as problematic, they may emphasize individual actions or experiences over systemic influences (over which they have little control). In this case, from the students' perspective, planning to build a community garden to help others in need or to teach others what they learned about nutrition was empowering (suggesting that they experienced this project as "equitable"), raising questions about the extent to which there is a need to push students to challenge systemic issues. Although the focus on individual health and nutrition ignored broader systems of privilege and oppression, the emphasis on individuals allowed students to imagine ways to advocate for change in a real and meaningful way. In the push to critique liberalism in TMSJ, to what extent are educators and scholars complicit in trying to teach students about their oppressive rather than honoring the way that students chose to empower themselves?

Doing authentic mathematical work and understanding complex social issues. Findings from Chapter 2 suggested that only by engaging in substantial and authentic mathematical work (i.e., articulating assumptions, weighing evidence, etc.) can students come to question liberal assumptions and construct counterstories accounting for race, gender, and class exploitation. Chapter 3 showed how students constructed counterstories about themselves, personally, but not about their broader community. Nevertheless, findings suggest ways of creating opportunities for students to reconstruct social justice storylines across settings, activities, and time in order to make social justice actions increasingly consequential. More specifically, approaches like CI and project-based learning, can complement TMSJ and help manage some of the tensions. In Chapter 3, CI encouraged students to work more independently (from the teacher) and collaboratively with each other even as they learned about new mathematics content (in non-procedural ways) alongside new social justice topics. Additionally, project-based learning helped balance the focus on learning about mathematics and learning about social justice. Because students were familiar with the interdisciplinary nature of project-based learning, time allocated to research and writing within the mathematics classroom was normalized and through teacher collaboration, students had opportunities to explore social justice topics more extensively from different disciplinary perspectives. Pairing TMSJ with other equity-minded teaching approaches is promising for teachers who wish to integrate mathematics and social justice at the high school level but are concerned about balancing learning about both mathematics and social justice topics.

Although promising, pairing TMSJ with CI and project-based learning still presents certain dilemmas. Listening to students suggests other possibilities for integrating mathematics and social justice and for making mathematics classroom more equitable spaces. Although students appreciated the opportunity to work towards building and sustaining a community garden and took up an interest in social justice issues related to living in food deserts, they still acknowledged that much of the project was teacher-driven rather than student-driven. For example, reflecting on the Community Garden Project, Blake shared:

> Yeah, [this project] could be anything. It doesn't need to be a garden. That's the problem with this project. We had to do a garden and write a proposal and blah blah. I think they [the teachers] should just say, "Help the community. Here's some cool ways to do it." Then we go off and do it how we want. I would learn more probably. The only thing against this is that they have things they have to teach us.

In other words, as long as secondary mathematics (and the school curriculum, in general) is what it is, TMSJ efforts will likely be somewhat inauthentic and constrained. Thus, the question becomes: How can teachers and students work within the existing constraints of the school curriculum while also collectively challenging and extending the boundaries for learning in the classroom context?

Moving Forward

This dissertation makes an important contribution to the literature on equity and social justice in mathematics education by amplifying students' voices. Although this study offers some promising ways that we (teachers, mathematics teachers, and researchers) can learn from students to support equitable experiences in mathematics, listening to students also raises new questions about tensions between teachers' goals for centering equity and social justice in mathematics and students' own perspectives on mathematics and social justice. Although the urge to address these tensions and find "solutions" may be tempting, moving forward, I hope, instead, to embrace the messiness inherent in focusing on equity and social justice in mathematics. I view this messiness as the space for contributing to a new way of moving forward and pushing the boundaries of mathematics teaching and learning (Gutiérrez, 2012).

As I enter my tenure-track Assistant Professor position, I am excited to transition from teaching secondary mathematics methods to working with prospective elementary teachers. Because of this change in the context of my work as a teacher educator, I present two sets of questions that will guide my work as I move forward: (1) questions that still remain for me about students' experiences in the context of this dissertation study, and (2) questions that I hope to pursue as I transition to working with elementary mathematics teachers.

I hope to address the first set of questions – those that still remain for me about students' experiences in the context of this dissertation – through continued analysis of data that has yet to be systematically analyzed (see Appendix A in Chapter 3 for information about all data sources across the school year). I list possible research questions below and provide some initial ideas for how I might approach analysis.

(1) How do the different combinations of TMSJ, CI, and project-based learning across the year (not just the three projects presented in this dissertation) emphasize achievement, access, identity, and power differently?

Using an adapted observation protocol, which I have used to operationalize access, identity, and power in student-mathematics, student-teacher, and student-student(s) interactions, I plan to analyze all of the video data. This will allow me to look for trends across the year as the teacher used CI, TMSJ, both CI and TMSJ, or neither CI nor TMSJ to support the yearlong emphasis on project-based learning.

(2) How can various critical and poststructural theories shed light on students' enacted mathematics identities at the intersection of race and gender?

I plan to use post-qualitative analysis to read theory and "read" data together in order to identify trends and multiple, alternative interpretations of the role of race and gender in Monique, Rosy, Warren, and Dante's experiences.

The second set of questions is broader, and designed to help me think about future research as I transition to my new role:

(1) How can project-based learning support TMSJ in which the social justice questions are determined by the students rather than the teachers?

(2) How can (elementary) teachers make connections across disciplines in order to support TMSJ enactments that challenge assumptions and center the unique voice of Color? What relationship with and understanding of mathematics do (elementary) teachers need to make these interdisciplinary connections?

My hope is that these questions will guide the collaborations I forge with teachers in my new position. By focusing first on teaching for equity and social justice, I will be able to build relationships with teachers in my home and learn alongside them about salient problems and tensions within elementary mathematics teacher education. Together with teachers, I aim to push the boundaries of disciplinary study across the K-12 curriculum and imagine new visions for bridging students' out-of-school and school-based experiences. Once I have developed meaningfully and lasting relationships with a core group of teachers committed to equity and social justice in and through mathematics, I hope to turn my attention again to research on students' experiences with equity-minded mathematics teaching.

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