Bank Street
Occasional Paper Series

Occasional Paper Series

Volume 2019
Number 41 *Critical Mathematical Inquiry*

Article 11

March 2019

Critical Mathematical Inquiry

Recommended Citation
(2019). Critical Mathematical Inquiry. *Occasional Paper Series, 2019* (41). DOI: https://doi.org/10.58295/2375-3668.1312

Critical Mathematical Inquiry

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Teaching for Social Justice through Critical Mathematical Inquiry

Steven Greenstein and Mark Russo

Mathematics education, like all disciplines of learning, sits within larger fields of social, cultural, and political beliefs and practices. As we think about the range of these beliefs and practices, we can imagine a linear spectrum of teaching, including mathematics teaching, with each point on the spectrum representing a set of often unacknowledged assumptions about the nature of teachers, students, knowledge, and authority.

At one end of this spectrum, imagine traditional, lecture-based teaching. Teachers are positioned as the knowledgeable ones, and students are positioned as compliant recipients of that knowledge. Teachers act with authority, and students are acted upon. This is where many of us spent most of our time when we were students in school.

Moving toward the other end of the spectrum, teaching becomes more oriented to inquiry. Pedagogy is informed by the tenets of a constructivist theory of learning, which assumes that we are not blank slates. Nor is knowledge passively received. Instead, learning is understood as a constructive process. As we wander the world and engage with it, we construct new knowledge as we make sense of and organize our experiences.

This model of knowing and learning calls for a pedagogy that immerses learners in experiences that support them to figure out—by thinking and reasoning, and reflecting upon their own thinking and reasoning—how to make sense of these experiences. It is an inquiry pedagogy, which recognizes existing knowledge as the basis for new learning and which is oriented to learners as knowers. Knowledge, then—cultural, conceptual, experiential, and linguistic knowledge—is regarded as a resource for learning. This is the interval of the pedagogical spectrum in which we, the readers of the *Occasional Paper Series*, begin to do our work.

Now, even further along the spectrum is where we situate *radical* teaching. We use "radical" as Jean Anyon did (2014), to refer to teaching that addresses the root causes of injustice. *Critical education*, as Ole Skovsmose (1994) describes it, is the purview of radical teaching. He writes, "If education, as both a practice and a research, should be critical it must discuss basic conditions for obtaining knowledge, it must be aware of social problems, inequalities, suppression etc., and it must try to make education an active progressive social force" (pp. 38-39). This is the interval of the spectrum where lowercase-critical thinking (e.g., making sound judgments) joins uppercase-*Critical* thinking (e.g., analyzing forms of authority and injustice) as teaching and learning center on issues of equity, diversity, democracy, and social justice.

The teacher, then, is one who understands the political nature of schooling (Gutiérrez, 2013) in terms of how power, access, oppression, and inequality cooperate (Picower, 2012). The teacher's role is to support and advocate for students' inquiries into the "inequities in the social order" (Cochran-Smith et al., 2009, p. 352), with an eye toward "transform[ing] society into a place where social justice can exist" (Westheimer

& Suurtamm, 2008). Teaching is not only about leveraging students' knowledge as a resource for learning, it is about positioning them as agentive intellectuals (Freire & Freire, 1994) who are oriented through a humanizing inquiry (Freire, 1970/2000) to posing and pursuing questions that have them "critically analyze and challenge oppressive relationships to create more just and inclusive alternatives" (Picower, 2012, p. 1). These are the purposes of critical education. Approaches to *teaching mathematics for social justice* are models of critical education, and *critical mathematical inquiry* is one of them.

Introducing Issue 41

Welcome to Issue 41 of Bank Street's *Occasional Paper Series*. The issue features a collection of papers by authors with a shared affinity for the work of critical mathematical inquiry (CMI). In what follows, we present our framing of mathematics education as a participatory venue for CMI and situate it in the context of another, perhaps more familiar approach to teaching mathematics for social justice (TMfSJ).

We'd like to briefly introduce ourselves and our positions in relation to this work. I (Steven Greenstein) was once a high school mathematics teacher and am now a professor at Montclair State University in northern New Jersey. I (Mark Russo) was also a high school mathematics teacher and now serve as a mathematics supervisor in the Pascack Valley Regional High School District, also in northern New Jersey. Our shared passion for critical mathematical inquiry has developed over the course of our professional careers, most notably in response to students' experiences in schools that attribute their (lack of) performance to deficit explanations or that alienate them by positioning them as compliant objects of instruction centered in curricula they did not choose. We've found the promise of CMI in our responses to these phenomena, including the co-construction of interest-driven, problem-posing, and culturally relevant mathematics curricula. These activities have served to broaden what it means to do mathematics and changed the nature of student agency, engagement, and participation. We invite you to explore this shared passion for CMI through the contributions to this volume. At the end of this introduction, we also offer readers links to curricular resources that we have found useful in our own preparation to teach mathematics for social justice.

Introducing Critical Mathematical Inquiry

We frame critical mathematical inquiry in the following way:

- Critical: an interrogation of systems of power, privilege, and oppression that strives to remedy political, educational, economic, and social inequities and injustices.
- Mathematical: powerful forms of thinking and reasoning that include pattern-seeking, conjecturing, connecting, experimenting, generalizing, visualizing, representing, and proving.
- Inquiry: an approach to knowing and understanding mathematics that draws on and builds upon learners' current knowledge by exploring the mathematical world, asking questions, solving problems, testing theories, validating ideas, and explaining relationships.

Like many others who engage in the work of teaching for social justice, we trace the roots of the journey we're on to Paulo Freire's *Pedagogy of the Oppressed* (Freire, 1970/2000). Freire's analyses of issues of power and oppression, agency and alienation, and the inequitable distribution of resources and opportunities are profound. His foundational text offers threads of a theory of critical pedagogy and a language one can use to articulate the purposes of public education in the context of the myriad inequities and injustices faced by students, their families, and their communities. One such thread is Freire's conception of literacy (Freire, Freire, & Macedo, 1998), which is social and expressive as opposed to hyper-individualistic and mechanical:

> *To acquire literacy is more than to psychologically and mechanically dominate reading and writing techniques. It is to dominate these techniques in terms of consciousness…. Acquiring literacy does not involve memorizing sentences, words, or syllables—lifeless objects unconnected to an existential universe—but rather an attitude of creation and re-creation, a self-transformation producing a stance of intervention in one's context. (p. 86)*

A second thread is Freire's concept of praxis, which refers to the "the action and reflection of men and women upon their world in order to transform it" (1970/2000, p. 79). Henry Giroux (1981, as cited in Frankenstein, 1983) defines the concept as:

> *a critical mode of reasoning and behavior…[that] functions so as to help people analyze the world in which they live, to become aware of the constraints that prevent them from changing that world, and, finally, to help them collectively struggle to transform that world (pp. 114, 116).*

The concept of praxis reminds us that confronting an injustice requires more than coming to understand it; it requires action to remedy it. In the same way, teaching math for social justice cannot be only about consciousness-raising curricular experiences, it must also involve a planned and executed course of action.

Teaching Mathematics for Social Justice

Just as many social justice educators have traced the intellectual roots of their work to Freire, many of us who teach mathematics for social justice trace the foundations of that work to Rico Gutstein's *Reading and Writing the World with Mathematics* (2006). In this section, we build up a model of teaching mathematics for social justice from Freire to Gutstein. In the section that follows, we lay out the distinctions we've made between Gutstein's framing of teaching mathematics for social justice (TMfSJ) and our framing of critical mathematical inquiry (CMI).

Freire's conception of literacy is embedded in his notions of reading the world and writing the world (Freire & Macedo, 1987). Reading refers to deepening one's "understanding [of] the sociopolitical, cultural-historical conditions of one's life, community, society, and world" (Gutstein, 2006, p. 24). "Freire's theory," writes Marilyn Frankenstein (1983), "compels mathematics teachers to probe… the connections between our specific curriculum and the development of critical consciousness" (p. 324). Mathematical illiteracy was a concern for Frankenstein, who warned us that "a mathematically illiterate populace can be convinced, for example, that social welfare programs are responsible for their declining standard of living, because they will not research the numbers to uncover that 'welfare' to the rich dwarfs any meager subsidies given to the poor" (p. 327). She proposed that a critical mathematics education could challenge students to question the ideologies below the surface of such contradictions (p. 329). This is the work of preparing for engagement in social movements, or writing the world.

Writing, then, is an instance of Freirean literacy, which is about transforming the world by means of "conscious, practical work" (Freire & Macedo, 1987, p. 35). Together, reading (reflection) and writing (action) constitute the dual processes of praxis. Gutstein's model of teaching mathematics for social justice (TMfSJ) relies on these dual processes and entails both mathematics and social justice pedagogical goals (see Figure 1).

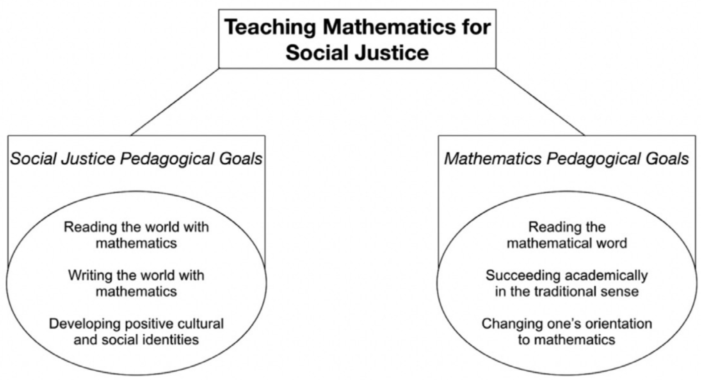

Figure 1. Eric Gutstein's model of teaching mathematics for social justice (recreated from Gutstein, 2006, p. 23)

Gutstein's (2006) mathematics pedagogical goals are reading the mathematical word, succeeding academically in the traditional sense, and changing one's orientation to mathematics. Reading the mathematical *word* (as opposed to reading the world with mathematics, which we explain below) means developing mathematical power, which has been defined either in reference to the National Council of Teachers of Mathematics' (NCTM's) (2000) *Principles and Standards* (e.g., students' capacities to engage in complex mathematical tasks, demonstrate flexibility in problem-solving, communicate ideas and results effectively) or to the National Research Council's (2001) five strands of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, productive disposition, and adaptive reasoning.

"Succeeding academically in the traditional sense," for Gutstein, "means that students achieve on standardized tests, graduate from high school, succeed in college, have access to advanced mathematics courses, and pursue (if they so choose) mathematics-related careers" (p. 30). This particular form of success is important to Gutstein, because students have historically been marginalized and excluded. This includes even those who *have* developed the requisite mathematical power but do not perform well on tests.

While we're on board with Gutstein in terms of the importance of ensuring that students remain centered and included, we propose a broadened framing. Mindful of the range of ways that people move through the world after—and even without—high school, we want students to accomplish whatever mathematical tasks with which they engage.

Finally, changing students' orientation to mathematics means changing their understanding of the nature of mathematics as a collection of disconnected procedures to be memorized and regurgitated, to seeing it as a powerful tool for analyzing and understanding complex, real-world phenomena.

Gustein's model has social justice pedagogical goals, as well, and this is where it derives its particular power. These include reading the world with mathematics, writing the world with mathematics, and developing positive cultural and social identities. Reading the world with mathematics is about using mathematics to "understand relations of power, inequitable distributions of resources, and disparate opportunities between different social groups, and to understand explicit discrimination based on race, class, gender, language, and other differences" (Gutstein, 2003, p. 45).

Writing the world with mathematics means using mathematics to change the world—and, in doing so, developing a sense of social agency and seeing oneself as capable of making change (Gutstein, 2003). As an example, Gutstein offers William Tate's (1995) work with students who wrote the world by presenting data-based arguments to their city council to confront the problem of a disproportionate number of liquor stores in their neighborhood.

Other examples of mathematics for social justice curriculum include "Home Buying While Black or Brown," "Sweatshop Accounting," and "The Geometry of Inequality," all of which appear in the edited volume, *Rethinking Mathematics*, by Rico Gutstein and Bob Peterson (2013). Links to additional resources appear at the end of this introduction.

Developing positive cultural and social identities, Gutstein's third social justice pedagogical goal, means grounding mathematics instruction in students' languages, cultures, and communities, while providing them with the mathematical knowledge they need to survive and thrive in the dominant culture (Gutstein, 2006). For this goal, Gutstein draws on Gloria Ladson-Billings' conception of culturally relevant pedagogy (1995), in particular, her notion of "cultural competence," which ensures that students are able to "maintain their cultural integrity while succeeding academically" (p. 476). Others also draw on the concept of funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) to enhance students' cultural and social identities.

Why CMI?

Gutstein's model of teaching mathematics for social justice (TMfSJ) is a powerful form of critical education. Indeed, it's so profound that just about any mathematics educator who regards the purpose of education as a tool for humanization and liberation draws on Gutstein to some extent. Then why the need for critical mathematical inquiry? We framed CMI as we did for several reasons. First, we wanted to emphasize that TMfSJ isn't only about curriculum. We offer you some curricular resources, but they don't fully constitute the essence of the work. Indeed, we regard curriculum as the experience (Dewey, 1938; Pinar, 2012) these resources can be used to generate—the *processes* of praxis and self-reflection. Furthermore, these resources are lessons grounded in an injustice identified by their authors, not by the students who will be using them. Written curriculum is a great starting point, but students' problem-posing is what's fundamental to Freire's liberatory, humanistic concept of education (1970/2000). It's also fundamental to Gutstein's model, and we want to emphasize it: TMfSJ is about supporting students as they pose and pursue their own inquiries. Moreover, we propose that *these inquiries need not be grounded in some injustice outside the classroom and in one's community*. This is where our framing of CMI diverges a bit from the ways that teaching mathematics for social justice is commonly understood.

In TMfSJ, the mathematics used to identify and ultimately challenge injustice is applied mathematics, that is, the application of mathematics, such as statistics, to solving practical problems. In contrast, the mathematics of CMI can be pure, that is, the study of mathematics for its own sake, independent of application—*as long as the pedagogy is critical*. Critical mathematical inquiry can take place in the context of pure mathematics, because there are injustices that occur not just outside the classroom, but also inside the classroom, such as when students experience the mathematics curriculum as alienating or disenfranchising. A critical pedagogy is a powerful force with which to confront these inside-the-classroom injustices, which is why we framed the critical in CMI above to explicitly include efforts to remedy educational inequities and injustices.

Anita Wager (as cited in Wager & Stinson, 2012) describes moving beyond teaching mathematics *about* and *for* social justice to teaching mathematics with social justice. These pedagogical practices support a co-created classroom and a classroom culture that provides opportunities for equal participation and status. For example, we've found opportunities to enact a critical pedagogy when we've asked students to prove mathematical theorems such as *The product of three consecutive integers is divisible by 6*. The problem isn't related to an injustice and it's not real-world, but they understand what the theorem *means* and that allows them to engage, sometimes enthusiastically.

Similarly, we note that CMI generates a space for student-directed inquiry. At times, students are interested in pursuing problems unrelated to injustice. In keeping with the commitments of teaching for social justice, honoring students' interests can be understood as a form of critical mathematics pedagogy. Furthermore, the moves and judgments we make as students pursue their inquiry, even within the space of a micro-moment of teaching—what Deborah Ball (2018) referred to as "discretionary spaces" in an AERA Presidential Address—have the potential to invite equitable and legitimate participation. They cultivate students' sense of connectedness (Maloney & Matthews, forthcoming) and well-being (Kokka, 2018), develop their identities as doers of mathematics, and provide them with opportunities they can leverage to act with agency. Ultimately, these moves and judgments help us broaden what it means to know and do mathematics so that new students emerge as able. These are the features of a critical pedagogy conducive to teaching mathematics for social justice.

One final point about TMfSJ in regards to pure mathematics problems: Dennis Almeida (2016) makes the argument that mathematical-proving activity is democratic in nature, because proofs of theorems must be convincing to the entire classroom community. Indeed, in a mathematics pedagogy that emphasizes student argumentation over getting right answers, arguments are presented, students participate in a discussion about the proof, they critically examine it, challenges are made to its validity, strengths and weaknesses are identified, and ultimately the proof is improved. If the primary purpose of teaching mathematics is less about the content (e.g., you'll never encounter a quadratic in the real world that can be factored) and more about providing a context for powerful forms of logical thinking and reasoning, then we can imagine that critical interrogations like these prepare students to make informed judgments and decisions about consequential issues outside of school.

The Contributions to this Issue

Our goal for this issue is to provide a venue for teachers and teacher educators to share their images of learning as participation in critical mathematical inquiry (CMI). We pursue this goal so that we may collectively identify, explore, and generate new pathways for praxis at the intersection of mathematical inquiry and education for democracy and social justice, with a particular emphasis on what "doing mathematics" looks like when math is pursued for critical consciousness. In the Call for Papers, we framed CMI according to its three features, but we did not suggest its meaning. Instead, we aimed to generate a space in which contributors to the issue could do that with us. They have. And this is how they did it.

Two contributions to the issue leverage **theoretical and historical perspectives** to generate broadened conceptions of curricular experiences associated with CMI within the field of mathematics education. Fahmil Shah uses an analysis by Harouni (2005, 2015) to track how school mathematics has historically been dominated by a commercial-administrative agenda. He proposes that a socio-analytical approach to standards, curricula, and standardized assessments can transform school mathematics into a tool for social justice.

Mary Raygoza utilizes Westheimer and Kahne's (2004) framework of personally responsible, participatory, and social justice oriented citizens to argue for the intersectionality of mathematics and civics education. For Raygoza, CMI invites students to understand, reveal, and inform action on issues of social inequality and requires math teachers to reimagine their classrooms as interdisciplinary spaces ripe for developing students' quantitative civic literacy.

Three contributions to the issue focus on **features of a critical pedagogy** that support environments conducive to student participation in CMI. Debasmita Basu and co-editor Steven Greenstein demonstrate how tasks they refer to as "knowledge-eliciting mathematical activities" can help teachers build relationships with their students and make instruction more effective by drawing out their students' home, community, cultural, and mathematical knowledge. Basu and Greenstein present two approaches they found to be productive through their work in a mixed-age middle school classroom, one involving modified *Would You Rather?* mathematical tasks and the other using a "contextual scaffold" grounded in a consequential community issue to bridge students' at-home and in-school knowledge.

Frances Harper emphasizes two particularly effective instructional strategies—complex instruction and project-based mathematics—because "*how* students learn" matters just as much as "what they learn." Harper draws on two food desert projects from a high school geometry class to illustrate how different pedagogical approaches position mathematical authority and ownership among the teacher and students.

Lynette Guzman and Jeffrey Craig explore how incorporating students' funds of knowledge, deconstructing dominant narratives, and engaging in transdisciplinary inquiry can support CMI. They describe an activity centered on *The World as 100 People* infographic, and they consider how digital media and transdisciplinary inquiry can help us reconsider which stories we choose to tell with or without mathematics.

Three contributions to the issue offer **images of CMI as they play out in mathematics classrooms.** An early childhood classroom is represented through Elinor Albin and Gretchen Vice's demonstration of how mathematics can support social-emotional learning with four- and five-year-olds. They describe how number lines and "power-o-meters" are used to help students better understand their own emotions, better empathize with their peers, and think more deeply about the meaning and importance of community.

There are two examples situated in elementary classrooms in this issue. The first, by Cathery Yeh and Brande Otis, uses textbook analysis to argue for leveraging and extending students' community and classical mathematical knowledge. Yeh and Otis describe how the strategy of "say-mean-matter" invites students to first identify the social and political messages conveyed in word problems, and then to reframe these problems into more personally meaningful, relevant, and socially just contexts.

The second piece, by Teddy Chao and Maya Marlowe, draws on principles from the #BlackLivesMatter movement to explore how first and fifth graders wrestled with the concept of fairness through a Peace Park activity. Their work highlights how relationships with parents and members of the community are essential in supporting a comprehensive and sustained study of Black culture and the insidiousness of racism.

Finally, Laurie Rubel and Andrea McCloskey describe some very real **challenges faced by critical mathematics educators** who engage with or advocate for CMI. Interrogating the ways in which the phrase the *soft bigotry of low expectations* and related ideologies have been used in political far right media and mainstream discourse about mathematics education, Rubel and McCloskey juxtapose the work of CMI against the context of powerful, public actors who seek to maintain the status quo by delegitimizing CMI. The authors' call to action both prepares and encourages educators to persist in their engagement with CMI as they critically analyze and challenge oppressive structures and relationships.

CMI is inherently an iterative, reflective process. Just as the authors in this issue describe some of the successes of their work, they also share their failures and ongoing struggles, emphasizing the real work of embedding CMI in an education framework of social justice. While each of these authors provides a unique perspective on CMI, taken together they demonstrate the power of student participation in critical mathematical inquiry as well as the urgency with which such participation must take place. Our hope is that by engaging with these contributions as a whole, powerful themes will resonate with readers who believe in the potential for social change through education, and that these themes will inform the development of critical pedagogies and curricular experiences for use in their own classroom communities and spheres of educational influence.

Curricular Resources

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Gutstein, E., & Petersen, B. (2013). *Rethinking mathematics: Teaching social justice by the numbers (2 ed.).* Milwaukee: Rethinking Schools. Available at https://www.rethinkingschools.org/books/title/rethinking-mathematics-second-edition

Osler, J. (2007). A guide for integrating issues of social and economic justice into mathematics curriculum. Available at http://www.radicalmath.org/docs/SJMathGuide.pdf

Stocker, D. (2017). Math that matters 2: A teacher resource for linking math and social justice. Ottawa, ON: Canadian Centre for Policy Alternatives. Available at https://www.policyalternatives.ca/publications/reports/math-matters-2

Additional Resources:

CEMELA: Center for the Mathematics Education of Latinos/as. Available at https://math.arizona.edu/~cemela/english/resources/links.php)

Creating Balance in an Unjust World. Available at http://creatingbalanceconference.org

Free Minds, Free People. Available at https://fmfp.org

Math and Social Justice: A Collaborative MTBoS Site. Available at https://sites.google.com/site/mathandsocialjustice/home)

NYCoRE: The New York Collective of Radical Educators. Available at http://nycore.org

TODOS: Mathematics for All. Available at https://www.todos-math.org

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Mark Russo is the district supervisor of mathematics and computer science for the Pascack Valley Regional High School District in Montvale, NJ and an adjunct professor at Montclair State University. He is interested in promoting equity in schools, supporting effective mathematics teaching and learning, and helping students experience the beauty and power of mathematics and statistics. He is currently exploring the development of algebraic reasoning in computer science and the utilization of quantitative reasoning through interdisciplinary connections between statistics and social studies (SASS).

Steven Greenstein is an Associate Professor in the Department of Mathematical Sciences at Montclair State University. He enjoys thinking about mathematical things… and how people think about mathematical things. Through his work, he aims to democratize access to authentic mathematical activity that honors the diversity of learners' mathematical thinking, that is both nurturing of and nurtured by intellectual agency, and that is guided by self-directed inquiry, mathematical play, and the having of wonderful ideas.

Re-designing Mathematics Education for Social Justice: A Vision

Fahmil Shah

When setting standards and creating mathematics curricula, policymakers and curriculum designers must make choices about what kinds of mathematics are included in our state or national standards as well as in our textbooks. A persistent question in the field of mathematics education is why and how these choices are made, to which there does not appear to be any clear, consistent answer (Harouni, 2015). However, a recent movement within the mathematics education community has shifted the conversation about the purpose and goals of school mathematics. Professional organizations, including the Association of Mathematics Teacher Educators (AMTE), the National Council of Supervisors of Mathematics (NCSM), TODOS: Mathematics for ALL (TODOS), and the National Council of Teachers of Mathematics (NCTM), have begun highlighting equity and social justice as top priorities within the field (AMTE, 2015, 2016; NCSM/TODOS, 2016; NCTM, 2012). The emphasis on social justice as a key aspect of teaching mathematics is now being considered both as a priority of professional organizations and as a focus of conferences within the field. This movement, described by some as a sociopolitical turn, has pushed mathematics education in the 21st century into a new era (Gutierrez, 2013; Stinson & Bullock, 2012), focusing school mathematics on social and political issues and solutions.

Despite these exciting changes, some critics have expressed skepticism about the effectiveness of school mathematics as a tool to illuminate and address issues of social justice (Martin, 2013). In alignment with Martin's argument that current efforts have not effectively challenged current power structures in society, I will consider issues of equity and social justice through a historical and political framework in order to articulate why mathematics cannot (in its current form) complete the sociopolitical turn. Furthermore, I will suggest directions for school mathematics and educational policy that can increase the effectiveness of current efforts in critical mathematics (Frankenstein, 1983, 2009; Stinson & Bullock, 2012) and social justice pedagogy (Gutstein, 2006) to tackle relevant social and political issues.

The Fundamental Problem

Mathematics education, in its current form, cannot be fully used as a tool for critiquing society. The fundamental problem becomes clear if one considers the historical context through which school mathematics has emerged and developed. Harouni (2005, 2015), through an analysis of that context, created a categorization of school mathematics that described the four types of mathematics (and mathematics problems) that have developed over the course of human civilization: (a) philosophical, (b) artisanal, (c) commercial administrative, and (d) socio-analytical. He argues that these categories developed as a result of both economic and political forces, and that the (word) problems that we see in mathematics textbooks emerge from those categories and are a reflection of the political and economic climate of their time.

Briefly, philosophical mathematics is focused on the abstract and used to understand logic and patterns without concern for their context. In practice, philosophical mathematics is more an intellectual exercise than a tool for finding solutions to real-life problems. Artisanal mathematics is concerned with problems in the workplace, such those faced by engineers, architects, and tailors; unlike philosophical mathematics, it is focused on dealing with practical, real-life situations. For example, it is used by a carpenter building a table and involves many variables. The carpenter must decide what type of wood to use, how to cut it, and how to make sure the table will remain upright.

Commercial-administrative mathematics focuses on the work of the merchant and is rooted in the activities of buying, selling, and trading. Unlike artisans, who are concerned with problems involved in measuring, merchants are interested in issues related to counting. Finally, socio-analytical mathematics moves beyond numbers and uses the solutions to mathematical problems to spark discussions about the implications of the mathematics for society, allowing for a critique of the status quo. While a mathematics problem on the growth of the federal minimum wage versus the cost of living might deal with some quantitative comparisons, the socio-analytical perspective compels the mathematician to consider the social impact of the results of those comparisons and the justice of the socio-economic system in which they are situated. Harouni (2015) describes each of these categories of mathematics and their historical roots at length.

There has been a push by researchers and practitioners to forefront political tensions in mathematics education—a movement that has been termed a sociopolitical turn (Gutierrez, 2013). Such a movement would require a greater focus on socio-analytical mathematics. However, I argue that the current form of mathematics education has instead forefronted commercial-administrative mathematics and has limited the appearance and importance of other forms, including socio-analytical mathematics (AMTE 2015, 2016; Gutierrez, 2013; Martin, 2013; NCSM/TODOS, 2016; NCTM, 2012, Stinson & Bullock, 2012). While I believe that philosophical and artisanal mathematics also deserve a place in school mathematics, the focus of this paper will be on ways in which socio-analytical mathematics can be forefronted more within school mathematics. In the following section, I will explain why I believe that school mathematics is currently most focused on commercial-administrative mathematics, and how this might be changed to increase the focus on the socio-analytical perspective.

The Relationship Between Commercial-Administrative Mathematics and Socio-Analytical Mathematics

Since merchants were among the first users of mathematics, commercial-administrative mathematics has been employed widely from the beginning of civilization. The use of mathematics in this form facilitated buying, selling, and trading through counting. Thus, at its roots, the practical use of mathematics is most readily obvious in economic contexts. One need only consider the common pedagogical approach of helping students make sense of a mathematical concept that they do not understand by "bringing it back to money." Out of necessity, most everyone in capitalistic societies recognizes money and understands how to interact with it. One cannot, in general, function in such societies without a working knowledge of how to buy, sell, and trade. The implicit importance of knowing how to accumulate or distribute goods is clear when we look at the types of problems that we commonly find in school mathematics. For example, in elementary school, the use of both join and separate word problems (Carpenter, Franke, & Levi, 2003) commonly involves students using addition and subtraction to accumulate, distribute, or remove something. Consider the following word problems, which were presented to children in grades 1 through 3:

- Wally had 3 pennies. His father gave him 5 more pennies. How many pennies did Wally have altogether?
- Tim had 8 candies. He gave 3 to Martha. How many candies did Tim have left? (Hiebert, Carpenter, & Moser, 1982, p. 87)

Students are thus introduced to mathematics through the process of accumulating and sharing goods. Those who have studied secondary mathematics may have been assigned problems involving simple and compound interest or calculating the cost of cell phone plans. Teachers bring students back to situations involving buying, selling, and trading because this is what they are used to. Furthermore, these "real-life" contexts are assumed to be very relevant to students' lives.

On the other hand, teachers and researchers have expressed interest in expanding the content of mathematics beyond what has traditionally been taught in school (i.e., the commercial-administrative perspective of mathematics). Some studies have investigated ways in which school mathematics can be used as a tool to challenge inequities in society. Work in a variety of areas has emerged to support the use of mathematics as a tool to address social injustices, including with pedagogies described as culturally relevant (Ladson-Billings, 1995), culturally responsive (Gay, 2010), culturally specific (Leonard, 2008), and culturally sustaining (Paris & Alim, 2014) as well as with critical mathematics pedagogy (Frankenstein, 1983; 2009; Skovsmose, 2014) and social justice pedagogy (Gutstein, 2003, 2006; Gutstein et al., 2005), among others. This work has involved redefining the purpose of school mathematics to include promoting not only what Gutstein (2006) has described as functional literacy (i.e., being able to do mathematics in the traditional sense), but also critical literacy, which involves approaching knowledge critically and developing the agency to act in order to make changes in the world. However, consider the following problem:

> Last June, about 250 students graduated from Simón Bolivar high school. Could the cost of one B-2 bomber give those graduates a free ride to the UW [University of Wisconsin–Madison] for four years? (Gutstein, 2006, p. 247)

This problem *could* be used to foster conversation about the amount of money that is spent on the military and how else that money could be spent (and if money could be used differently to benefit society). However, even if this problem presents opportunities for rich discussion and analysis of our society's decisions around funding (i.e., for students to engage in socio-analytical mathematics), it is ultimately still tied to commercial-administrative foundation of mathematics. By design, this problem requires students to reduce a complex societal issue to a comparison of the monetary value of the bomber and the cost of the college education. Even though such problems provide opportunities for students to engage in socio-analytical mathematics, they are still grounded in the same commercial-administrative perspective that students are accustomed to. Some researchers therefore argue that this pedagogical approach does not actually challenge deeper underlying societal issues such as institutional racism and income inequality (Martin, 2013). Martin states that critical analyses of market-oriented projects have typically left underlying racial projects unanalyzed, and that mathematics education itself is an instantiation of a White institutional space. He states that mathematics educators must continue to question what kind of project mathematics education is, and whose interests are served by the field.

I argue that school mathematics has developed in such a way that commercial-administrative mathematics forms its foundation, and that deep critiques of society have been placed in a secondary position within this system. The centrality of a commercial-administrative perspective has given it a privileged position in the teaching of mathematics in the United States over other perspectives that might allow mathematics education to serve a different and perhaps deeper purpose. This begs the question: What would school mathematics look like without a foundation in commercial-administrative mathematics? Would it be possible to create a system where we instead begin with socio-analytical mathematics as the foundation from which school mathematics emerges and develops? In what other ways could students' early mathematics experiences be shaped? The following section will address these questions, elaborating on what might be possible if we reframe students' early experiences in mathematics to forefront the socio-analytical perspective.

Envisioning a Socio-Analytical Approach to Mathematics Education

In order to truly embrace moving school mathematics toward the sociopolitical turn, we must use a more balanced approach that introduces the socio-analytical perspective at the beginning of a student's education. If we wait, we fall into the same patterns that have hindered progress in making that turn. I believe real, effective change involves considering the most fundamental aspects of mathematics from the socio-analytical perspective.

Mainstream mathematics education in the United States (and in many other countries) begins with the four basic operations: addition, subtraction, multiplication, and division. Students then are asked to use the operations in order to find values they will obtain as a result of using these operations (i.e. 3 plus 4 equals 7). Such a framing communicates to students that "equals" is used to indicate that the following quantity is the result of a mathematical operation. This framing, however, is limited, and does not account for other situations that students encounter later in mathematics (e.g. when dealing with algebraic expressions, multiple expressions set equal to each other, or equations where the unknown is not the right-most quantity). Students' early misconceptions resulting from this initial use of the equal sign can lead to misconceptions that need to be addressed in later mathematics courses.

Recently, there has been a focus on making sure that students know what the equal sign "means" (Powell, 2012). Although children often think of the equal sign as operational (i.e., used when one has done a calculation and found the answer), mathematics education researchers have advocated for helping students instead see the equal sign as showing a relationship between the expressions on each side of the equation (i.e., that the two expressions have the same value), either in situations where they must compare existing expressions, or ones where they must generate their own expressions in order to create equality. Students can understand the use of the equal sign as a relational symbol rather than an operational symbol to deepen their early understanding of mathematics, and reframing their understanding of this symbol can have positive benefits as they move toward more advanced topics.

While the use of the equal sign as a relational symbol can deepen students' understanding of this mathematical symbol, I argue that such a framing of equality can be expanded further, in a way that might facilitate early discussion of issues relevant to socio-analytical mathematics. Clearly, mathematics has a strong interest in equality, as we begin using the equal sign explicitly as early as elementary school and continue to use it in the most advanced mathematics. In many mathematics textbooks, you are likely to see equality in most, if not every, chapter. Students are not often asked how this mathematical concept relates to the real-life concept of equality. For example, students in mathematics classrooms are not typically asked the question "Why is equality desirable, and why is it useful to be able to recognize or create it?"

The concept of equality has important value inside and outside of mathematics, and discourse around equality can connect these in a meaningful way, starting at an early level. For example, students in mathematics classes who are learning about equal sharing division might be asked to consider why we want to give an equal number of our 20 candies to each of four people, as opposed to giving everyone a different amount? Why is this a good way of distributing them versus any other? A student who is working on comparing the area of two rectangular plots of land with different dimensions given to two farmers might be asked about what questions might be considered when deciding how much land each should get and in what contexts it might be justified in not receiving the same area of land in situations where the total amount of land is limited.

The socio-analytical perspective around equality is an example of a way that such conversations can begin at an early age for mathematics students, and I argue that these types of discussions can continue to happen at all levels of school mathematics. Meaningful discussion around socio-analytical mathematics can be extended to include more advanced concepts throughout the K-12 curriculum around topics such as fractions, proportional reasoning, and geometry. However, I argue that the current structure of school mathematics is not arranged in a way that facilitates this development, and that there are a number of steps that might be taken in order to support a sociopolitical turn towards a more socio-analytical form of school mathematics. The following section offers a set of steps that might be taken in order to support such a form of school mathematics.

Steps Toward a Socio-Analytical Approach to Mathematics Education

The steps and examples discussed in this section refer to the current structure of mathematics education in the United States, but the underlying principles could be adapted to be relevant to school mathematics in any context. Here I will describe a set of steps that could be effective in moving school mathematics in the United States toward the sociopolitical turn.

1. Standards must be adapted to support the socio-analytical perspective

   The Common Core State Standards of Mathematics (National Governors Association Center for Best Practices, & Council of Chief State School Officers, 2010) have currently assumed a prominent position in mathematics in the United States. Since curriculum developers often work with the current content and practice standards in mind (whether or not these are explicitly listed within the textbooks associated with the curriculum), they play a vital role in how the mathematics curriculum is created and how the curricular content is presented. There has been criticism of the Common Core State Standards of Mathematics (CCSSM) and its effectiveness (e.g. Martin, 2013), just as there have been critics of standards for decades (e.g. Darling-Hammond & Wise, 1985). My critique of the CCSSM is not based on the quality or effectiveness of the CCSSM as currently envisioned or implemented, but instead on the belief that the implementation of these standards, as currently designed, does not offer opportunities for a socio-analytical approach to teaching mathematics in schools.

   Currently, none of the CCSSM practice standards directly address issues that are central to socio-analytical mathematics. Critique, a basic element of socio-analytical thinking, is addressed in Practice Standard 3: "Construct viable arguments and critique the reasoning of others" (National Governors Association Center for Best Practice, & Council of Chief State School Officers, 2010). However, the elaboration of this standard does not include any reference to using this critique to address issues of inequality or inequities in society. For example, a teacher may ask students to choose the "best" way to distribute a limited set of resources among a number of individuals or groups and then defend their choice to the whole class, which may have groups who support a different distribution. Such a discussion may be very rich, as deep conversations may develop as students form their opinions based on different assumptions about what is fairest or most desirable. The current form of this standard, however, does not ask this of teachers or of students, and so one can very reasonably address the current standard without having meaningful discussion around issues of social justice. Adjusting the standard to include examples such as the one above can encourage the inclusion of such socio-analytical discussion in mathematics classroom discussions.

   Similarly, content standards must be rewritten to incorporate goals of challenging or upending the status quo. Currently, content standards exist that support the use of commercial-administrative mathematics, but not of socio-analytical mathematics. Consider the following examples given in the CCSSM for K–12 mathematics topics:

   - Grade 7 – Proportional Relationships: simple interest, tax, markups and markdowns, gratuities, commissions, and fees
   - High School – Algebra: calculation of mortgage payments to derive the formula for the sum of a finite geometric series (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, n.pag.)

   Additionally, consider the following contexts given for teaching content standards within the CCSSM:

- Grade 7 – Real-life problems: If a woman making $25 an hour gets a 10% raise, she will make an additional 1/10 of her salary an hour, or $2.50
- High School – Functions: Calculating the number of person-hours it takes to assemble "n" engines in a factory
- High School – Modeling: Designing stalls at a fair to maximize profit and modeling savings account balance or investment growth (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, n.pag.)

Clearly, even with recent math curriculum reforms, in our content standards there is still much attention paid to issues related to commercial and administrative work. While there are a few examples in the content standards of contexts that might be considered socio-analytical (such as in discussing how water and food might be distributed or in analyzing risk in pandemics or terrorist attacks), there are no standards that require students to engage in this type of analysis. Furthermore, the socio-analytical aspect of this work (e.g., discussions of how resources might be distributed) is not even mentioned in the standards. Therefore, even if socio-analytical contexts are used, it is possible that no critical analysis will be done beyond the mathematical calculations required to solve a given problem (e.g., calculating the number of gallons of water each household is given following a disaster, if resources are evenly distributed).

2. The content of mathematics curriculum must change

As mentioned before, the word problems that are currently part of mathematics curriculum are most often grounded in the commercial-administrative perspective. In order to change the status quo, problems that investigate issues of social justice, equity, and equality must be presented at all grade levels. Consider the following problem:

> Tim has 10 cookies. His teacher said that he should share his cookies with Bill and Kevin because they do not have any cookies. How many cookies should Bill and Kevin be given in order to be fair?

This question does not necessarily have a straightforward answer. We might consider a few options. If Tim wanted to distribute the cookies equally to Bill and Kevin, they should each get five. However, that might not be fair, because then Tim would have none for himself. He could give three each to Bill and to Kevin and keep three for himself, but then there would be the question of what to do with the tenth cookie. One possibility would be to break the last cookie into thirds, which would result in all of the cookies being divided equally. Another problem could involve toys (which cannot be broken into pieces) instead of cookies; then there would be the issue of what to do with the tenth toy. Perhaps one could argue that Tim should keep it, since all the toys were his to begin with. One might also consider whether Tim is obligated to share his toys at all. Should he have to give them up because other children don't have as many (or any)?

Other questions can be asked as we develop mathematics for higher grades. For example, is it fair to distribute everything equally, or are there cases where we ought to divide things proportionally?

In the US Congress, we choose to do both, with proportional representation in the House, based on population, and equal representation in the Senate. Why do we do both? What does this choice tell us about what we value as a society? With regard to the current political issue of tax reform, some would argue that proportional approaches make more sense than "equal" amounts of tax, and yet, we have tax brackets where people at different levels pay different percentages of their incomes in taxes. Is this fair? What does this choice say about us as a society, and does this need to be reformed?

I argue that such questions can and should be asked in socio-analytical mathematics classrooms. However, without standards that push curriculum developers to create materials to support this approach (and with no incentive for teachers to do so), it is unlikely that it will gain any significant traction in the near future.

3. Standardized assessments must be changed (or removed)

Finally, we must consider how we can assess socio-analytical mathematics knowledge. Often, the effectiveness of teachers and schools in implementing standards is based on how students perform on assessments that frequently take the form of high-stakes standardized testing. The SAT exam is an important high-stakes exam, as it is taken by many high school students and is often a requirement for college admissions. The mathematics section of the exam currently features calculator and non-calculator sections covering three areas of math: Algebra, Problem Solving and Analysis, and Passports to Advanced Math. These sections are designed to provide real world skills that can be applied to college courses, jobs, and students' personal life (College Board, 2019). The SAT test has undergone many changes over the years, and the latest shift of the exam has intentionally moved it towards testing the mathematics covered in the CCSSM to more accurately represent the mathematics covered during students' schooling. Because the current SAT exam is a reflection of the CCSSM, the limitations of the standards themselves are thus transferred to the college admissions process, further extending the reach of the current system.

If the current standards were adjusted, however, assessments that currently are gatekeepers to higher education access might also be adjusted in order to reflect a shift in school mathematics. In response to changes in the CCSSM, high-stakes standardized tests such as the SAT might begin to include open-ended questions that require students to both solve a mathematical problem and offer an articulate justification of their reasoning, allowing an assessment of both mathematical and writing ability at the same time. For example, given information about the population distribution in Flint, Michigan, and the amount of water available there, students could be asked to write a plan in which they discuss how resources could be distributed (and over what time period) to ensure that the public has clean drinking water as changes are made to the infrastructure of the city. To create the plan, students would have to use mathematical calculations and provide justification for their decisions. These types of questions would address standards that incorporate socio-analytical mathematics skills and assess the extent to which students have met these standards. As it stands, however, current assessment practices continue to perpetuate the commercial-administrative focus that dominates school mathematics. While it would be possible to eliminate this issue by simply removing high-stakes testing from the college admissions process, it seems unlikely that this would be a realistic option within the current US educational system.

The relationship between standards, curricula, and assessments is complex and is controlled by a variety of societal, political, and economic forces. For this reason, large-scale systemic change must be a result of change in all three of these areas. It is only through a holistic overhaul of school mathematics that the discipline can embrace a greater use of socio-analytical mathematics and move towards a substantive, lasting sociopolitical turn.

Conclusion

The current educational landscape has developed in such a way that the commercial-administrative perspective has been given a privileged status, and other perspectives have often been neglected. Although a number of mathematics approaches, such as social justice mathematics and critical mathematics, have attempted to take the sociopolitical turn, they often do not effectively create a meaningful challenge to the status quo (Martin, 2013). I argue that our current vision of school mathematics hinders our ability to use mathematics for a truly significant critique of inequities and injustices in society. This paper presented options for how mathematics education might be re-envisioned to support a new school of mathematics, with more balance.

By developing an approach that forefronts socio-analytical mathematics from the ground up, and which is supported by modified standards, curricula, and assessments, the field can support the movement toward the sociopolitical turn, which will support students' ability to meaningfully discuss inequities in society and to develop ways to challenge them.

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Quantitative Civic Literacy

Mary Raygoza

Mathematizing the World

In the mathematics content breakout session of a teacher education course I teach at Saint Mary's College of California, Humanizing Education Methods, we devote a segment of each class to learning about how mathematics teachers and students "mathematize the world." We draw on texts such as *Rethinking Mathematics* (Gutstein & Peterson, 2013) and *Math that Matters 2* (Stocker, 2017), blogs such as Frances Harper's *Solving World Problems* (2018), and websites such as as RadicalMath. As a mathematics education professor and researcher and former urban high school mathematics teacher, I engage in this work as part of a larger aim to prepare future mathematics teachers to teach for a more socially just world.

One evening, in a lively discussion on how students may learn about the difference between mean and median as they explore data on U.S. family income and wealth over time, one of my teacher education students wondered aloud: How can we not only study societal inequality in math class but also support students to *do something* about it?

Civics education is often positioned as the social science teacher's job.[1] However, if we view mathematics as a discipline that is essential to understanding, revealing, and informing action on pressing issues of societal inequality, then it is also the job of the math teacher. As we do the work of reimagining mathematics classrooms as interdisciplinary, problem-posing spaces that connect to students' lives, communities, and the world, how can we help prepare young people to develop as civic actors, using their mathematical knowledge and skills to build their *quantitative civic literacy?*

In response to the student's query, I turned my teacher candidates' attention to the *teaching for social justice* (also referred to as *critical mathematics*) scholarship and practice-based pieces we had read. Indeed, these texts put forth a goal that teaching mathematics should be to support young people to be critical and active participants in their democracy. In *Rethinking Mathematics*, Gutstein and Peterson (2013) explain, "As students develop deeper understandings of social and ecological problems that we face, they also often recognize the importance of acting on their beliefs. This notion of nurturing what Henry Giroux has called 'civic courage'—acting as if we live in a democracy—should be part of all educational settings, including the mathematics classroom" (p. 4).

Gutstein (2006) refers to students taking action as "writing the world with mathematics," borrowing from Freire's (1970) notion of "reading and writing the world." He emphasizes that students coming to write the world with mathematics is a gradual process that occurs over time. No single mathematics lesson can offer the range of ways that people may take action on issues of inequality. However, teachers can build students' sense of agency, supporting them to see ways they are "capable of contributing to historic processes" in collective endeavors (p. 27), which they can apply in the future and in contexts outside of the mathematics classroom. So that students can understand how mathematics can be an "instrument

1 While most states require civics coursework, participatory elements and community engagement are not common.

of social change" (Brelias, 2015, p. 10), what are some examples of how mathematics teachers integrate action in their mathematics lessons about societal inequality?

Taking Action in Mathematics Class

In a germinal piece, Tate (1995) examines a case study of a mathematics teacher of African-American middle school students, noting that the teacher's overarching goal is to "develop students into active participants in the democracy" (p. 170). The teacher seeks to connect social issues to mathematics, asking students to explore the ratios of different community resources to people, and then compare those ratios to ones in neighboring communities. Drawing on their mathematics work with proportions, the students ultimately present data to their city council to challenge the disproportionate number of liquor stores in their neighborhood.

In a more recent case study, Gregson (2013) describes how a mathematics teacher drew on her own background as an activist to design a unit on the discrepancy between workers' wages and a fair wage. She supported students as they wrote letters to a fast food chain reporting their findings and also accompanied them to a rally related to workers' rights. Gregson argues that these actions offered students "a powerful example of how collective organizing can improve social conditions" (p. 25).

Youth Participatory Action Research (YPAR)—a process in which youth identify an area of inquiry, design and conduct a research study, and then take action—is another domain where students can take action related to mathematical or statistical learnings. Some examples include Terry (2011), who describes Black male youth in South Los Angeles engaging in mathematical counter-storytelling to challenge dominant narratives. Yang (2009) describes students creating their own school report cards with quantitative ranks to measure areas important to the students, such as culturally relevant teaching. I have written up the results of a YPAR project in which my Algebra students conducted a school-wide survey on school food injustice, presented their results to the cafeteria manager, and invited the community's Healthy School Food Coalition to be partners in their work (Raygoza, 2016a).

Rethinking Mathematics (Gutstein & Peterson, 2013) also presents examples of student action informed by mathematics, including students who spoke out in public forums after doing a mathematical analysis of overcrowding at their school, and students who wrote letters to a social studies textbook publisher after doing a mathematical analysis of slaveholding presidents and noticing the textbook did not address this part of history.

What Kind of Mathematics Student?

While these examples help us to imagine civic action with mathematics, it is important to keep in mind that there is not a singular way of conceiving what it means to develop students as civic actors. Just like teachers come into the profession with a wide range of ideological views on the purpose of schooling, they have various ideas about what it means to be a "good citizen." Especially if not centered in teacher education and professional development, mathematics teachers may not have had opportunities to develop clarity in their vision of the kind of "good citizen" their mathematics students could become.

For guidance on thinking through this further, I turn to Westheimer and Kahne's (2004) "What Kind of Citizen?" article on the different ways social studies teachers conceptualize young people as citizens of a democracy. They argue that there are different visions of developing students as civic actors, and such visions are political in that they include particular perspectives on societal inequality and how people could improve society. In other words, the curricular and pedagogical decisions made by teachers advance a vision of the kinds of democratic citizens young people could become. Specifically, Westheimer and Kahne identify three over-arching conceptualizations of citizenship based on theoretical perspectives and their empirical research on civics education programs: the *personally responsible citizen*, the *participatory citizen*, and the *social justice-oriented citizen*. I will discuss each of these conceptualizations and apply them to different ways students could engage in civically minded mathematics.

The *personally responsible citizen* engages in charitable acts, such as donating to a food drive or giving blood, or participates in community service such as picking up trash. A mathematics teacher could engage students in looking at data reflecting structural inequality and give examples of or create space for personally responsible acts as responses to such inequality. In a study of elementary and secondary social studies teacher education students' perspectives on citizenship, Martin (2008) found that teachers tend to emphasize community service over political engagement. Do mathematics teachers also emphasize community service over political engagement as they engage their students in study of social problems?

Another example that Westheimer and Kahne provide for the *personally responsible citizen* is a focus on financial literacy, which mathematics teachers may take up, because particular mathematics concepts are key to financial literacy (e.g., the role of compound interest in loans and in saving). Baron's (2015) Count on Yourself program, designed to teach students and parents the mathematics behind financial literacy, operates from the perspective that if students and their parents have greater mathematical abilities, they will be more financially prosperous *and* more informed citizens.

While developing a *personally responsible citizen* is essential, Westheimer and Kahne argue that a combination of characteristics of the *participatory citizen* and *social justice-oriented citizen* are required to prepare young people to participate in a democracy, because these conceptualizations assume a greater focus on collective action than individual action. For example, to participate in a democracy, people must go beyond following the laws as "responsible" individuals, to knowing how laws are developed, voting on them, and organizing to change them. *Participatory citizens* "actively participate in the civic affairs and the social life of the community at the local, state, or national level" (p. 241). They participate and take leadership in government or community organizations in order to advance change as a collective. In the mathematics classroom, this form of participation might look like students using mathematics as a tool to inform voters on policies relevant to inequality or as a tool in "participatory budgeting," a process through which citizens exert control over governmental budgets (Pateman, 2012).

The *social justice-oriented citizen* believes that "citizens must question, debate, and change established systems and structures that reproduce patterns of injustice over time" (Westheimer & Kahne, 2004, p. 240). This view of citizenship is perhaps most consistent with the ideology underlying *teaching mathematics for social justice* (Aguirre & del Rosario Zavala, 2013; Bartell, 2013; González, 2009; Gutstein, 2006; Tate, 1995; Wager & Stinson, 2012). This involves acting to change social, political, and economic structures.

Whereas *a personally responsible citizen* would donate to a food drive and a *participatory citizen* would organize it, the *social justice-oriented citizen* would identify and challenge the root causes of hunger. Key to preparing a social justice-oriented citizen is exploring the role of social movement and grassroots organizing to challenge systemic injustice. In the mathematics classroom, students might explore how mathematics is a tool for grassroots organizing on racial and economic injustice, such as within the Black Lives Matter movement or the Occupy movement.

Mathematics teachers can explore ways to develop their students as civically engaged mathematics students by bringing these conceptions of different kinds of citizens to the mathematics classroom and asking them, "What kind of mathematics student would you like to be?" Just as in social science classrooms, in the mathematics classroom we can equip students to understand civic action through a personally responsible, participatory, and/or social justice lens. In professional development with teachers, Bartell (2013) found it was common for mathematics teachers to "recognize that action is a critical component of teaching mathematics for social justice" but "not take a stand on whether or not that action is about students transforming their world" (p. 13). How can we as mathematics educators articulate and sustain our visions for supporting students to transform the world with mathematics?

Developing a Pedagogy for Quantitative Civic Literacy

I hope to continue to work with my teacher candidates to think about what forms of quantitative civic literacy we hope to help students cultivate. In future work, I am committed to taking up the following, and would like to call on other mathematics educators to join me in dialogue around these areas:

- Extend frameworks for what it means to develop quantitative civic literacy.
- Develop an eye for finding examples of people using mathematics as a tool for social change (recognizing that social and political consciousness are always evolving), and support the continuous development of that eye in one another.
- Seek to observe (in-person or via video examples) classroom activities designed to enhance quantitative civic literacy, focusing on how teachers build classroom community, center students' lives in the exploration, pose questions, facilitate dialogue, and support students to engage in action.
- Learn how other teachers have advocated for the curricular time and space to teach and develop quantitative civic literacy, considering that the pressures and constraints of high-stakes testing often prevent teachers from doing this kind of work (Raygoza, 2016b).
- Identify and contribute to venues in a school beyond the mathematics classroom where students can develop quantitative civic literacy (e.g., as part of interdisciplinary project-based learning units that span classes, in leadership or advisory classes, or in youth participatory action projects in after-school spaces).

- Arrange guest speakers and field trips that enhance students' quantitative civic literacy.
- Attend conferences such as Creating Balance in an Unjust World Conference on Mathematics and Social Justice and TODOS Mathematics for ALL to learn about ways in which young people specifically have engaged in a range of actions informed by or with mathematics—globally, nationally, and locally.
- Discover how students feel critical mathematical exploration influenced them years beyond their time in the class (e.g., see Buenrostro, 2016, who interviewed students years after taking a social justice mathematics class), and use those understandings to inform future work on teaching quantitative civic literacy.

If mathematics educators collectively engage in these practices and share their wisdom and experiences, we can deepen our understandings of how to teach quantitative civic literacy.

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Cultivating a Space for Critical Mathematical Inquiry through Knowledge-Eliciting Mathematical Activity

Debasmita Basu & Steven Greenstein

As teachers, we know that learning is more effective when instruction connects the mathematics we aim to teach and the home, community, and cultural knowledge students bring with them to school. Indeed, classrooms can only operate as venues for critical mathematical inquiry if instruction draws out and builds on this knowledge. We also realize that the benefits extend beyond making learning more effective. Engaging this knowledge also helps us cultivate the kinds of caring relationships that nurture students' sense of belonging (Horn, 2017) and contribute to the myriad ways we experience the joys of teaching and learning.

It is one thing to know the benefits of leveraging what Turner and her colleagues refer to as children's *multiple mathematical knowledge bases* (MMKB) (Turner et al., 2012)—or "the understandings and experiences that have the potential to shape and support children's mathematics learning—including children's mathematical thinking, and children's cultural, home, and community-based knowledge" (p. 68). It is quite another to undertake the considerable effort required to elicit this knowledge from students. While teachers tend to believe the effort is worthwhile, they often find they lack the time to do it (Gonzalez et al., 1993, p. 1390). Thus, tasks that reveal students' multiple mathematical knowledge bases can be useful to teachers who wish to leverage their students' knowledge as resources for more effective instruction. However, such tasks are hard to find and even harder to create.

In this article, we share the findings of a project we undertook, which we titled *knowledge-eliciting mathematical activity*, or KEMA. Our goal for the project was to develop task design principles that teachers could use to reveal their students' multiple mathematical knowledge bases. We present some of the tasks we found to be effective along with some of the things we learned, aiming to offer guidance to teachers to develop their own tasks. We believe the principles we used to design these tasks will be useful to teachers who wish to enact a responsive mathematics pedagogy that is deeply connected to their students' bases of mathematical knowledge.

Participants

This study was implemented in a community charter school in a low-income, urban setting in Newark, New Jersey. The school has an enrollment of 110 students, and 92% of them are eligible for free or reduced-priced meals. Many of the students are either immigrants or first-generation children born of immigrants from countries including Brazil, Cameroon, Ecuador, Ghana, and Nigeria. One mixed-grade class of 15 elementary and middle school students ranging in age from 9 to 13 years old participated in the study. The classroom teacher is a mathematics teacher; he allowed us to assume control of the classroom while we were there. We asked for this permission so that we could do our best to assume the role of teachers who had much to learn about their students.

Phase 1: Knowledge-Eliciting Mathematical Tasks

Every student brings a range of everyday and out-of-school knowledge with them to school, and these culturally determined ways of knowing frame their perspectives and determine what they see (Schoenfeld, 1992). Our first attempt to develop mathematical tasks that we hypothesized would elicit children's multiple mathematical knowledge bases involved the use of *Would You Rather?* tasks, which we found at the website, **www.wouldyourathermath.com** (Stevens, n.d.).

Would You Rather? tasks offer two options to students and call on them to choose one and justify their decision. By their nature, the tasks invite students to use mathematics to craft their justification. We were drawn to these tasks because we have found them to be richly revealing of students' mathematical knowledge. A sample appears in Figure 1.

Figure 1. A sample *Would You Rather?* task

We saw the promise in revising and modifying these tasks so that they had both mathematical features and real-world contexts that we thought students would relate to. In this way, they could reveal students' cultural, home, and community-based knowledge, as well as their mathematical knowledge.

Figure 2 presents two of the tasks we modified. The one on the left poses the question, "Would you rather live a 10-minute bike ride from school or a 5-minute bus ride?" This task could be answered by relying solely on the mathematics—that is, 5 is less than 10—but we also imagined that it would engage other forms of knowledge. Some students may prefer to ride a bike, some may enjoy the company of friends on the bus, and some may be all too familiar with the effects of traffic and how it varies, depending on the time of day.

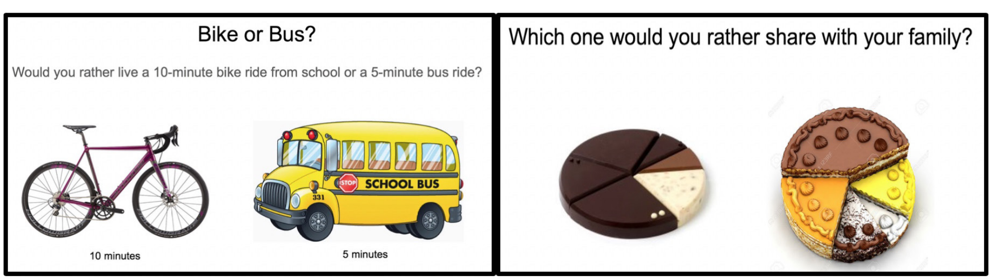

Figure 2. Two modified *Would You Rather?* tasks

When we implemented the task, students emphasized the waiting time for a bus and the lengthy pick-up and drop-off times, and expressed concerns about local traffic conditions. One student argued, "I will choose the 10 minutes by bike over a bus, because sometimes there could be lots of traffic and in a bus, I have to wait for a longer time…. Riding a bike is also like exercise." Another student preferred the bus, because "it is quicker and gives you more opportunities to chat with your friends."

The task on the right in Figure 2 is also revealing. Students were shown pictures of two cakes, the first a one-layered cake and the second, a five-layered cake, and asked, "Which one would you rather share with your family?" Students picked one of the two cakes and then provided justifications for their decisions. A student who chose the five-layered cake explained, "If you have big family, you can eat it all. It will be like no leftover." Another student chose the one-layered cake for a reason that also related to sharing. She added, "Say, like, if you have like a small family, it would be like – I realize that the pieces are not same, but you can share with your family." These students' choices reflected knowledge of sharing that is rooted in both family knowledge and mathematical knowledge (as partitioning).

Phase 1 Results. Through our design and implementation of modified *Would You Rather?* tasks, we sought to elicit students' multiple mathematical knowledge bases. Some of our tasks failed to reveal much knowledge at all. For example, one task offered the option, "Would you rather walk to the grocery store or walk to the library?" One student expressed a desire to go to the library in order to "feed her brain knowledge," while another realized that although he was given a choice, he would *need* to go the grocery store at least once a week. Still, another preferred to go to the grocery store rather than the library because at the grocery store, "you can talk while you get things you like." Similarly, another less productive task offered the choice between collecting loquats or cleaning trash from the beach. Students didn't know what a loquat was, but they assumed it was healthy. And the beach reference didn't fully resonate, although some students did express the importance of keeping it clean. That task told us something about what students *didn't* know.

On the other hand, other tasks, including the ones we presented above, elicited students' mathematical knowledge related to fractions, rate, ratio, and area. This is to say that we used those tasks in conjunction with teacher discourse moves like waiting, probing, and revoicing to press students for the forms of knowledge we sought to reveal. For instance, they couldn't just say, "I'll take the cake on the right because it's prettier." These tasks also provided a window into students' experiences traveling to school, their disposition toward sharing among friends and family members, their food preferences, and the concerns they have about the costs of things. For instance, in the cake task, one student chose the one-layered cake and added, "I chose the first one, because, to be honest, like around here, like a lot of people don't have a lot of money and they wanna save on other things. So I chose the one that looks like it has the lower price."

To the extent that we sought to design tasks to elicit mathematical knowledge, we were delighted. That said, we realized that much of what we learned about these students is what we might expect to learn from any group of students. That is, we didn't know, for example, whether it was reasonable to attribute the disposition to shared cultural norms. In fact, our findings made us question just what constitutes cultural knowledge. We had thought of it as some sort of static trait attributable to a particular group of people. However, it may be better understood as intersectional and related to a variety of ways people experience the world, their home, their school, their faith, and their social networks. This is a question we're still pursuing. We wondered whether there might be something missing in the design of our tasks that was preventing them from evoking the diverse forms of knowledge we sought to assess.

We were also disappointed that the tasks failed to generate much in the way of productive whole-class discussion (Stein, Engle, Smith, & Hughes, 2008). We initiated the prompts, students responded, and we struggled to find follow-up opportunities that would generate student-to-student conversation. There seemed to be no reason for the students to listen to, talk to, or respond to each other. As a result, there were missed opportunities for students to elaborate on the knowledge they shared and for us to make connections across their responses. That precluded us from identifying patterns in their experiences which we could use to make claims about their collective knowledge.

We sensed that we had made good progress toward developing strategies for eliciting students' multiple mathematical knowledge bases but that there was more potential to realize. Consequently, we decided to take a new approach to task design in Phase 2 of the project.

Phase 2: Community Issues as Scaffolds for Mathematical Learning

Students in school often fail to find the relevance of what they're learning. In particular, the kinds of problems they solve in school often have little to do with the kinds of problems they need to solve in everyday settings outside of school (Lave, Smith, & Butler, 1988; Roth & McGinn, 1997). Science education researchers Bouillion and Gomez (2001) framed this disconnect between out-of-school knowing and in-school learning in the form of the following challenge:

> A challenge facing many educational institutions, especially those in urban settings aiming to serve culturally and linguistically diverse populations, is the disconnect between schools and students' home communities. Schools are *in* communities but often not *of* communities. (p. 878)

In order to remedy the disconnect, Bouillion and Gomez developed an instructional approach known as "connected science" that bridges the real-world problems students face in their communities with the science content they are expected to learn in school. Connected science uses real-world problems as "contextual scaffolds" for linking students' community-based knowledge and school-based knowledge—or what we've been referring to as students' multiple mathematical knowledge bases.

The Research Context

We implemented Phase 2 at the same school in Newark, New Jersey, in March 2018. At the time, Newark was one of the twenty finalist cities being considered by Amazon.com for the location of its second headquarters, or HQ2. It wasn't until November 2018 that Amazon announced two new locations for

HQ2: Long Island City, in the Queens borough of New York City, and Arlington, Virginia. In the lead-up to this announcement, the twenty cities were involved in intense analyses of the potential costs and benefits of having Amazon's second headquarters.

Amazon promised that they would spend around $5 billion in construction costs on HQ2 and bring in 50,000 new, high-paying jobs. The situation in Seattle, Washington, where Amazon's first headquarters is located, had some citizens of Newark feeling optimistic about the potential benefits if Amazon were to move to the city. From 2010 through 2016, Amazon contributed $38 billion to Seattle's economy, and each of those dollars generated an additional $1.40 in the city's economy. Some Newark citizens were not only imagining thousands of new jobs, they also foresaw thousands of additional jobs and tens of billions of dollars in additional investment in the communities surrounding Newark. After Newark offered Amazon $2 billion in tax incentives, former governor of New Jersey, Chris Christie, was so confident about the benefits of having HQ2 located in Newark that he promised Amazon an additional $5 billion. That $7 billion was larger than any tax break offered by the other 19 cities vying for Amazon's attention.

In order to understand the full meaning behind the potential Amazon might have brought to the citizens of Newark, it's instructive to consider the city's tumultuous political and economic history.

Newark, New Jersey, is one of the most populous cities in the U.S. and is one of the nation's major air, shipping, and rail hubs. Though several leading companies have their headquarters in Newark, including Prudential, PSEG, Panasonic, Audible.com, and IDT Energy, 31% of its residents live below the poverty line, and the city's unemployment rate is 12%. Not unrelated, it is the "most violent" city in New Jersey according to the FBI (Brown & Kiersz, 2018). The economic situation hasn't always been so bleak. Newark was once a flourishing industrial center. In the 19th century, it was known for its leather factories, breweries, and insurance industries. One historian noted, "its heavy industries, its whirring factories, its prosperous building trades, and its noted public works made it a confident and optimistic community" (Jackson, 1985, p. 275). He continues: "As late as 1927, a prominent businessman could boast":

> Great is Newark's vitality. It is the red blood in its veins—this basic strength that is going to carry it over whatever hurdles it may encounter, enable it to recover from whatever losses it may suffer and battle its way to still higher achievement industrially and financially, making it eventually perhaps the greatest industrial center in the world (p. 275).

Soon thereafter, though, when the Great Depression hit in 1929, Newark suffered a precipitous decline in economic activity. Manufacturers and industrialists left the city and took their jobs with them. Conditions worsened when the Newark race riots broke out in 1967. Middle- and upper-class Whites fled the city, leaving behind poor and polarized communities of color. The demographics of the city have shifted since then, as the African-American population increased from 2.7% in 1990 to 52.4% in 2010, and the White population decreased from 97.2% to 26.3% over the same period of time.

The adversity Newark experienced over the last century may have played a role in it being identified among a list of 20 potential locations for Amazon's second headquarters. As primary stakeholders, the citizens of Newark along with their homes and communities, stood to experience an unknown mix of positive and negative consequences as a result of the decision.

Bridging In-School and Out-of-School Learning

About a year after we implemented Phase 1 of the project, we returned to the school. We wanted to continue our efforts to develop knowledge-eliciting mathematical tasks, and the timing was right to leverage the Amazon issue as a contextual scaffold for linking students' community- and school-based knowledge.

Reports on Amazon's deliberations around HQ2 intermittently appeared in the news. However, these reports only offered the perspectives of politicians and the business community. Too few of them captured the perspectives of local residents. We hoped that through our conversations with students and their families, we would learn how they were feeling about the prospects of HQ2 being located in their community, which in turn would help us to leverage their out-of-school knowledge and experience to develop mathematical tasks that were meaningful to them. Accordingly, we took a *funds of knowledge* approach to acquiring this knowledge.

Luis Moll and his colleagues use the term "funds of knowledge" to refer to "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll, Amanti, Neff, & Gonzalez, 1992, p. 133). In their attempts to better understand the border region between Mexico and the United States, they visited homes, conducted observations, and implemented interviews. What they found were diverse forms of funds of knowledge that include knowledge related to farming, sales, construction, trade, auto repair, contemporary medicine, and household management. And what they learned was that households possess a wealth of cognitive and cultural knowledge that provide a counterpoint to deficit framings of marginalized students and that can be leveraged as resources for classroom instruction.

Teachers' schedules are already overloaded, and conducting home visits and writing up the findings takes more hours than they have available. In fact, teachers who have expressed a desire to visit their students' homes have cited a lack of time as the primary reason that they do not engage in these activities (Gonzalez et al., 1993). Furthermore, accumulating students' funds of knowledge requires an already existing, trusting relationship between teachers and their students, making it particularly complex for new teachers (Moll et al., 1992). Indeed, accommodating these realities is one of the motivations for this project. Accordingly, when we wanted to assess what the students in our project and their families knew and felt about the prospect of Amazon's second headquarters being built in their community, we took an approach that we felt would be much more feasible.

The Amazon Problem

In our first interaction with students around the Amazon problem, we presented the issue to them. We showed them what the situation was like for Amazon's first headquarters in Seattle (see Figure 3).

We mentioned the prospects of 50,000 new jobs, the $100,000 salaries, and the infusion of funds for construction. We also mentioned the tax incentives and how they could result in reduced government spending on things like roads, schools, libraries, health care, and housing. Then we had a whole-class discussion in which we gathered students' thoughts about the issue and what they imagined to be the benefits and drawbacks of having HQ2 located in Newark. We posed questions like:

- What changes do you think you might see in Newark and in your neighborhood?
- Will that make things better or worse for your community?
- Do you know anyone who might be interested in working there?
- How do you think local and family businesses will be affected?
- What do you think about the government's decision to offer Amazon a $7-billion tax break?

Here are some of the things they said. We've italicized some of the words to forefront the mathematical ideas embedded in their responses – ideas about rate and change and so forth:

> "*Taxes will be raised* and local business will suffer. If *salaries increase*, the area will become *too expensive*, causing business and families to be displaced," said one student. "I live in downtown Newark and Amazon's presence will drive *housing demand so high* that tenants may not be able to afford their *monthly rent* and other amenities," added another.

Other students sounded more hopeful. They were eager to welcome Amazon to their town.

> "There will be *positive changes. Security presence will be high* and that will *reduce the crime rate* in the city. Also the city's *economy will improve* and that will put a favorable spin to our status. It will make things better and more people will come back to Newark."

After this discussion with students, we asked them to use the same questions we had asked them in class to interview a parent, caretaker, or any other member of their community about the issue. This is the strategy we used to approximate a funds of knowledge, in-home visit.

Figure 3. Amazon's first headquarters in Seattle, Washington

When students returned their completed interview protocols to us, we independently read their responses and identified the same three primary themes in the data: 1) space for Amazon, 2) housing and rental prices, and 3) traffic. Though students and their families generally expressed optimism about HQ2, an underlying concern was perceptible across their responses. They wondered, "Where would Amazon construct HQ2?" They were concerned about "the degree level necessary to fill the positions." And they worried that "housing demands [could be] so high that tenants may not be able to afford their monthly rent and other amenities." In response to what we had learned, we created the following three mathematical tasks, one for each of the themes we identified. Each of these tasks was designed to leverage the community knowledge we had assessed as a resource for students' mathematical instruction.

Where Will It Go? is an activity connected to concepts of geometry and measurement. Students were given a live Google map of Newark (Figure 4) and asked to explore where Amazon could locate HQ2. We stated the problem as follows: Amazon's Seattle campus is 8 million square feet. That's equal to 2,828 feet on a side, or about 3,000 square feet. Look at the map of Newark and try to spot an empty place of this size where Amazon could build HQ2.

Students used the map's *measure distance* feature to lay out an area approximately equal to the size of Amazon's Seattle campus, and they considered whether it would be worthwhile to trade open spaces like parks and gardens. Finding a place for HQ2 proved to be a struggle. They soon realized that there was no viable place unless the city compromised an area currently occupied by places such as West Side Park (yellow marker in Figure 4), Fairmount Memorial Cemetery (red marker), the Prudential Center (blue marker), or the Red Bull Arena (green marker).

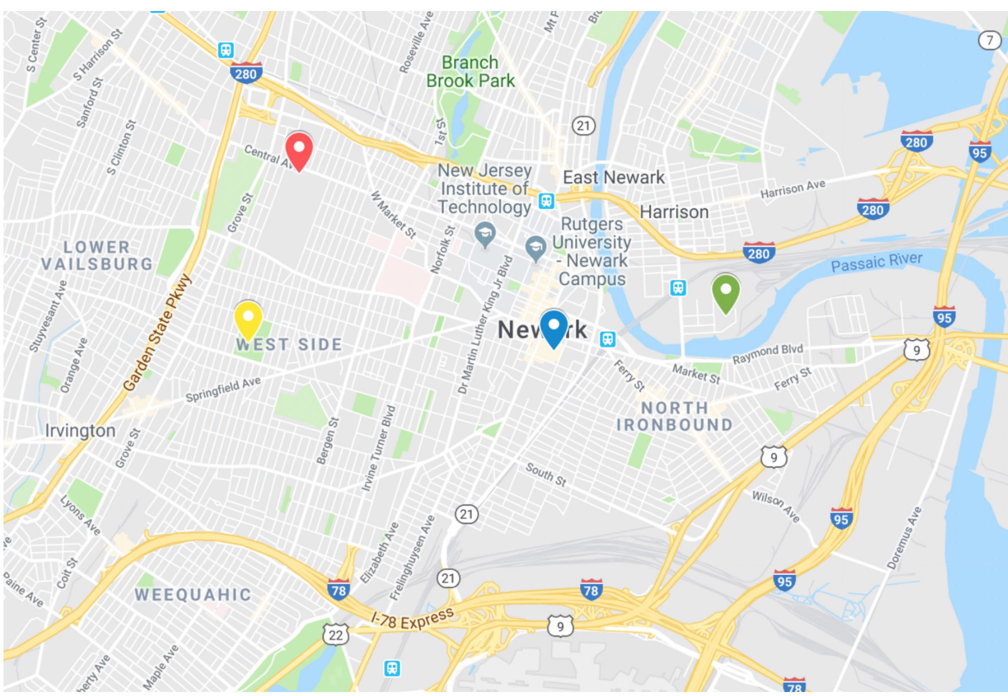

Figure 4. Map of Newark, New Jersey

Home and Rental Prices was the second task we developed. We directed students to the website of an online real estate database company. There they found graphs of Newark rental prices and home values over a period of about the last ten years (see Figure 5). We had them analyze those graphs using questions like:

- What's going on here?
- What do you notice about how these prices have been changing?
- When were home values increasing the fastest?
- What do you think was happening with rental prices between 2012 and 2014?

Then we had them make predictions about what the graphs would look like if Amazon were to locate HQ2 in Newark and provide real-world and mathematical justifications for those predictions.

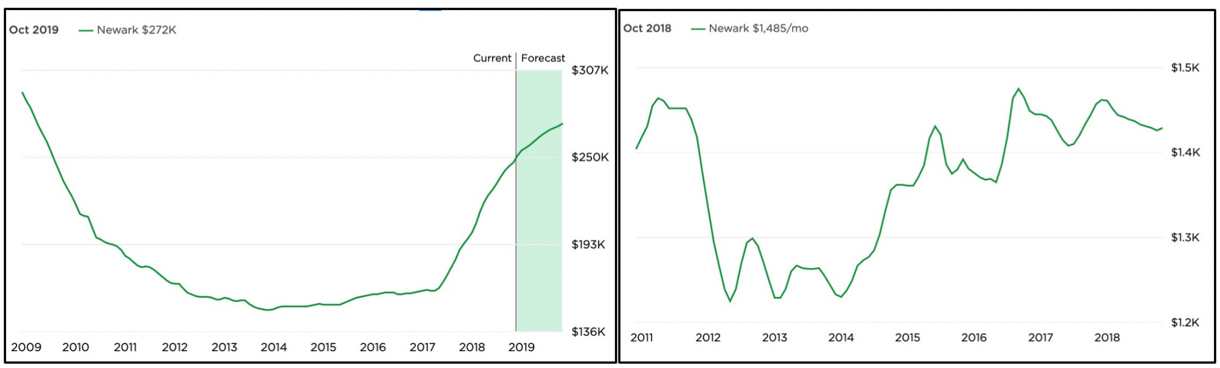

Figure 5. Changing median home values (left) and rental prices (right) in Newark

Students used hand gestures, pointing upward, to denote the regions of the graphs where home and rental price were increasing. They gestured to indicate "more steeply" when predicting what the graphs would look like if Amazon were to locate HQ2 in Newark. When asked to justify their predictions, one student explained,

> When Amazon comes in, a lot of jobs are gonna come in, as well, and a lot of people are gonna move in, and those people might have more money than the current residents of Newark. So current homeowners might sell their homes at higher prices to make profit off of, like, those influxes of people. So the home prices are definitely gonna go up.

In response, another student reiterated a concern that current residents might be displaced due to the rate hike.

For the third and final task, students participated in a NetLogo (Wilensky, 2009) participatory simulation called *Gridlock* (Figure 6) (Wilensky & Stroup, 1999). All the students connected to the simulation from Chromebooks and each student controlled one traffic light in a fictional town called *Gridlock* whose road design and traffic situation we used to simulate what traffic might look like in Newark if Amazon were to locate there. Their task was to work together to find a way to improve traffic flow. In order to do that, they first had to mathematize what good traffic flow means. Three graphs were provided: the number of stopped cars at any moment, the average speed of cars, and the average wait time of cars. Students worked together to iteratively develop a strategy to optimize traffic flow by referencing the real-time data produced by the three graphs.

One strategy used by the students involved monitoring the traffic at their intersection and changing their light to maintain traffic flow. This proved to have little effect on traffic flow by any of the three measures represented by the graphs. Another strategy involved organizing the students and their traffic signals by rows in the grid and then changing their lights at regular intervals (e.g., every five seconds). That, too, had no significant impact on overall traffic flow. In the end they decided that, regardless of how they defined it, there were just too many cars moving through the grid. Traffic never moved smoothly. Hence, an optimal solution could not be found in some algorithm for coordinating the changing traffic lights; it had to be about reducing the number of cars. That realization was followed by a discussion in which students seemed at a loss about how to facilitate "good" traffic. They suggested that Newark would have to find a way to limit the number of cars that could flow through town at one time. Otherwise, given that severe traffic congestion was an inevitable consequence of the decision, it may not be worth locating HQ2 in Newark.

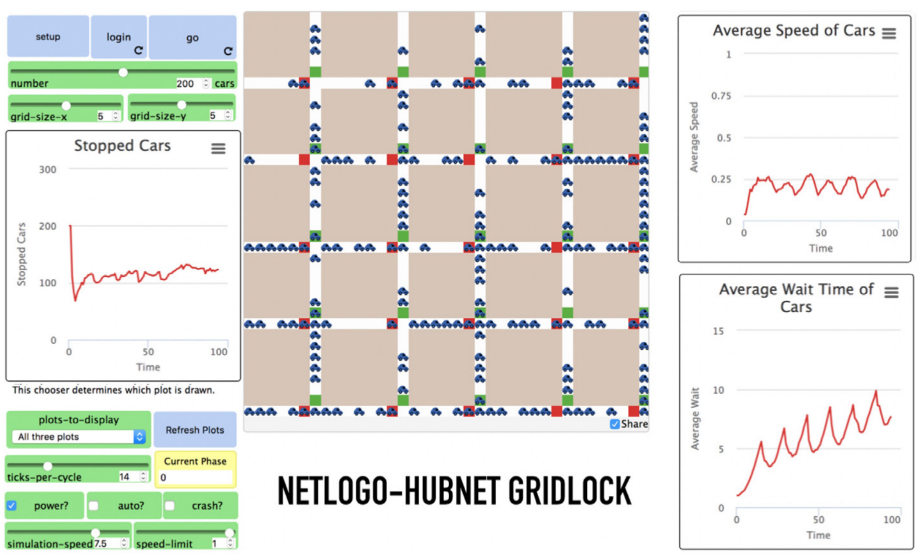

Figure 6. Screenshot of NetLogo's Gridlock Participatory Simulation

Discussion

We undertook the KEMA project to find ways to help teachers learn more about their students. We acknowledged that learning is more effective when teachers leverage this knowledge for their instruction, and more importantly, this knowledge is essential to building the kinds of caring relationships that are fundamental for classrooms to operate as communities for learning. The approach we took to assessing this knowledge was to develop tasks that—in concert with follow-up discourse moves that press students to dig deeper—could reveal their home, community, and cultural knowledge. We know these tasks are hard to find and even harder to create.

We developed two kinds of tasks that we found to be productive. In our first phase of the project, we administered modified *Would You Rather?* tasks. We modified these tasks guided by the following principle: Tasks should compel students to make a choice and defend their decision. These tasks should feature both mathematical concepts and real-world contexts that students could conceivably relate to.

The tasks we implemented proved to be revealing of students' mathematical knowledge while also providing a window into their lives at home and in their community. However, as revealing as they were, they didn't generate the kind of whole-class discussion that would allow us to explore students' responses more deeply or make connections across their responses. Thus, we couldn't be sure that the individual responses we received were indications of some sort of shared community knowledge. We needed more evidence.

As a result, we took an approach in Phase 2 of the project that was guided by a different design principle: Identify a compelling local issue and leverage it as a contextual scaffold for bridging students' out-of-school community knowledge with their in-school learning of mathematics. The issue we identified was the prospect of Amazon locating its second headquarters in Newark. This issue proved to be the kind of compelling, contextual scaffold we hoped it would, as the task bridged students' in-school and at-home knowledge, and our implementation helped us learn quite a lot about them and their families. We were then able to use that knowledge as contexts for the development of three mathematical activities that students engaged with as if they were meaningful to them. That is, their mathematical engagement in rich tasks was structured by their own thoughts and concerns related to the contextual scaffold we had provided.

Interestingly, the day after the Amazon HQ2 decision announced its decision to locate in Long Island City, members of labor unions and progressive grassroots organizations gathered in Queens to state their opposition to a decision they believed would widen current income gaps and exacerbate the city's ongoing displacement crisis. They spoke out against the $3 billion in tax breaks promised to Amazon by New York Governor Cuomo and New York City Mayor de Blasio amidst the city's ongoing infrastructure funding needs. They also voiced their concerns about the deleterious effects Amazon might have on local businesses, new incentives to raise the costs of housing in an already competitive market, and the realization that public subsidies were given to Amazon whose new offices would be built on land that had been reserved for the construction of 1,500 units of affordable housing. We find it noteworthy that this range of reactions to Amazon's decision resembled those that we heard from students and their families. They and other Newark residents may be breathing a sigh of relief that their city wasn't chosen.

Towards a Responsive Pedagogy for Critical Mathematical Inquiry

Students' multiple mathematical knowledge bases constitute the funds of knowledge upon which new knowledge is constructed. Consequently, eliciting this knowledge is fundamental to engaging students in critical mathematical inquiry (CMI). Indeed, critical consciousness, by definition (Freire, 1970), can only develop from the awareness of one's own circumstances and reflection on one's own experiences. Thus, if teachers wish to operate their classrooms as participatory venues for CMI, it is essential that they assess their students' multiple mathematical knowledge bases. The two kinds of tasks we implemented were shown to do just that. We have taken this opportunity to share the design principles we identified with other teachers who wish to enact a responsive pedagogy. By engaging students in knowledge-eliciting mathematical activity, teachers can be better prepared to reveal their students' knowledge and connect it to the mathematics they intend to teach.

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Steven Greenstein is an associate professor in the Department of Mathematical Sciences at Montclair State University. He enjoys thinking about mathematical things—and how people think about mathematical things. Through his work, he aims to democratize access to authentic mathematical activity that honors the diversity of learners' mathematical thinking, that is both nurturing of and nurtured by intellectual agency and that is guided by self-directed inquiry, mathematical play, and the having of wonderful ideas.

Collaboration and Critical Mathematical Inquiry: Negotiating Mathematics Engagement, Identity, and Agency

Frances K. Harper

Theories of critical pedagogy imagine a problem-posing model of education. This means students raise their own questions about social injustice and work alongside their teachers to address those questions, using the most appropriate disciplinary content (Freire, 1970). Translating this vision to mathematics education suggests that students critically interrogate causes of and remedies to social injustice through powerful forms of mathematical reasoning and inquiry that builds on their knowledge of mathematics and their community to ask questions, solve problems, and explain ideas—that is, critical mathematical inquiry (CMI).

There are examples of this approach to CMI in mathematics classrooms (e.g., Aguirre, Mayfield-Ingram, & Martin, 2013). Often, however, efforts to realize CMI in the school context result in more teacher-led than student-led activities, particularly at the secondary level (Harper, in press). The mathematical inquiry involved in tackling authentic social justice questions is quite "messy." CMI often requires mathematics content above students' grade level, and the interdisciplinary nature of CMI presents significant challenges, given the isolated nature of secondary mathematics. In response, teachers often revert to procedural or direct instruction in an attempt to make CMI more accessible to students, but this response may inadvertently limit students' engagement with mathematics (Gutstein, 2003) and with the social justice topic.

Mrs. Stone's Geometry Class: A Context for Collaborative CMI

At the time of the study, Mrs. Stone (all names are pseudonyms) had been teaching for four years, all at Victory High School. Victory is located in the Midwestern United States in a small city with a racially and ethnically diverse population made up of many low-income families. Mrs. Stone is committed to challenging the systems of oppression that her students of color from low-income families face, by ensuring equity in mathematics engagement and by interrogating social justice issues in her mathematics teaching. She and I have collaborated towards those goals since 2013, focusing mainly on her development of CMI. I also introduced her to complex instruction–a specific approach to classroom collaboration designed to support more equitable access and interactions in small groups. Strategies within complex instruction aim to: (a) delegate authority from the teacher to students; (b) center the curriculum around multiple-ability tasks that require positive interdependence and promote group and individual accountability; and (c) disrupt status issues that limit students' access to and participation in small groups (Cohen, 1994). Mrs. Stone pursued additional professional development on complex instruction in mathematics on her own.

In 2014, Mrs. Stone helped establish Victory's school-within-a-school magnet program. The open-enrollment, STEM-themed program's mission emphasizes technology-driven (1:1 student-to-laptop computer ratio), project-based learning, defined as collaborative exploration aimed at solving authentic, real-world tasks or problems; and using ideas, knowledge, and skills across a range of disciplines. Mrs. Stone views project-based learning as complementary to her CMI and complex instruction efforts, and she integrates complex instruction strategies and CMI in all her projects.

In 2015-2016, Mrs. Stone taught 9th grade geometry through this project-based approach for the first time. She welcomed me into her geometry class to try to understand students' experiences of her unique approach to mathematics teaching. Although I spent the entire school year in Mrs. Stone's geometry class, this paper focuses on understanding students' experiences in only two collaborative CMI projects.

Overview of the Collaborative CMI Projects

The two collaborative CMI projects both center on social injustices related to disproportionate access to healthy and affordable food in the students' local urban community. Across the projects, a *food desert* was defined as a low-income area where residents have limited access (more than one mile in urban areas) to a supermarket or large grocery store (United States Department of Agriculture, USDA, 2016).

Mrs. Stone selected this topic because it supported the learning of geometry topics within the required curriculum. She also recognized limited food access as a relevant social injustice in the students' communities. Both projects reflect Mrs. Stone's efforts to use CMI. She planned for students to work collaboratively to: (a) interrogate causes of and remedies to food deserts (i.e., critical); (b) engage with grade-level appropriate mathematics by connecting, generalizing, and representing various geometry topics (i.e., mathematical); and (c) draw on their knowledge of mathematics and their community to ask questions, solve problems, and explain ideas (i.e., inquiry).

Food Desert Project 1

This project took place over five days in October. Mrs. Stone designed it as a mini-project situated within a larger 17-day project focused on lines and angles. The mathematical goal of the mini-project was for students to develop the necessary proficiency with the mathematical distance and midpoint formulas to move forward with the larger project. Typically, Mrs. Stone used problem-centered, inquiry-based lessons to introduce the necessary geometric content within larger projects, but she saw an opportunity to introduce the distance and midpoint formulas through CMI.

Students determined whether or not they lived in a food desert by using the USDA definition and the distance formula to calculate the distance between their home and the nearest supermarket. They then used the midpoint formula to determine a possible location for a new supermarket. Finally, they made recommendations on whether that location would be a desirable place for a supermarket based on their knowledge of the community.

Food Desert Project 2

This project took place over twelve days in January. Mrs. Stone drew from Teaching Tolerance's *Food Deserts: Causes, Consequences and Solutions* lesson (2018) to introduce social justice issues related to food access and affordability, modifying it to include mathematics. Students began the project by exploring the causes and consequences of food deserts. They used the USDA Food Access Research Atlas to locate broader areas of food deserts in their city. Then, to determine desirable locations for a grocery store to help alleviate food deserts, they used triangles and their various centers (e.g., incenter, orthocenter).

Mrs. Stone used a problem-centered, inquiry-based approach to introduce the necessary geometry content over three days. Simultaneously, in their BioHealth course, students were learning about nutrition and creating dietary plans based on USDA guidelines. The project concluded with the students creating presentations in which they shared causes and consequences of disproportionate access to healthy and affordable food and possible locations for supermarkets to remedy local food deserts. These presentations were highlighted at a school showcase open to the public.

Research Approach

I spent the 2015-2016 school year in Mrs. Stone's geometry class in an effort to understand students' experiences with CMI and complex instruction. I observed 93 classes, recording field notes for every observation and creating video and audio recordings for selected classes (specifically those that included CMI and/or complex instruction). I also conducted individual and focus-group interviews with students in order learn about their perspectives on classroom activities and interactions and to gain insight into how they negotiated their mathematics identity with their social identities (e.g., race, gender).

Focal Students

The focal group of students includes:

- Rosy – a Korean-American girl with perceived high status in mathematics
- Jane – a Black girl with perceived medium-low status in mathematics
- Blake – a White boy with perceived medium-high status in mathematics
- Dante – a Black boy with perceived low status in mathematics
- George – a White boy with perceived low status in mathematics

Students' racial and gender identities are based on self-identification. The descriptions of status are based on Mrs. Stone's experiences with students in geometry and as their 8th grade mathematics teacher, as well as my observations and analysis of how students positioned themselves and others during classroom interactions and in interviews across the year.

I characterize students based on status rather than achievement because the construct of status recognizes that abilities in mathematics are socially constructed rather than cognitively fixed. Status is an idea commonly used in complex instruction to describe the social ordering of individuals based on perceived academic ability and social standing, where everyone agrees it is better to have a higher status (Cohen, 1994). Status can change in moment-to-moment interactions as students with perceived low status can make valuable mathematical contributions (Wood, 2013). Overarching perceptions of status, however, often lead students to describe themselves and others as "good at math" and "not good at math" in more rigid ways.

Data Sources

I observed and video-recorded four of the five days of Project 1. I conducted an individual interview with George during Project 1, but the interview was a "getting to know you" interview that focused more on understanding how he positioned himself as a mathematics learner. I had conducted a similar interview with Rosy prior to Project 1. When Project 1 was complete, I facilitated a focus-group interview in which Blake, Jane, and other students participated. I asked the focus group to share their perspectives on interrogating food deserts through CMI. I also asked some questions about collaboration, but I did not focus on complex instruction because Mrs. Stone did not draw on complex instruction strategies in Project 1.[1]

I observed nine of twelve days of Project 2 and video-recorded eight of those days. I also collected various artifacts of student work in five classes. At the end of Project 2, I conducted individual interviews with Rosy and George to understand their individual experiences with interrogating food deserts through CMI and complex instruction. I also facilitated a focus-group interview in which Rosy, Jane, Blake, Dante, George, and other students participated to get a broader perspective on interrogating food deserts through CMI and complex instruction.

Data Analysis

I drew on *figured worlds* as the analytical basis for this study. Figured worlds is a construct that helps us to make sense of experience. People use various social, cultural, and political "worlds" as frames of reference to "figure out" the significance of certain individuals, actions, or the value of particular outcomes (Holland, Lachicotte Jr., Skinner, & Cain, 1998). As people and actions come together with social, cultural, and political forces (e.g., norms for classroom behavior; stereotypes about women in mathematics), a social group develops taken-for-granted expectations, or *storylines*, for how to make sense of individuals' roles and actions (Holland et al., 1998).

For example, consider this scenario for collaborative mathematics projects: "At the beginning of a project,

1 This was unusual for Mrs. Stone. She normally incorporated at least some complex instruction strategies into every project. I inferred that one possible explanation was because she envisioned Project 1 as a mini-project supporting the larger project. Thus, she was trying to minimize the time needed for Project 1.

one student takes the lead." This is a common storyline that we see when we task students to work together in mathematics. One student will naturally act as the leader of the group, and students have come to take this for granted. This is not the full story, however, because how groupmates interpret the leader's actions can vary greatly.

Students willingly follow the lead of some students more than others, and these different interpretations and reactions are shaped by social, cultural, and political influences. When the "world" of groupwork in the mathematics classroom intersects with the broader "world" of gender, for example, students tell different stories about boys and girls who are leaders. They may position boy leaders as "smart" and girl leaders as "bossy" for similar actions (Langer-Osuna, 2011). The identities of "smart" and "bossy" are enacted by students and assigned by their peers based on taken-for-granted "stories" (i.e., storylines) about both classroom leaders and gender.

Storylines constructed within figured worlds provide the context for what counts as mathematical engagement and for how students make sense of themselves as successful or not in relation to that engagement. In other words, students' mathematics identities are shaped as they come to see themselves and are seen by others as mathematically capable (or not) in relation to storylines (Horn, 2008). I used storylines to analyze how students negotiated (i.e., took up, resisted, or shifted) mathematics identities in collaborative CMI projects.

Figured worlds provide a powerful analytical tool for analysis, because they allow us to consider influences on mathematics teaching and learning that are not explicitly discussed (e.g., gender) or physically present within the classroom (e.g., food deserts). I analyzed field notes, interview transcripts, and video of classroom observations across projects to identify the figured worlds at play. Theories of CMI (e.g., systems of privilege and oppression, problem posing) and complex instruction (e.g., status, group work) helped me identify relevant figured worlds and connect classroom interactions to storylines within these figured worlds. The findings below describe the taken-for-granted expectations, interpretations, and actions "storying" engagement and identity across Project 1 and 2.

Findings

Table 1 shows how classroom participation structures (as different figured worlds) varied across projects. During Project 1, students spent most of their time engaged in whole-class activity and doing individual work. From Project 1 to Project 2, the decrease in teacher exposition and the increase in small group work are striking. Here, I share selected excerpts to illustrate how the mathematics classroom storylines within these figured worlds changed from Project 1 to Project 2 as students took up and negotiated the teacher's efforts to encourage equitable small group work during CMI. Because the mathematics classroom figured world was immediately and physically present, identification of these storylines relied heavily on both talk and actions, and this is reflected in the excerpts.

Table 1: *Percentage of time devoted to each classroom participation structure by project.*

Participation Structure			Project 1 (% of time)			Project 2 (% of time)		
Whole Class			47.37			16.78		
Launch	Exposition	Discussion	15.93	20.96	10.48	7.75	0.61	8.42
Small Group			3.57			58.08		
Individual			48.19			24.36		
Other*			0.87			0.78		
Total Time			3 hr 17 min			7 hr 29 min		

**The video camera ran before and after class, when students were setting up or packing up.*

Storyline 1 (Project 1)

The teacher guides students procedurally (as a class or individually), using the necessary mathematics.

Excerpt 1 *(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.

Excerpt 1 illustrates how Mrs. Stone's launch led to her procedurally guiding the whole class to use technological and mathematical tools (i.e., exposition). Mrs. Stone attempted to explain how to use the technology and to give meaning to the distance formula, but when students expressed confusion (Excerpt 1), she calculated the distance for the first pair of coordinates at the board (Figure 1). She continued teacher exposition for the remainder of class, showing students how to calculate square roots using their calculators. She modified the assignment for the following day to give the students more practice using the distance formula, but she had not provided them with a conceptual meaning for the procedure. As students worked, Mrs. Stone provided individual help on using the formula as needed.

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.

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

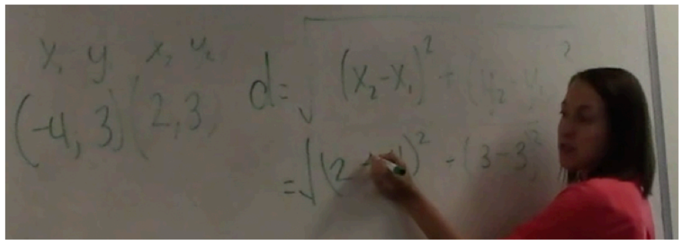

Figure 1. Introducing the distance formula. This figure shows the first part of the worksheet with Mrs. Stone calculating the distance between the first pair of coordinates.

Storyline 2 (Project 2)

Students work collaboratively with each other but independently of the teacher to figure out how to use and make sense of the necessary mathematics.

> **Excerpt 2** *(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.

In Project 2, Mrs. Stone introduced students to centers of triangles by asking them to collaboratively construct and manipulate triangles with various points of concurrency to discover the properties of the centers of triangles. Unlike in Project 1, where 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, in Project 2, students made their own constructions and their own discoveries about the mathematics.

Excerpt 2 shows how students worked collaboratively with peers, 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. Using the YouTube videos Mrs. Stone created to show how to make constructions, Dante explained to George how to make the constructions in Geogebra on his computer.

Figure 2 shows George looking at Dante's computer as they watched the video, and Excerpt 2 shows how Dante would subsequently look onto George's computer as George did the construction with Dante's guidance. During more than 30 minutes of small group work, they re-watched the teacher videos together as needed, completed most of the constructions, and answered open-ended questions about their discoveries without help from Mrs. Stone.

Figure 2. Dante and George watch videos and make constructions in Geogebra together.

Storyline 3 (Project 2)

The teacher reinforces norms for small group tasks that require collaboration and the participation of every group member.

Excerpt 3 *(Observation: Jan, 11, 2016)*

Rosy (to Dante, George, and Blake): 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 4 *(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! [*More loudly and with a different tone than usual.*]

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 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.

In Project 2, Mrs. Stone introduced three complex instruction strategies (Esmonde, 2009b; Featherstone, Crespo, Jilk, Parks, & Wood, 2011) to encourage collaboration:

1. **Group questions:** Students can only ask the teacher a question if they ask everyone in the group first and everyone has the same question. (Excerpt 3)
2. **Checkpoint:** Students must stop at checkpoints on the worksheet to make sure the group is together and to check in with the teacher before moving to the next part of the task.
3. **Participation quiz:** The teacher evaluates groups on how they participate collaboratively. Mrs. Stone assigned groups to sort cards with different properties using the table shown in Figure 3. Groups were assessed on their ability to: (1) get started quickly; (2) provide justification when they sorted the cards; (3) ask their groupmates why they sorted the cards in a particular way; and (4) make the materials accessible to all.

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

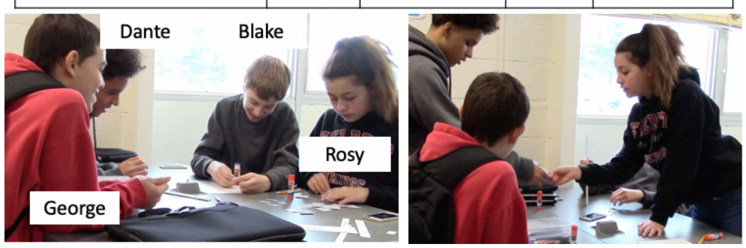

Figure 3. Students work on sorting cards during participation quiz. Initially Rosy had most of the materials, and Dante, George, and Blake had to lean in to have access to the cards (*left*). After Rosy distributed the cards at Blake's request, each student in the group contributed to sorting (*right*).

Together, Excerpts 3 and 4 show variation in how students took up norms for collaboration. In both cases, students played along and participated (at least superficially) as the teacher instructed. Sometimes this "playing along" seemed insincere and for the benefit of the teacher. In Excerpt 3, Rosy's question and Dante's response suggest that Rosy simply wanted the group to agree to having the question before calling Mrs. Stone over. This way, the group could get help without actually discussing the mathematical concept.

Likewise, in Excerpt 4, Blake made a comment about how the group was working (i.e., using technology well), seemingly to score a positive evaluation from the teacher. Prior to this, Blake made a similar comment when he noticed Rosy initially had all the materials. As Mrs. Stone walked near the group, Blake loudly reminded Rosy to make the materials accessible to all, and she distributed cards to everyone (Figure 3). As Excerpt 4 and Figure 3 illustrate, after the materials were accessible, George and Dante provided mathematical justifications that there were differences in the visual images and that one of the diagrams must be the median. The group correctly sorted the cards without soliciting any help from Mrs. Stone.

Discussion

Project 1

Even though the school's mission and the teacher's goals promoted collaborative, creative, and critical work, Project 1 reinforced a storyline that is typical when mathematics learning is an individual and procedural endeavor: classroom interactions were dominated by teacher exposition and individual work. The teacher was viewed as the mathematical authority and the "owner" of mathematics knowledge. In Storyline 1, mathematical power resided with Mrs. Stone as she provided and explained the distance formula and guided students through its use. Mrs. Stone held the 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 correctly solve problems without help from others or from Mrs. Stone. The "critical," "mathematical," and "inquiry" components of Mrs. Stone's plan and vision for the project fell short of being realized.

Project 2

In contrast, during Project 2, storylines emerged that were more consistent with mathematics learning as a collaborative endeavor and aligned more closely with goals for mathematical inquiry in CMI. Mathematics authority and "ownership" of mathematics knowledge was shared among students and teacher. Although the teacher still held elevated authority to determine what was mathematically correct, mathematics knowledge was collectively constructed through small-group and whole-class activities (Table 1). By working autonomously (Storyline 2), students had more opportunities to take on mathematics identities as good at math because the features of the task supported them to work without direct help from the teacher.

In Excerpt 2, Dante and George, two students with perceived low status in mathematics, were able to rely on each other to engage in the mathematics work with only limited direct help from Mrs. Stone. In those moments, they enacted identities as students who are good at mathematics. Moreover, the reinforced norms for collaboration (Storyline 3) offered more diverse ways for students to demonstrate their ability to do mathematics. In this class, being good at mathematics meant more than getting correct answers; it came to include being able to communicate mathematical thinking and provide justifications for claims. In Excerpt 4, Dante and George correctly and meaningfully communicated their mathematical reasoning and moved the mathematical work of the group forward when working with Rosy and Blake.

A less often discussed aspect of teachers' efforts towards equitable collaborative learning is also demonstrated in these findings. Although Dante and George had numerous opportunities to take on identities as good mathematics students throughout Project 2, differences in status persisted. Namely, Rosy and Blake maintained higher academic status than Dante and George. In Excerpt 4, Blake assumed a facilitator role (by encouraging the group to do what is necessary to do well on the quiz), and Rosy assumed the role of mathematics authority (e.g., "owning" the cards initially; evaluating Dante's mathematical thinking). Persistent distinctions between those who are good at mathematics and those who are not are problematic and consequential. 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. When students who are perceived to have high status talk, group members (and their teacher) listen, thereby validating their competence and allowing them to dominate group interactions. In contrast, when students perceived to have low status talk, their contributions are often overlooked by group members (and their teacher) (Cohen, 1994; Esmonde, 2009a, 2009b).

In Project 2, Mrs. Stone reinforced features of complex instruction designed to disrupt these inequitable power dynamics (Storyline 3). For example, in Excerpt 4, these features encouraged Rosy to share ownership of the materials so that Dante and George could take on mathematics identities as students good at mathematics. This strategy resulted in Rosy explicitly positioning Dante as smart. While some researchers have found such complex instruction strategies to be effective at encouraging more equitable group interactions in mathematics (e.g., Boaler & Staples, 2008), Excerpts 3 and 4 illustrate how the shift towards equitable collaborative learning is a more complex process. Students might only superficially take up features designed to disrupt power differences, which can be problematic when students do not collaborate to enhance group mathematics learning as intended (Excerpt 3) and when status differences persist (Excerpt 4). Nonetheless, superficial uptake may also be an important step towards overall increases in collaboration on the part of the teacher (Table 1) and shifts towards more equitable interactions on the part of the students.

In other words, supporting every student to engage in the *mathematical inquiry* necessary for CMI is not a straightforward task. Promoting interrogation of social injustices through mathematical inquiry may necessarily start with challenging systems of privilege and oppression that operate within the classroom itself. Additional research in classrooms where teachers are combining complex instruction or other equity-minded strategies with CMI could help teachers and teacher educators better understand how to effectively introduce and enact CMI in classroom spaces.

Relevance to Critical Inquiry

This particular analysis focused heavily on understanding the nature of *mathematical inquiry* within CMI. Elsewhere, I have described an analysis across these same projects focused on understanding shifts in the storylines about social justice issues related to disproportionate access to healthy and affordable food (Harper, 2017). In that analysis, I found that students first passively accepted and then resisted Mrs. Stone's definition of food deserts. Eventually (in a third project related to the same social justice topic), students took up the USDA definition, but reframed the social justice issue to focus on nutritional education rather than access to supermarkets, which empowered them to imagine and take action towards alleviating access to healthy food in the community (Harper, 2017).

This analysis showed how Mrs. Stone maintained mathematical authority in Project 1, and analyses elsewhere showed how Mrs. Stone also maintained authority over the social justice topic in Project

1 (Harper, 2017). She did so by insisting on a particular definition of food desert as a way of 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 (e.g., Bartell, 2013). In this study, however, the teacher strove to shift authority (in mathematics and social justice) across projects. By Project 2, these efforts showed promise of balancing the focus on mathematics inquiry (this analysis) and critical inquiry (Harper, 2017) while allowing for student agency in regard to both mathematics and social justice issues.

This suggests an important relationship between students' mathematical agency and students' capacity for taking up critical inquiry in meaningful and relevant ways in mathematics classrooms. In other words, as students take more ownership of and more equitably distribute mathematics learning, they may also be better equipped to frame social justice questions and take actions towards social change. This case of collaborative CMI 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.

Significance

Naturally, in the figured world of the mathematics classroom, students' mathematics identities were salient, specifically in regards to their relationships to mathematics (Horn, 2008). My analysis of classroom interactions shows the fluidity of mathematics identity in different instructional contexts (teacher exposition and individual work in Project 1 and small-group collaboration in Project 2). Students enacted different mathematics identities in different moments throughout the two projects. Other researchers have observed this phenomenon (e.g., Wood, 2013), but the analysis here extends these findings by illustrating how the teacher's introduction of equity-minded pedagogical efforts was associated with different storylines within the same classroom in a relatively short period of time.

Much of the research on complex instruction at the secondary level in mathematics focuses on "master" teachers who are experienced with the pedagogical approach (e.g., Boaler & Staples, 2008) or contexts in which students experience complex instruction across the curriculum (e.g., Horn, 2008). Moreover, there is no research on complex instruction that considers how this approach might supplement other sophisticated teaching approaches, such as CMI. These findings are important because they illustrate how the different and emerging storylines that accompanied complex instruction strategies provided opportunities for students to perform identities as capable mathematics doers, even though the teacher's enactment and the students' adoption of the strategies were still emergent. Understanding the process of introducing and enacting more equitable teaching strategies in CMI is an important step in transforming mathematics classrooms into more socially just spaces.

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The World in Your Pocket: Digital Media as Invitations for Transdisciplinary Inquiry in Mathematics Classrooms

Lynette DeAun Guzmán and Jeffrey Craig

How might mathematics education serve students who are digital natives and who are constantly connected to global and local issues? When all students have access to live streams of social justice movements and trending pages updated every time there is breaking news of a mass shooting or a natural disaster across the world, what should a mathematics classroom look like? How should mathematics classrooms respond? As mathematics educators, we have thought about our own teaching practices in order to address these questions (Craig, 2017; Craig & Guzmán, 2018; Guzmán, 2017).

In 2016, an estimated 3.17 billion people had access to the internet, with the top three internet-accessible countries being China (730.7 million), India (374.3 million), and the United States (246.8 million).[1] American society constantly consumes digital media infused with quantitative and visual rhetoric—and so we have numerous opportunities to engage critical mathematical inquiry (Craig, 2017; Mehta & Guzmán, 2018). Like many educators, we have considered the affordances and constraints of using digital media in our classrooms. These considerations have informed a teaching philosophy centered on the idea that we can build and engage a curriculum from our pockets using smartphones connected to the internet and social media.[2] We draw upon our students' lived experiences and local communities, but we recognize that social media and the internet can localize the world, too, as global issues transmit to the phones in our pockets.

Digital media and constantly evolving digital technologies are becoming more integrated into social interactions, blurring boundaries between media and lifeworld[3] (Mitchell, Simmons, Matsa, & Silver, 2018). This integration underscores an important potential role for digital media in K-16 education. As digital media literacies become more intertwined with cultural knowledges and practices, mathematics educators might consider how multimodal sensemaking of digital media might be relevant to their classroom contexts. Because internet-based "information is more widely available from people who have strong political, economic, religious, or ideological stances that profoundly influence the nature of the information they present to others" (Leu, Kinzer, Coiro, Castek, & Henry, 2013, p. 1161), the rapid pace of production of a wealth of online digital media requires us to take a critical stance toward this information.

Not only is the amount of, and access to, quantitative information affected by democratized access to the internet, the nature of quantitative representations has also changed. The pervasive creation and use of digital media in the United States provides an increasing number of encounters with *information graphics*, or *infographics* (Lankow, Ritchie, & Crooks, 2012). An infographic communicates information through visual signals in a quick and accessible manner (Tufte, 2001). Although infographics existed prior to

1 *The World Factbook* (CIA): https://www.cia.gov/library/publications/the-world-factbook/index.html.
2 Guzmán (2018) discusses examples of "reading and writing the world" through your pocket in a YouTube vlog: https://youtu.be/afcDtwrBNhA.
3 Merriam-Webster Dictionary defines "lifeworld" as "the sum total of physical surroundings and everyday experiences that make up an individual's world."

widespread internet use (Pasternack & Utt, 1990), the internet has increased their relevance by facilitating their creation and sharing. Building a curriculum from online digital media may provide opportunities for students to draw on related experiences across their lives, deconstruct dominant narratives, and engage with complex multimodal artifacts through transdisciplinary inquiry.

Theoretical Perspectives

This article focuses on an example of how we have both used a digital infographic, *The World as 100 People*, to engage students' funds of knowledge to unpack global and local issues in mathematics classrooms. Both of us teach undergraduate courses of primarily freshmen and sophomore students, but in different settings. Lynette teaches a mathematics content course for future elementary educators who are often positioned in research-based recommendations as not liking or having strength in mathematics (e.g., Conference Board of the Mathematical Sciences, 2012; National Research Council, 2001). Jeffrey teaches quantitative literacy courses that he co-developed with his colleagues as new introductory mathematics courses that count toward the university's mathematics requirement. These quantitative literacy courses focus on mathematical and statistical tools—such as arithmetic, quantitative data, and modeling—as applied to everyday life. Quantitative literacy itself, however, involves a set of social practices that are mediated by quantities, such as "[taking] out a second mortgage, [voicing] a perspective on a new economic policy, or… [inquiring] about the absence of quantitative information" (Craig & Guzmán, 2018, p. 9). Students placed in these courses have often been labelled as "unsuccessful" at college-level mathematics.

Funds of Knowledge

We view mathematics learning in terms of participation (Lave & Wenger, 1991) in the practices and discourses involved in *mathematical experiences*. In previous work (Craig & Guzmán, 2018; Guzmán, 2017), we considered mathematical experiences as people engaging with quantification, patterns, or spatial reasoning. Mathematical experiences are, therefore, not limited to what happens in mathematics classrooms; rather, mathematical experiences happen frequently, in many spaces, alongside and intertwined with other types of experiences. By broadening what constitutes mathematical experiences, we widen what counts as engagement with mathematics to legitimize multiple knowledges and practices in mathematics education.

Mathematical knowledge is fundamentally linked to cultural practices (Nasir, Hand, & Taylor, 2008). Research calls for incorporating students' home and community-based mathematical *funds of knowledge* to support student learning (Aguirre, Turner, Bartell, Kalinec-Craig, Foote, Roth McDuffie, & Drake, 2012). Originally coined by Vélez-Ibáñez (1988), funds of knowledge refers to an array of historical and cultural knowledge and skills, which are often "essential for household or individual functioning and well-being" (Moll, Amanti, Neff, & Gonzalez, 1992, p. 133). When teachers consider students' funds of knowledge, they are taking an assets-based perspective, allowing students greater opportunity to engage in lessons that honor and incorporate their knowledge and experiences (Aguirre et al., 2012).

Deconstructing Dominant Narratives

Chubbuck (2010) suggests that "socially just teachers recognize the need to look beyond the school context and transform any structures that perpetuate injustice at the societal level, as well" (p. 198). Social justice education work involves the development of critical consciousness (Freire, 1974) by interrogating systems of power, privilege, and oppression. Students engage in this work as they question, challenge, and critique structural inequities (Young, 2010).

Engaging in critical mathematical inquiry involves interrogating and deconstructing the dominant narratives that shape the lens through which we see and experience the world. We draw on Gutiérrez's (2012) critical axis for framing equity in mathematics education—which centers on dimensions of identity and power—to identify and make sense of the dominant narratives. We view narratives as dynamic, shared storylines of circulated discourses, which are "continually taken up, reproduced, and resisted in multiple ways in daily life" (Nasir & Shah, 2011, p. 26).

For mathematics education, these narratives are stories that are told about students, about teachers, and about mathematics. Commonly recirculated discourses within mathematics education construct dominant narratives about what counts as mathematics and who can do mathematics. This includes (but is not limited to) racialized narratives (e.g., Larnell, 2016), gendered narratives (Leyva, 2017), and disciplinary narratives. For example, narratives about mathematics often emphasize that it is about solving equations and providing solutions that are either right or wrong. Stories about being a "math person" (or not) suggest that mathematics belongs only to certain people. These examples are recognizable narratives that are well-entrenched in schools (and, of course, our broader society) and that constrain what is possible for mathematics education. Some students are marginalized by traditional practices in mathematics classrooms. Engaging with digital media, however, provides potential for blurring the boundaries of an increasingly connected world.

Transdisciplinary Inquiry

In contrast to the strict disciplinary boundaries of many schooling contexts, we conceptualize schooling in the digital age to be better suited to *transdisciplinary* approaches that "step outside the limiting frames and methods of phenomenon-specific disciplines" (Davis, 2008, p. 55). A transdisciplinary approach values the multiplicity of knowledge from different disciplines and their fusions (Lawrence, 2010). Transdisciplinarity, then, can redraw the boundaries of inquiry around specific contexts or problems—for instance, by asking what disciplines and their fusions can contribute to addressing and resolving a problem, rather than whether a problem belongs inside a discipline. Transdisciplinarity "is created by including the personal, the local, and the strategic, as well as specialized contributions to knowledge" (Brown, Harris, & Russell, 2010, p. 4). In other words, all knowledge is relevant and applicable to resolving the problems.

These three ideas—funds of knowledge, dominant narratives, and transdisciplinary inquiry—can coalesce to organize schooling experiences in new ways. The next section focuses on our experiences engaging with these ideas in our mathematics classrooms. We share an example of using an infographic, coupled with undirected and multidirectional inquiry, to support a transdisciplinary educational experience.

The World as 100 People

Jack Hagley, an infographic designer from London, created *The World as 100 People* infographic[4] based on global data from a collection of sources. In this graphic, Hagley scaled quantities from a world population of over 7 billion people down to 100 people for each of 14 categories. For example, population by continent for a world of 100 people would include 60 people living in Asia, 15 people living in Africa, 11 people living in Europe, 9 people living in South America, and 5 people living in North America. Other examples of categories on this infographic (see Figure 1) include religion (Buddhist, Christian, Hindu, Muslim, other, no religion); internet (can access the internet, cannot); nutrition (overweight, adequate, undernourished, starving); and housing (have a place to shelter, have no shelter).

Figure 1. The World as 100 People infographic by Jack Hagley.

Teaching Contexts

Although we have different teaching contexts and students, we have collaborated in developing, revising, and debriefing the activities we describe in this paper. We share selected examples from one semester of Jeffrey's quantitative literacy course as the research context. Both authors analyzed student work in iterative stages, involving individual analysis followed by co-analysis to revise for more nuanced

4 See http://www.jackhagley.com/The-World-as-100-People for full resolution of infographic (Figure 1).

interpretations. During this process, we discussed common themes in student discourses, both in terms of their mathematical sensemaking and the narratives they made connections to.

Learning Goals

Students were expected to explore, interrogate, and make sense of quantities within real-world contexts. They were asked to consider how their preconceptions of the world might be inaccurate and explore why this discrepancy may exist (e.g., media discourses, commonly recirculated narratives). We expected students to draw on mathematical ideas such as proportional reasoning, relative error, and conditional probabilities at least informally in making sense of statistical data. Finally, students were expected to engage in *Common Core Standard for Mathematical Practice 4: Model with Mathematics* (Common Core State Standards Initiative, 2010), in their sensemaking. Not only did we intend for students to analyze, interpret, and critique quantitative information, but we had goals for centering philosophical explorations about what quantification means within complex global contexts.

There are likely other mathematical connections that students might explore. In our discussion, we encourage educators to creatively use their professional skills and expertise to make other connections to mathematical (and non-mathematical) ideas as they see fit.

Prediction Task

We began with a prediction task where we imagined our world population shrunk down proportionally to a village of 100 people. What would our village look like? The facilitation of this task may be adapted to fit different classroom contexts. For example, students could be asked to fill out a survey before class for all the categories depicted in the infographic, or to choose a few categories to fill out at the beginning of class. They should be asked to keep the following in mind:

- Carry this out as an individual activity
- Draw on your knowledge and lived experiences
- Do not look up data
- It is not about being "right"

We avoided positioning students as the targets of jokes about their ignorance. Instead, we made discursive moves in the form of *sympathetic pain*, which Grawe (2015) proposed as an alternative way to talk about ignorance. Explicitly stating that this predictive task was not about being "right" or "precise"[5] (unlike expectations in traditional mathematics classrooms), we recalled our own first encounters with the task—full of surprise, inaccuracies, and questions. We encouraged students to write down their initial predicted values and to make note of any questions about the ways we were defining particular labels for our later discussions.

5 This is in contrast to *Common Core Standard for Mathematical Practice 6:* Attend to precision.

Data Revelations Through a Kinesthetic Task

After the prediction task, we structured the data reveal using physical space. The purpose of this task was to demonstrate common perceptions about the world in our classroom community. We used a nearby hallway space as a scale with label markers from 0 to 100. Students took their predictions with them as we called out various categories to model. If the world were 100 people:

- How many would have cell phones?
- How many would be able to read and write?
- How many would be Christian? Muslim?
- How many would live in Africa? Asia?
- How many would speak a first language other than Arabic, Bengali, Chinese, English, Hindi, Japanese, Portuguese, Russian, or Spanish?

Using physical space allows for a spatial arrangement of each person's individual prediction. When the whole class participates, there are visual cues for clusters of students (indicating similar guesses) and an embodied distribution for the range of values predicted across the entire group. After students position themselves along the scale and can see what other students have predicted, the teacher reads out the reported data from the infographic. Then, students may write a brief reflection about the prediction task and movement exercise to identify what surprised them the most and least.

What Do We See, Think, and Wonder?

Teachers might provide a graphic organizer for students to document their reflections about what they see, think, and wonder. This activity can be completed online as well through platforms such as Padlet (www.padlet.com) or a classroom-shared Google doc. An advantage of using digital platforms is that students can add attachments, insert images and hyperlinks for multimodal engagement, and comment on each other's work.

What do we see… reflects on what students notice about the infographic. Typically, it involves minimal interpretation and centers observation in various areas, such as:

- Individual categories (e.g., religion) or labels (e.g., male and female for gender)
- Quantities in the infographic and/or in our predictions
- Provided definitions[6] and/or data sources

6 Selected definitions for categories in *The World as 100 People* may be found at http://www.100people.org/statistics_detailed_statistics.php.

What do we think… builds on initial thoughts and unpacks these observations. Students use interpretation to make sense of information displayed, often with supporting evidence from their lived experiences and funds of knowledge. Guiding questions might include:

- What do you find most surprising, and *why* is this surprising to you?
- Which of your predictions were accurate (or not), and *why*?
- How do you make sense of the information and documents?

What do we wonder… extends beyond the specific media artifact. Students identify broader thoughts and questions for further application or analysis (e.g., zooming in on world wealth distribution[7]). For instance:

- What are you still wondering about related to global issues? *Why* does this matter to you?
- Why might someone create this image? What stories might we tell about this media?

Extension: *100 Person Country Project*

In our classes, we extended *The World as 100 People* by having students complete an assignment that recreated the infographic for a specific country of their choice. This research assignment was done primarily in class, using the phones in students' pockets or laptops on their desks, with students searching for data sources, sharing what they found, and verifying the validity of the numbers they had discovered.

At home, students completed their own infographics, formatted similarly to the worldwide infographic, and returned to class ready to share. In groups of five, students passed around their 100-person country infographics (see example in Figure 2), viewing each one for two to three minutes and recording their observations (e.g., similarities and differences compared to the world or to other countries). After two passes, we held a brief discussion about the strategies students were using to make sense of each infographic.

7 See Global Wealth Inequality: https://youtu.be/uWSxzjyMNpU and Wealth Inequality in America: https://youtu.be/QPK-KQnijnsM. Lynette used these videos in an adaptation of a lesson by Hersh & Peterson (2013).

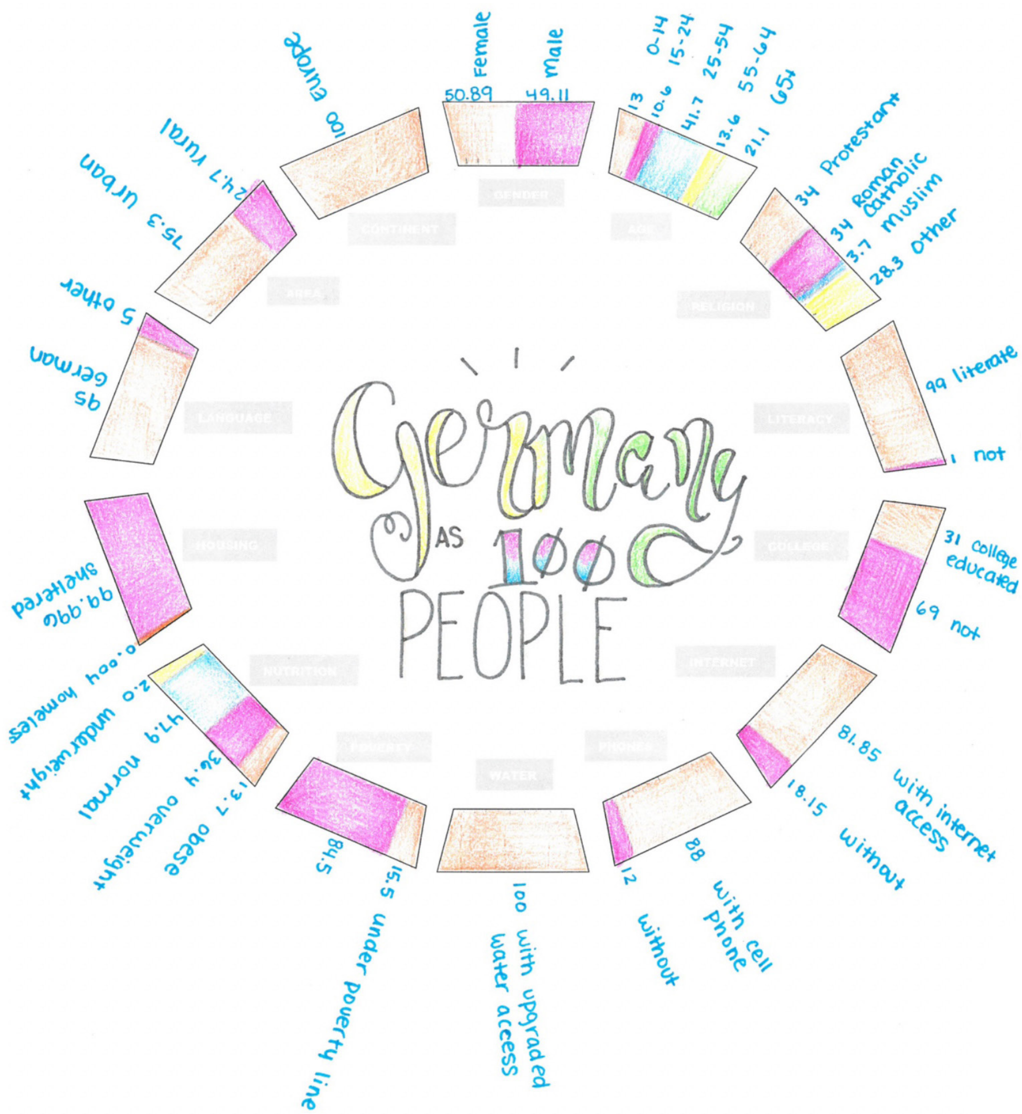

Figure 2. Student work for infographic of Germany as 100 People.

Once all five passes were complete, students debriefed their findings, noting:

- Any patterns they noticed across the infographics
- Questions that came up for specific country data
- General reactions to specific country data (e.g., any categories that were surprising)
- Possible connections between categories

In closing, teachers might facilitate a discussion about how perceptions are related to sampling issues. For instance, our news media presents perceptions of the world from a United States perspective tied to American societal values and expectations. Additionally, news segments often highlight events that are outliers (rather than normalized), which might link to dominant narratives that are circulated about particular groups of people or regions of the world.

Leveraging Students' Funds of Knowledge with *The World as 100 People*

When we embraced critical mathematical inquiry in our classrooms, we found that our activities, practices, and content necessarily involved more than just mathematics, which was helpful for leveraging students' funds of knowledge. In particular, we needed to draw attention to how students were invoking multiple kinds of narratives to connect local and global contexts. Drawing broadly on critical perspectives, we explored epistemological and ethical questions. For instance, if in a world of 100 people only five people speak English as their first language, why is there such an interest in teaching students to speak English (particularly in the United States)?

Opening up our critical mathematical inquiry, we wondered how our students were negotiating their particular and personal knowledge and experiences with the global data presented to them in this infographic. Students were seen to engage with this complexity in multiple ways—by considering possible intersections or relationships between categories and by investigating definitions to determine what data is counted and how it is organized. For example, regarding how many people in our 100-person world would have cell phones, one student commented, "Everybody's got phones." Moments later another student responded, "...in America." Students had opportunities to use their experiences (e.g., living in a place where it seems that every person has a phone) as a reference point while also recognizing the limitations of their own experiences (e.g., pointing out that we live in the United States and cannot speak for the whole world).

Unpacking Dominant Narratives in Students' Sensemaking

The World as 100 People infographic demonstrates how important narratives about the world can be constructed and shared. Considerations include thinking about how data collected in different countries can be aggregated and how variables like poverty and literacy are defined. Part of our facilitation role is to bring out the complexity in this seemingly simplified infographic product:

- How/why was it made?
- Where did this information come from?
- What do our reactions reveal about our values and assumptions?

A major component of our small-group and whole-group debriefing involves grappling with our ignorance about the world. What happens when drawing on students' funds of knowledge brings out dominant narratives that are stereotypical or even wrong? Single stories (Adichie, 2009) that portray groups of people or regions of the world in essentializing ways can flatten the complexities of diverse human experiences.

For example, Maria wrote in her reflection of the 100-person country extension, “Mainly I paid attention to education levels, religion, and quality of life like internet and cell phone access. I was surprised that 89 percent of people in Cuba do not have access to cell phones.” Although Maria described “quality of life” as access to the internet and cell phones, she did not explain why it was surprising that 89 out of 100 people in Cuba did not have access to cell phones.

It is possible that Maria’s surprise might be connected to the kinds of stories that are shared about Cuba or the kinds of stories shared about quality of life. In the future, we might address this type of response by having students revisit their words from this assignment to further articulate why they were surprised by the data with a specific prompt to identify specific knowledge and experiences that may seem to contradict what is represented in the data. Alternatively, we might bring up an example that several students noted in their reflections to discuss in small groups to tease out reasons why the data might be surprising to some people. Keeping in mind that we do not want to position students as targets of jokes or embarrassment, we might address this situation differently with different groups of students.

There were also moments where students felt compelled to explain their sensemaking, often by leveraging their previous knowledge and understandings of historical contexts. Beth, for example, wrote about a large percentage of Roman Catholic people in Costa Rica (76 percent), “but in South America I guess that makes sense when people first came over and converted everyone.” Drawing on her understanding about Spanish colonization of the Americas, Beth placed a historical context onto making sense of the data.

In Beth’s initial reflections about *The World as 100 People*, she noted being surprised that there were more Christians (33) than Muslims (22):

> The way Christianity is portrayed in pop culture and publicly typically tends to put them in a poor light. I’m surprised that the number wasn’t lower… I was equally surprised the number of Muslims was lower than Christians. It seems like the media in most countries immediately zero in on people who practice this religion and claim that the number is growing within their ranks and that people should be afraid. They make it seem like there are more than there are. So, the numbers were surprising to me.

Beth pointed out a fear-based dominant narrative where “[media outlets] make it seem like there are more [Muslims] than there are.” She drew on critical data interpretation to question this dominant narrative, which falsely portrays Muslim people as a growing threat. A dominant single story that suggests “people should be afraid” of a growing number of Muslim people is an example of essentializing, which flattens the diversity of experiences and perspectives within this group of over 1 billion people.

Similarly, Terrell pointed to media discourses as contributing to his perception and sensemaking. Reacting to a classmate's comment on Cuba, Terrell wrote:

> Amazing to think that nearly 90 percent don't have access to cell phones... I know it sounds bad, but I expected the poverty rate [85 not in extreme poverty, 15 in extreme poverty] to be higher based on some of the things I've heard in the media about the country being so poor.

This example demonstrates that students are often aware of dominant narratives, and Terrell explicitly admitted, "I know it sounds bad" in his reflection. If a single story about Cuba in news media is heavily centered on high poverty, then it can be surprising to see data that 85 out of 100 people in Cuba are *not* in extreme poverty. We can further examine, however, different definitions for what counts as poverty (or in this case, "extreme poverty").

Students also considered relationships between having a college education and other categories (e.g., literacy, internet, cell phones). In Matt's written reflection on 100-person countries, he commented that Denmark "seems like it is a very educated country which seems to correlate with the amount of clean water, low poverty, housing, etc." He also said he was surprised that in South Korea "only 61 percent go to college or have degrees given that S. Korea has such a high value on education." While a discussion point might involve unpacking the specific claim that, culturally, people in South Korea value education, an implicit assertion in this statement might be that countries with a low percentage of people with college degrees do not value education. These are complex discourses worth further interrogation because there is a potentially dangerous single story that could essentialize people in South Korea. In other words, a complexity of diverse perspectives and experiences that people in South Korea might have about education can be minimized and erased.

Discussion and Possibilities

In this piece, we have shared our experiences as mathematics educators using a digital infographic in our classrooms to support critical mathematical inquiry. We navigated hesitations and conflicts in drawing on students' existing knowledge about people and locations in the world that were simultaneously problematic and rich with opportunities for critical inquiry. In particular, we want to reiterate that these students, who have often been typecast as less capable of engaging with rich mathematical ideas, were exploring complex, global contexts. They drew on both mathematical and non-mathematical knowledge in their transdisciplinary inquiry.

With an increasingly connected world, digital media is constantly produced, recirculated, and remixed through multimodal platforms. Greater access to information supports a focus on critical literacy in schools. Critical literacy, as a social practice, can contribute to emancipatory participation in the contemporary world (e.g., Freire, 1970). Specifically, critical literacy can be used as a tool in the emancipation of oppressed people or to reconstruct existing social power structures (Giroux, 1984). We focus on critical literacy in this piece as an approach for emancipatory practices, although there are certainly other approaches educators might explore.

What we hope to offer is that our experiences using *The World as 100 People* pushed back on (1) the way mathematics should be formally taught in schools and (2) common practices around social media restrictions in schools. Rather than being a distraction, our students engaged in powerful and interesting critical mathematical inquiry by examining artifacts produced online. And rather than solely privileging mathematical content, students were able to explore transdisciplinary inquiry through these digital media invitations.

What we appreciated from our experiences using *The World as 100 People* is that this infographic is a simplified product of a complex world and provided ample opportunities for students to explore in depth (e.g., how and why it was created, where the information came from). These explorations allow us to examine complex models and data through critical lenses. For example, we could explore the politics of creating metrics and counting (Andersson & Wagner, 2018) framed by the question, "How do we decide what to count and what not to count to produce these data?"

What Stories Do We Choose to Tell With/out Mathematics?

A key point of this lesson was to interrogate what stories we know, about whom, and why. Do we only know single stories about particular groups of people and categories?

As educators, our goal is not to make people feel bad for not knowing mathematics (or the entirety of global data). We cannot individually know everything about the world; that is not reasonable to expect from students. What we can do, though, is provide space for students to interrogate why we have specific perceptions about the world and acknowledge the dominant stories that we (re)circulate. Collectively, we know a lot of things that a single person alone might not; however, discourses shape perceptions that might be flawed.

Hesitations and Conflicts

As millennial educators, we both grew up with the internet; however, the ways social media and our collective digital literacies have evolved pose challenges for a constantly connected world. This spring, for instance, I (Lynette) had strong reservations about exploring *The World as 100 People* with my students. I wondered about my contribution to a spotlight on global (and local) issues and how my students might be affected by this intense focus. When tragedies such as mass shootings seem to occur with disturbing regularity, I personally have experienced a paralyzing existential crisis: Does mathematics education actually matter in the face of tragedies, terror, hate, pain, and destruction? This reflection is often complicated by being a woman of color who is exhausted from fighting to exist and thrive in an imperialist white supremacist capitalist patriarchy (hooks, 2004). I do, however, also feel a responsibility to provide space for my students to process, grieve, heal, and not be afraid to speak about atrocities in our world.

For me, Jeffrey, the challenge of *The World as 100 People* and its illustration of the world in our pocket is how strongly it conflicts with the current organization of schooling. My perspective is that schools are built around the idea of isolation and self-containment. Students are expected to leave their problems at home, or in other classrooms where they belong, or out in the hall. Teachers are expected to implement problems from mandated curricula that do not affect or intersect with home, or other classrooms, or the complex everyday lives of their students.

Most attempts to connect with students' lives or the world outside the classroom are oversimplifications, as though students are not ready to confront the actual problems of their lives and world (Freire, 1974). But students already have the world in their pockets; they bring their personal and the world's problems with them into the classroom only to see them ignored in favor of attempts at neutrality. Although I find the majority of mathematics curricula to be mundane, I am also concerned about bringing the world's problems into the classroom, precisely because students already engage with them constantly. A third option must be available, and perhaps it is classrooms being spaces of healing, where problems are posed and processed with patience and care. This seems reasonable, as classrooms are face-to-face spaces that can offer something not available in digital spaces.

A current question that guides our teaching involves continually asking ourselves, "Is this worth our time and energy right now?" This question forces us to make visible our value judgments for what contexts we connect to mathematical ideas and practices. It makes us focus on temporal and historical contexts, often centering the psychological and emotional needs of our students and their histories. And finally, it offers educators a frame to choose how we might engage our creative energies and connect mathematics to other subject areas or social, political, and historical contexts in our work.

Critics of our work might ask us to defend why these activities belong in a mathematics classroom, or suggest that rich critical inquiry is in tension with requirements that mathematics educators are pressured to follow. If content coverage is a concern, we suggest supplementing critical mathematical inquiry with other types of activities that serve students' needs. Overall, this process is a continual negotiation of multiple goals for mathematics classrooms. Bartell (2013), for example, outlines how teachers balanced mathematical goals with social justice goals as they implemented and revised lessons focused on teaching mathematics for social justice. If time is a concern, we suggest making small changes in curriculum materials or bringing in an activity from an existing resource, such as *Rethinking Mathematics* (Gutstein & Peterson, 2013). Teaching critical mathematics is a long-term project that requires much time and revision, as some mathematics educators have pointed out (e.g., Gutstein, 2012; Wamsted, 2012).

As educators, we make decisions about what we value in our classrooms. In doing so, we engage questions about mathematics education itself. Do we value specific content standards or should we focus on other things? One area of growth that we see for mathematics education involves making sense of quantitative information through online media spaces. More specifically, we are interested in how people critically examine and respond to information regarding the intersections of mathematics and social issues. Infographics, as prevalent visual representations of data in media, fit these interests. At the same time, we cannot solve global issues with mathematics alone. In our continued work, we hope to open up more spaces in our mathematics classrooms for transdisciplinary inquiry where students articulate difficult problems and are open to explore the messiness of working with more than “just” mathematics (Craig, Guzman, & Krause, 2018).

Finally, we close with more questions than definitive answers. We are mathematics educators who are writing, teaching, and creating work that is not solely mathematics. We are fully aware of the elephant in the room: “Where’s the mathematics?” But the reason we gravitate toward transdisciplinary inquiry is because of the challenges and limitations we have faced as educators who have been pressured to focus only on mathematical content in our classrooms.

As multidimensional human beings who engage practitioner-inquiry in our scholarship, we have found ample opportunities to question ourselves and the kind of work we do with critical mathematical inquiry. Our hope is that other mathematics educators join us to create new experiences, which might mean blurring disciplinary boundaries where mathematics comes in and out of focus. With each of us having the world in our pocket, there are endless possibilities.

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Power to Change: Math as a Social-Emotional Language in a Classroom of Four- and Five-Year-Olds

Elinor J. Albin and Gretchen Vice

"Can I help you? I see you're not feeling that powerful." A five-year-old girl quietly approaches a peer who has just moved a picture of herself down a number line from a 10 to a 1. The number lines are part of an interactive documentation wall on the side of the classroom nearest to the block area. The child, who was approached by her peer, looks up from her work at a round table nearby and makes eye contact with the other child. The two girls sit next to each other at the table, occasionally looking up and smiling at one another as they work.

The connection between numeracy and social-emotional learning may not be obvious when discussing the ins and outs of school for four and five year olds. Social-emotional learning—teaching children how to manage their emotions—is a foundation of any early childhood classroom (Tominey, O'Bryon, Rivers, & Shapses, 2017). Building emotional intelligence happens during every interaction, not to mention through dramatic play, storytelling, and reading books.

Mathematics is ever present within the early childhood classroom as well. Children construct with blocks, sort and categorize at the sensory table, and develop numeracy skills through morning meeting routines, such as finding patterns on the calendar or counting how many people are at school each day (Fosnot & Dolk, 2001). Mathematical thinking is intrinsically part of every young child's day.

In this paper, we—Elinor Albin, a classroom teacher in the pre-kindergarten classroom at an independent elementary school in Boston, Massachusetts, and Gretchen Vice, the school's dean of faculty—review our work in the early childhood classroom there. In the fall of 2014, we, along with Elinor's co-teacher, Karen First, joined together to explore the many ways we could incorporate numeracy, measurement, algebra, and logical thinking into our daily schedule in relation to the growth of children's social-emotional skills. While the development of both mathematical and social-emotional skills is immersed within our school's early childhood classrooms, we seldom use numeracy as a tool for building emotional intelligence. Through our work with students around the question, *What does it mean to be powerful?*, we found a way to blend social-emotional learning and developmentally appropriate number concepts in a meaningful way for our students.

As we will describe in what follows, over the course of the investigation we developed several theories about why bringing mathematical thinking to social-emotional intelligence seemed to have a strong impact on the students. We noticed that children's understanding of their emotions was clearer when we attached the feelings they had to concrete ideas—in this case, to a number from one (least powerful) to 10 (most powerful). Second, because of this clarity, the scale or weight of the emotion became easier to define and consequently change. For example, accepting a friend's apology did not mean that a child necessarily changed from feeling frustrated to feeling happy right away; instead, the impact of the apology could be more gradual, so that a child's feeling changed from a one to maybe a three or four. Finally, as the class began to play with how their individual numbers could be combined, the students saw the impact of how one child's feelings affected the greater group, allowing the class to explore more complex understandings around empathy and the strength of being and learning together.

Social-Emotional Learning Within the Early Childhood Classroom

Early childhood teachers are tasked with educating young children not only in the development of their academic skills, but also in learning how to navigate their social-emotional world. Fostering social-emotional learning involves teaching children how to label and deal with their feelings, make friends, enter into play, and face hardships, among other things. This kind of learning prepares children to work collaboratively, persist through challenges, and advocate for their own needs and for the needs of others. Tominey et al. (2017) explain that "Developing emotional intelligence enables us to manage emotions effectively and avoid being derailed" (p. 1).

At the beginning of the year, teachers in early childhood classrooms often focus on building a community of friends and learners. The children may create their first classroom agreements, participate in classroom jobs, and think deeply about themselves and who they are as individuals (Denton & Kriete, 2000). Students often begin to communicate their thoughts and observations through drawing self-portraits and pictures of the world around them.

Early in the year as they observe trends in how children enter into play with each other and with materials, teachers discuss their observations, reflect, and construct new opportunities for exploration based on what they notice. In our early childhood classrooms, long-term investigations emerge in which, through teacher facilitation, children explore a topic together over the course of many weeks. These long-term investigations often center on the big questions that continue to surface, such as *How do you measure love? Is a bad guy always a bad guy? What does the best possible community look like?*

In the fall of 2014, after carefully observing the children's play, we had questions about the patterns of interactions that we hypothesized were related to the children's sense of efficacy or—as we ended up naming it with the class — "feeling powerful." We had noticed that the children spent a great deal of energy using physical actions, such as giving strong, tackling hugs or knocking down blocks, to say hello, ask to enter play, invite others into play, and maintain play scripts. Some of these actions were problematic because they created more conflict rather than leading to the collaborative play that the students wanted to take part in. Children entered the classroom with a wide range of strategies and different experiences with sharing and coping with their emotions. We began to wonder how we could help our students find more effective ways to communicate their feelings, needs, and desires to one another.

Through collecting observational notes as our students played, we came to hypothesize that if the children had a better understanding of personal feelings of power or powerlessness, they might be better able to think about how to effectively get their social needs met. Through this reframing, we landed upon the question that became the guide for our long-term investigation. We wondered together, *What does it mean to be powerful?*

After we introduced that guiding question to our students, we worked with them to develop a list of supporting questions that were important to our understanding of children's learning:

- What does being powerful look like?
- Who do you know who is powerful?
- How do you get your power back?

Mathematics Within the Early Childhood Classroom

The mathematics of the early childhood classroom includes concepts of sets, number sense, counting, number operations, patterns, measurement, data analysis, spatial relationships, and shapes (Brownell et al., 2014). These concepts emerge through play and are reinforced and primarily taught through daily explorations or activities, such as building with blocks, participating in snack time, or answering the morning question. Throughout the year, these concepts emerge informally as children do mathematical things; it is the teacher's job to be aware of, name, and in some way formalize the mathematics that is occurring, connecting it to mathematical language and more explicit mathematical explorations. In this way, children can explore concepts, deepening their understandings as the year progresses.

We believe that mathematics should play a role in our long-term investigations, and we routinely delve deeper into mathematical concepts, reimagining ways they might provide various access points for exploring the topic of our investigation. Key questions we ask are:

- How does math naturally fit within this investigation?
- What concepts or ideas within this investigation are illuminated or better understood if we include mathematics concepts in the explorations?
- How could mathematics make this investigation more meaningful to our students?
- How will children be able to engage with mathematics or "mathematize" their world within this investigation?

Making connections between mathematics concepts and long-term investigations is not always easy. We found this to be the case at the beginning of the 2014–2015 school year as we asked ourselves which math concepts might naturally fall within our long-term investigation about feeling powerful. Many of the obvious links between mathematics and the guiding questions for that investigation highlighted issues within the classroom community that we were trying to avoid. The most obvious initial mathematical connections to feeling powerful involved physical strength or power: *How much weight can I lift? How far/*

fast can an object go? However, we wanted the children to move beyond the concept of physical power. Instead, we began to think about feeling powerful as an emotional state that could be envisioned as existing on a numerical scale, and we decided to explore the number line as an interactive way for the children to represent how powerful they felt.

Exploration of Number Lines Within an Early Childhood Classroom

Because we decided to connect the concept of feeling powerful to a numerical scale, we wanted to make sure that the students understood the mathematical concepts behind using a number line—numeracy concepts such as quantity, the steady pattern of growth, and even the spatial distribution of quantity—from the outset. Therefore, we set up numerous explorations for our students around number lines before connecting number lines with the social-emotional language.

One of the first investigations our students made was to look for number lines that were already present in their world, and one of the first number lines that the children found was on a ruler. Typically, we teach measurement through non-standard units, such as cubes, teddy bears, or hand lengths. However, in this investigation, we used rulers and meter sticks (using both US customary units and metric standard units) to measure items within the classroom and around the school because we felt that rulers provided a real-world example of the use of number lines.

We had the children explore using the number lines on rulers through measuring the depth of snowfall and the heights of their classmates and objects around the room. Working with small groups, we introduced the incremental pattern of growth that occurs on a number line by building number lines using blocks, gems, and other manipulatives. Children recreated these number lines as they played at the light table or with natural materials—pine cones, leaves, rocks, etc.—during morning exploration. Similarly, students investigated incremental changes in sizes and sounds in connection to music: playing xylophones and discovering how changing the quantity of water in a glass jar altered the pitch of the sound they heard when they struck the jar.

Through these experiences of seeing and touching the differences between numbers of objects in sequence, children developed an understanding of the increasing quantities of the numbers on the number line. We observed that through this repeated exposure to quantity in conjunction with a number line, students developed the ability to sequence and subitize numbers up to 10.

Number Lines and Quantifying Power

While students interacted with these number lines, we introduced math vocabulary. The concepts of *most* and *least* and of *more* and *less* provided the first connections to using number lines as a concrete representation of feeling powerful. One (1) represented feeling the least powerful, while 10 represented feeling the most powerful. The children then began to quantify feelings of “sort-of powerful” or “only a little powerful” within this range.

We supported the children in learning to quantify feeling powerful through using multiple representations of least to most to help them find social-emotional meaning within their understanding of numbers and quantities. To document our exploration, we created a wall of number lines—with one number line for each student—displayed under the question, *How powerful do you feel today?* Because children could use them to answer that question, the number lines were soon nicknamed *power-o-meters*.

On each child's power-o-meter number line, there was a picture of themselves in a powerful pose. The pictures were mounted on a piece of string, which allowed each child to slide them up and down the number line. Children were encouraged to interact with their picture however they wanted. That activity was part of the daily morning routine and also provided a touchpoint for the class at key times of the day, such as after recess or before rest. By using their number line to represent their emotions, children found a consistent way to think about and represent their feelings and to articulate them to their peers and teachers. We began to notice and talk about how a range of emotions was ever present in our classroom, and that these feelings varied throughout the day.

Taking the time to discuss abstract ideas, such as where our feelings come from, allowed us to deepen our understanding of emotions and their role within our behaviors. During a conversation around this, one child shared, "They are in your body and they pop out when you feel happy or sad." Another added, "Feelings live outside your body and they come in when somebody does something to you. They come in and tell your brain what to do." One child moved her power-o-meter to 1 ("not powerful") every morning when she came into the classroom. Throughout the day, she would change her power-o-meter to reflect how she was feeling. Sometimes she would slide her picture all the way to 10 ("very powerful") and, at other times, just halfway up her number line.

We started asking the children more questions:

- What do you do when you are sad?
- How can you make yourself feel better?
- What do you do when you don't feel powerful?

These discussions led us to work with the children to develop a set of coping strategies to use when they didn't feel powerful. Children revisited these strategies throughout the year and were able to express magnificent ideas, such as "You can learn stuff to make you feel more powerful. You could do lots of yoga poses" or "[You can] listen to [stories on] headphones."

Teachers as Researchers

We cannot provide quantitative evidence that children during the 2014–2015 school year were better at regulating their emotions than their peers in previous years had been. However, we observed such a significant amount of growth within just the first few months of school that it led us to ask what about the investigation might have contributed to the children's social-emotional development. *Why did our students become better able to see the weight and impact of their emotions on others so clearly?* As teacher researchers, we hypothesized and drew conclusions based on the changes we had made to that year's long-term investigation. We considered the different aspects of the investigation: the materials used, big concepts explored, questions asked. We discovered that the one underlying element that influenced each of these was the inclusion of using numbers as a language for how students felt.

Mathematics as a Language for Expression

"The 100 Languages" is a poem written by Loris Malaguzzi, founder of the Reggio Emilia approach to education. The poem illustrates a key principle of the approach, which is that there are many "languages" that children use to express their ideas, (mis)conceptions, and emotions (Edwards, Gandini, & Forman, 2012). It also depicts the idea that children have an unlimited amount of potential and are capable citizens within our communities. At our school, we are profoundly inspired by this way of thinking about children. The poem represents how we, as teacher researchers, see mathematics as a language that children can tap into to express their emotions.

We found that children's understanding of their feelings and of others' can be deepened by connecting emotions to concrete mathematical concepts. By making feelings visible for children through associating feelings with number quantities, we as teachers were able to build a more sophisticated understanding of our students' emotional journeys throughout the day. Each child expresses feelings differently and with different intensities. For example, when a child quietly enters the classroom, a teacher might interpret their silence as contentedness and readiness for the next task at hand. However, if the child then moves their picture on their power-o-meter to 1, they are indicating the feeling of powerlessness reflected in their quiet demeanor. The visible representation of children's emotions, created through using mathematics, can thus allow teachers to better understand their students' feelings and to support their students in attending to their own needs.

We saw a group of children who were challenged in expressing themselves make tremendous strides in their abilities to connect with peers and advocate for themselves. Further, we knew the children were transferring this knowledge to their home lives as well. More than one family shared that their child was talking about power and lack of power at home. One child even went so far as to create a power-o-meter for herself at her home. By thinking of it as a language of expression, we discovered that mathematics was an incredibly powerful tool that children can use to describe and talk about their emotions.

Defining the Space Between Emotions

We know that for young children, emotions can feel all consuming. Through our investigation, children were taught that they could think about and find satisfactory ways to respond to emotional states. Many of the children came to realize that what they were feeling at a given moment would not last forever and, that after a while, they might feel better. They started thinking about what they could do when peers were not feeling powerful. We asked, “What could you do to help your friend move up the number line?” Children answered with a multitude of ideas: “By doing something that makes them powerfuller” and “Snuggle with another kid!”

The power-o-meter also gave children a way to discuss less extreme emotions because it allowed children to see that not everything is a 1 or a 10. Instead, there are many numbers and emotions that fall on a continuum. This understanding of the in-between areas gave children more information about how to process their feelings. In one case, a child explained the complexity of an in-between, dual emotion: “Sometimes I feel happy and sad at the same time. Like when my brother breaks my Legos and then helps to fix them.”

Although all the power-o-meters had the same numerals on them, the way that each student used their number line was unique. Each child’s continuum of 1 to 10 represented their personal emotional state, which could not be measured against another student’s. We discussed whether it mattered if each child interpreted their emotions in a different way and decided that that did not impede our group understandings of number or emotions. Instead it allowed each student flexibility in thinking about what their 3 might feel like. We talked about how one child might feel a power level of 3 when their blocks fell down, while another child might feel a power level of 1 under the same circumstances. That idea led the group to have conversations centered around empathy and perspective taking.

Building on the Emotions of Others

Young children are developing their understanding of how they can be both an individual and part of a larger group. During the investigation of the meaning of power, we started with individual number lines as a way for children to concretely express and share their own independent feelings of power or powerlessness. We eventually began asking students to notice when their peers had a low number on their power-o-meter and what that might mean for those children. We asked, “How can you help your peer who feels like a 1?”

At the same time, students were fascinated by larger numbers and counting past 10. During morning meeting, we decided to explore what would happen if we added the numbers on each individual’s power-o-meter together. Every student in the class collected the quantity of gems that matched the number on their individual power-o-meter. We laid the gems along a longer number line and began to count them together. The children remarked that students whose meters were at higher numbers increased the collective sum more than those whose meters were at lower numbers. Students also noted that the sum would be smaller if all of the addends were smaller or, conversely, greater if all of the addends were greater. With this as inspiration, a class community power-o-meter from 1 to 100 was created on our documentation wall for children to explore how their individual power numbers could combine to make a greater whole.

As students began to make the connection between adding numbers of different quantities and the magnitude of the sum, we again drew the connection between the math and social-emotional learning. The following conversation occurred during a class meeting in response to the class community power-o-meter:

Teacher: Are you looking at this?

Child A: Yeah!

Teachers: It feels good?

Child A: Yeah!

Teacher: What does it tell you about the group?

Child A: We feel 52 altogether.

Teacher: And what does 52 feel like?

Child A: Powerful!

Child B: It's a good thing and a bad thing 'cause a couple of us are feeling 1 and some smaller numbers, but a couple of us are feeling more powerful.

This comment—that 52 is both a good thing and a bad thing—demonstrates how the children were recognizing that the community is impacted by each individual's emotions. Following this, the class came to their own conclusions around how a community cannot thrive if members are feeling powerless and how we, as a community, were stronger together than each of us was alone.

The mathematical understanding of numbers and quantity impacted the children's emotional awareness. The more we discussed the quantity of each number and what emotions it represented for each community member, the more the children's understanding of both emotion and number increased. In addition, exploring the larger number line taught the students that each child's power-o-meter played a significant role in our class community power-o-meter. Individual feelings of relative powerlessness (represented by low numbers on a child's meter), compounded together in the greater community power-o-meter, resulted in a less powerful group. It became important to help each student feel powerful to benefit the whole.

Conclusion

During this investigation, we followed our interest in children's efforts to communicate feelings, needs, and desires to their community. By connecting mathematics with this concept, we could use the concrete language of mathematics to help the students understand the social-emotional realm. During this long-term investigation, the children thus simultaneously developed an extensive set of social-emotional skills and a greater understanding of mathematical concepts. As their math skills grew, the children's understanding of the complexity of social-emotional ideas and their ability to talk about those ideas grew as well. Furthermore, the numbers became real; the numbers had a voice and gave us a voice. They were more than numbers; they were us.

Acknowledgements

We would like to acknowledge the children in the ECC Brimmer classroom as well as co-teacher, Karen First, for their essential contributions to this investigation of mathematics and social-emotional learning.

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Mathematics for Whom: Reframing and Humanizing Mathematics

Cathery Yeh and Brande M. Otis

Introduction

Schools are "inherently cultural spaces where different forms of knowing and being are being validated" (Nasir, Hand, & Taylor, 2008, p. 206). Every decision a mathematics teacher makes, "[w]hich properties of arithmetic, which formulas in algebra, which theorems in geometry, and in what context, and for what purpose" (Kumashiro, 2004, p. 96), sends powerful messages about what is valued and whose knowledge and experiences are deemed important.

Mathematics is traditionally seen as the most neutral of disciplines, removed from the arguments and controversies of politics and social life. We join an emerging group of mathematics educators, researchers, and activists to contend that mathematics is political (Frankenstein, 1983; Gutiérrez, 2013; Gutstein, 2008; Yeh, 2018a). Mathematics has been used as a weapon to legitimize capitalist interests, producing stratified achievement levels and positioning some children and families of color at the bottoms of social strata (Ellis, 2008; Yeh, 2018a). How children perform in mathematics is not a reflection of innate ability, disposition, or soft skills, but instead is a product of the organization of schooling, shaped by cultural, historical, and political roots (Ellis, 2008; Nasir, et al., 2008; Yeh, 2018a).

As educators committed to a more humanizing pedagogy, we see education as a site of social reproduction *and* as a potential site for transformation. Schools can be places in which students' ideas and identities are honored and leveraged, and education can, among other things, help bring equality and justice to an unjust world (Freire, 1970). As critical mathematics educators, we see mathematics as a tool to understand and critique the world, and mathematics education as a tool to deconstruct power structures that continue to marginalize certain groups. Transformative pedagogy involves educators developing curriculum that draws from students' knowledge and experiences and supports the development of both sociopolitical consciousness and mathematical competencies (Freire, 1970; Gutstein, 2007).

In this paper, we share a process in which we, as mathematics teacher educators and education researchers, have worked in collaboration with K–6 teachers and students to analyze the purported neutrality of mathematics textbook word problems and to consider ways to use mathematics to analyze social inequities in the world. In the sections that follow, we describe the framework that grounds our development of justice-oriented mathematics curriculum and share an example of how textbook analysis can serve as an entryway to investigations that raise students' awareness of social issues while developing their power as mathematics thinkers and doers. Drawing from these experiences of creating and teaching mathematics projects, we end with a discussion of the complexities, challenges, and possibilities of creating justice-oriented mathematics curriculum in elementary-school settings.

What's the Hidden Message in Mathematics?

Schools teach us more than just reading, writing, and arithmetic; they send powerful messages to students about what is valued and whose knowledge and experiences are deemed important (Jackson, 1968; Nasir et al., 2008). In this paper, we consider the concept of the hidden curriculum, which has come to be understood as the transmission and reproduction of culture—the norms, values, beliefs—conveyed in both the formal educational context and daily school interactions (Giroux & Penna, 1979; Jackson, 1968). Typically unrecognized and unchallenged, the hidden curriculum is one of the means through which structures of power and privilege are maintained.

Mathematics education is rarely considered for its role in the reproduction of dominant ideas, beliefs, and norms. All artifacts encode systems of power, and mathematics texts themselves serve as transmitters of hegemony (Bright, 2016). Mathematics education is a powerful apparatus, inscribing different rules of participation and status and contributing to the taken-for-granted logics that grant authority to some while undermining the authority of others (Gutstein, 2006; Moses & Cobb, 2001; Skovsmose & Valero, 2001; Yeh, 2018a). Mathematics education centers instruction around a narrow set of goals, including individualistic gain, employment, economic competitiveness, and national security and promotes norms and discourses that contribute to ongoing inequalities in our society (Ellis, 2008; Yeh, 2018a; Yeh & Rubel, under review).

Building from the work of critical pedagogy (Freire, 1970; McLaren & Kincheloe, 2007) and critical mathematics scholars in the field (Bright, 2016; Frankenstein, 1995; Gutstein, 2006), we argue that mathematics literacy for all students should be more than an economic necessity—it should be a necessary prerequisite for democracy (Moses & Cobb, 2001; Skovsmose & Valero, 2001). When students use mathematics to describe and make sense of real-life contexts, they improve their decision-making skills and develop problem-solving abilities (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010). More importantly, mathematics can be taught in a way that deepens students' understanding of society and prepares them to be critical participants in a democracy (Gutstein & Peterson, 2005).

Classical, Community, and Critical Knowledge

We do not believe that mathematics education should be limited to helping students develop mathematics literacy as traditionally understood; rather, the goal is to conceive of mathematical knowledge as the ability to use mathematics to analyze, critique, and transform oppressive structures—that is, as "knowledge for liberation from oppression" (Gutstein, 2006, p. 211). We use Gutstein's (2006) community, critical, and classical knowledge bases (3Cs) as the framework within which we develop mathematics curriculum.

Classical knowledge refers to the traditional mathematics knowledge typically taught in schools. It is the formal, in-school, and often abstract knowledge taught in textbooks and assessed in standardized tests. Community knowledge refers to the informal knowledge students already know and bring to school with them; it is the knowledge that resides in individuals and in communities and that is often left out of school curriculum. Community knowledge can be referred to as students' funds of knowledge (Gonzalez, Moll, & Amanti, 2005) or indigenous knowledge (Mack, 1990). Critical knowledge refers to students' understanding of their sociopolitical context. It includes knowledge about why things are the way they are and about the historical, economic, political, and cultural roots that shape one's immediate and broader existence. This knowledge builds from Freire's critical literacies of "reading the world" (Freire & Macedo, 1987). In Freire's (1970) early work on literacy campaigns with Brazilian farm workers, he discussed culture circle sessions in which farmers studied codifications (representations of daily life through cases, stories, and photos) and reflected on their meaning. These sessions allowed culture circle members to examine their lives from different perspectives, to deepen their understanding of their present life situations, and to transform community knowledge about the everyday world—knowledge that has often been normalized—into critical knowledge about the same situation.

Critical Mathematics with K–6 Students

There is a growing commitment to teaching mathematics for social justice in various settings (e.g., middle school and high school classrooms, remedial high school courses, adult education classes, and pre-service and in-service teacher education programs); yet there is little work on critical mathematics in elementary school settings (Bartell, 2013; Frankenstein, 1983; Gutstein, 2006; Gutstein & Peterson, 2005). Students' early experiences with mathematics have lasting effects on students' perceptions of themselves and of mathematics and mathematics competence (Boaler, 2015; Martin, 2006; Nasir et al., 2008). In addition, recent literature in critical mathematics suggests that students demonstrate positive changes in their perceptions of mathematics and its utility after they use mathematics as a vehicle to understand and uncover structural inequities (Brelias, 2015; Gutstein, 2003; Gutstein, 2006). Therefore, it becomes increasingly important to engage younger students in diverse applications of mathematics and provide opportunities to engage in this sort of social inquiry early in their educational careers.

Our desire to engage in textbook analysis with elementary-age students is informed by our own work as educational researchers and as teacher educators (Yeh, 2017; 2018b; Yeh & Rubel, under review). We have examined hundreds of mathematics textbook word problems; the process of analysis has increased visibility of the tradition of silence with regard to sexism, heterosexism, classism, and consumerism that is typically reified through mathematics texts and has made it "unhidden" (Yeh, 2017; 2018b; Yeh & Otis, in progress). Interrogating word problems in terms of assumptions and values as well as in terms of whose experiences the problems valorize has allowed the teachers we have worked with to then undertake a process of reframing, pushing back against stereotypes, and interrogating the problem's implicit values. We believe that elementary school students too can be engaged in this process of developing consciousness about word problems and reframing them, a process whereby students can reframe mathematics texts to be better mirrors of their identities, experiences, and values as well as those of others (Gutiérrez, 2007).

We turn now to a short example of textbook analysis with linguistically and ethnically diverse elementary-age students in an urban[1] public school setting. The authors worked in collaboration with Ms. Jamaica Ross, a fifth-grade teacher in Long Beach, California, to develop a lesson to analyze the purported neutrality of the word problems in their mathematics textbook. The collaboration builds from an established partnership in which Ms. Ross and the first author are part of a family and educator advocacy organization for supporting gender-expansive and transgender children and youth.

A Peek Inside a Classroom

The example that follows highlights an activity that took place in Ms. Ross's class in a school serving low-income Black and Latinx populations. For years, Ms. Ross has been using literacy practices to develop students' critical sociopolitical consciousness while following the school's standards-based English Language Arts curriculum. Specifically, her class engages with literature that explores the social construction of difference, identities, privilege, and power. However, prior to engaging in the activity discussed below, her class had not yet explored *mathematics* as an extension of their conversations around diversity/inclusion. The lesson we describe here centered around critiquing mathematics textbook word problems and leveraging the textbook analysis to begin investigations of social issues. In addition, we provide classroom artifacts (photos and video recordings) and descriptions of this classroom's first attempt at analyzing word problems.

Intentional Word Problems

This process begins with Ms. Ross's class analyzing the mathematics curriculum, specifically their grade-level textbook word problems. We started with a series of problems in the fifth-grade *Math Expressions* (2015). We selected the following word problems to connect with the class's current read-aloud of *George* (Gino, 2015). *George* is a novel by Alex Gino that shares the story of a 10-year-old transgender fourth-grader and her struggles with acceptance among friends and family. In addition to presenting a list of word problems from the Math Expressions unit that might lead to a discussion on genderism, we intentionally included word problems that highlight different representations of fractions (linear, set, and area models):

1. *Amie used 7/9 yard of ribbon in her dress. Jasmine used 5/6 yard of ribbon in her dress. Which girl used more ribbon? How much more did she use?*

2. *A fifth-grade class is made up of 12 boys and 24 girls. How many times as many girls as boys are in the class?*

3. *Ms. Hernandez knitted a scarf for her grandson. The scarf is 5/6 yard long and 2/9 yard wide. What is the area of the scarf?*

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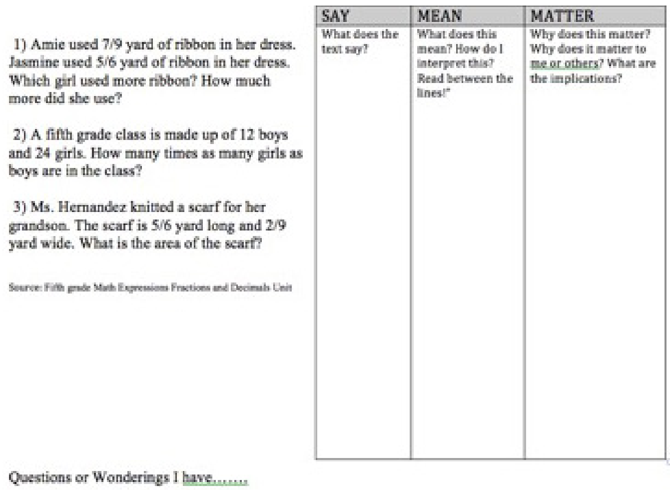
1 The term urban takes on multiple meanings in public discourse and in educational research. Here, urban denotes a place with a high population density, and urban schools have two distinguishing characteristics. First, urban schools serve a diversity of students across racial, linguistic, and socioeconomic backgrounds. Second, urban schools are part of a large school district characterized by bureaucratic leadership structures, an emphasis on standardized testing, and high teacher turnovers.



1) Amie used 7/9 yard of ribbon in her dress. Jasmine used 5/6 yard of ribbon in her dress. Which girl used more ribbon? How much more did she use?

2) A fifth grade class is made up of 12 boys and 24 girls. How many times as many girls as boys are in the class?

3) Ms. Hernandez knitted a scarf for her grandson. The scarf is 5/6 yard long and 2/9 yard wide. What is the area of the scarf?

Source: Fifth grade Math Expressions Fractions and Decimals Unit

SAY	MEAN	MATTER
What does the text say?	What does this mean? How do I interpret this? Read between the lines!"	Why does this matter? Why does it matter to me or others? What are the implications?

Questions or Wonderings I have…….

Figure 1. Say-Mean-Matter-Graphic Organizer

What Does This Say?

Ms. Ross used the close reading strategy *Say-Mean-Matter* and a graphic organizer in order to help students question the word problems, search for deeper meanings, and make connections between the text and their lives (see Figure 1). We began our initial analysis of the word problems with the question, "What does it say?" This first layer of analysis—eliciting from students what the text says, which words are actually used—attends to classical knowledge. The focus here is on the meaning-making and sense-making of the problems.

Students were asked to look closely at the mathematical text and explain the problems. We encouraged students to use words, drawings, and numbers as well as their native language as they developed their explanations. Power and status are communicated in how we allow and encourage students to engage in the mathematics, and language and opportunities for multi-modality play a critical role in discourse and student access (Moschkovich, 1999; Razfar, Khisty, & Chval, 2011).

Examining the three word problems led to conversations exploring fraction and measurement concepts. For example, the knitted scarf problem led to a discussion comparing the characteristics and units of measure of area and volume. Students also discussed different methods of problem solving based on what made sense to them in relation to the context of each problem.

Making Meaning

In the second level of analysis, Ms. Ross asked students to consider what the text means, generating interpretations that tap into their community knowledge. Most students have never been asked to consider the hidden curriculum embedded within mathematics textbooks. Cultural hegemony works to normalize the experiences portrayed in textbooks. We have found that most students read these word problems, at this level of analysis, without seeing that there are limitations with regard to whose lives are represented in them (Yeh & Otis, in progress). This in itself is particularly problematic in that the contexts in which word problems are embedded are not representative of the lives of all people—or in fact of most people.

Mathematics texts carry rich complexity and contextualization. Students bring into the classroom diverse histories and their own rich complexity and contexts within which they see and make sense of the problems they encounter, thus leading to differing interpretations and discoveries. To ensure multiple voices are heard, students are given time to think about the meaning on their own, then share their ideas in pairs, and later share them with the whole class. In doing so, the class as a whole is provided with multiple opportunities to see the problem through differing perspectives. We have found that responses are always diverse, as students bring in different lenses through which to view and interpret the text (see Figure 2).

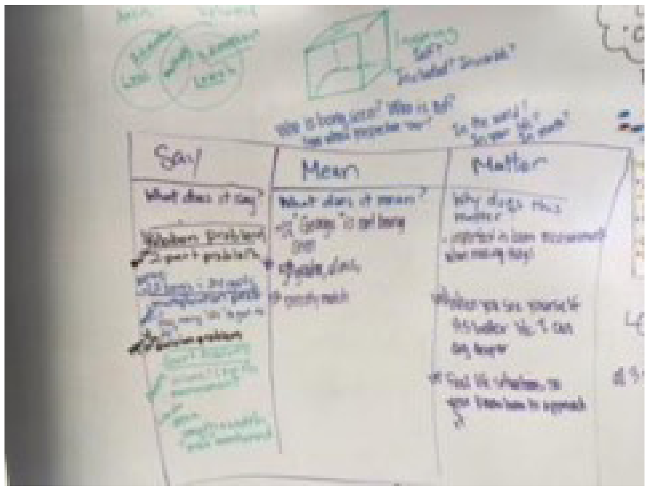


Figure 2. Whole class Say-Mean-Matter

Why This Matters

The heart of our conversation rests in the third column of the graphic organizer, "Why does this matter ... to me, to mathematics, to the world?" These questions have been central in helping us see that all word problems are carriers of cultural values and privilege certain worldviews. We center observations on identifying perspectives and points of view in the text and look for the "silences" in them (e.g., What prior knowledge and experiences [aside from mathematics] are needed to solve the problem? Whose lived experiences are not included?). We then consider how the narrative or its consequences might be different if a given character were different. In the example problems above, the students considered the implication of having a character be a boy instead of a girl, or vice versa.

Throughout this practice, we recognized the importance of student participation and dialogue surrounding the question of "Why does this matter?" Through think-aloud sharing and student participation, students learn from each other, and we can better understand student thinking around mathematics.

Click this link for a clip of how Ms. Ross starts the discussion of why word problems "matter": **https://youtu.be/csDtaVqvkJw.** Notice how Ms. Ross wrote down each student's idea on the board and would consistently ask a follow-up question. The norm in her class is that a student initiates an explanation and then others contribute to and build on that explanation. Since any group of people, including students, has diverse histories and experiences, this norm encourages differing interpretations and discoveries that can overlap or even contradict. Analysis followed by group discussion, therefore, enables multi-vocality and provides alternate discourses that would likely be unavailable if individuals conducted the analysis alone. To provide some context (see Figure 3), below are observations and questions that arose from the problem set:

- What constitutes “boys’ things” and “girls’ things”?
- Word problems with girls’ names provide context related to looking pretty, being helpful, and being a homemaker.
- Word problems with boys’ names focus on sports and competition.
- Playing sports is seen as a boy’s thing while playing house is seen as a girl’s thing.
- Are certain things—toys, games, activities, etc.—the sole and primary preserve of either girls or boys?
- Are there word problems about ribbons, cooking, or knitting that use a boy’s name?
- Do these word problems really matter in real life? Do they represent mathematical calculations needed to engage in daily life?

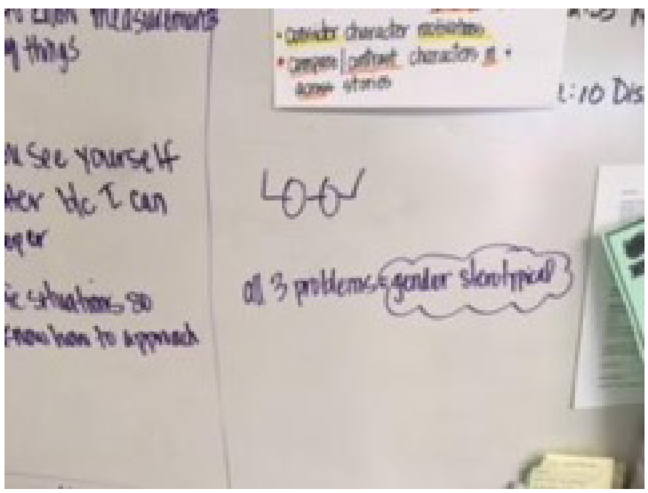


Figure 3. Student input

Students’ Mathematical Investigations

The initial analysis of the word problems allowed students to interpret and assess the ways that gender and sexuality norms are relegated and naturalized by the context made available in the word problems and served as a springboard for students to work in groups and engage in their own mathematical investigations. Students followed their analysis of the word problems in the fractions and decimals chapter by posing their own questions about the contexts for those problems. These investigations provided material for a meaningful experience with basic concepts of data analysis: asking questions and gathering and organizing data in order to make an analysis (National Council of Teachers of Mathematics, 2000).

Analysis of patterns across all word problems in the curriculum helped students to identify a consistent message about gender normativity—the idea that there is only one way to be a boy and another, different way to be a girl. While there were a few instances of a problem context that challenged gender stereotypes (e.g., David's dad baked a dozen cookies to share with David, his sister, and his mom), textbook problems continued to perpetuate heterosexism. Mathematics textbooks seldom contain problems involving non-nuclear families (e.g., two moms or a single dad) or problems including scenarios beyond those featuring opposite-sex relationships, such as male-female dances.

However, we want to note that it is not enough to simply have students notice these patterns; it is also necessary to question why certain things (e.g., toys, activities, careers) are perceived as being only for girls or only for boys and what the implications of these assumptions are. Learning is about disruption, including supporting students in redefining their understandings of sexuality, sexual orientation, and gender by bringing the oppression that results from labeling and categorization to the forefront of classroom dialogue. *Why does this matter? Who does this privilege? Who is silenced?* (See the following video clip of a student discussing why it is important for people of all genders to see themselves in stories: **https://youtu.be/H3MPuhE5mms.**)

Why does genderism matter? Conventional borders around sex, gender, and sexuality maintain marginalization and oppression. The current trend in the United States regarding definitions of gender and corresponding laws about school bathrooms is toward construing gender only as equivalent to one's sex "as assigned at birth." Such legislation is currently being introduced across the United States, although these laws effectively deny many students from feeling comfortable in school and make them vulnerable to harassment and physical violence.

Ninety percent of gender-nonconforming students indicate that they have received negative remarks about their gender expression, and more than half reported being subject to gender-based physical violence in the past year (Kosciw, Greytak, Palmer, & Boeseen, 2014). Even students who are just perceived to be gender nonconforming are significantly more likely than their peers to be harassed and assaulted at school (Kosciw et al., 2014). Examining the meaning of this set of data became a natural opportunity for the class to use mathematics as a tool to understand the role of genderism in school-based violence and to develop new mathematical knowledge on percentages. Physical tools were used to help students develop understanding of percentages building from the students' existing understanding of the base-ten system. The physical representation, using square tiles to model what 90 percent of a group of 10 people or of 20 people would mean (see Figures 4 and 5), provided a kinesthetic model of the data to facilitate student interpretation and sense-making of school-based violence.

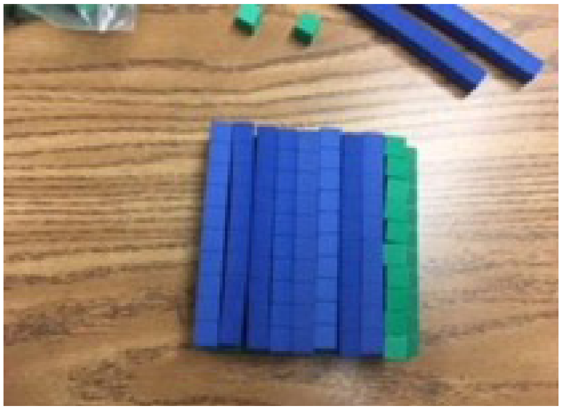


Figure 4. Groups of 10

Figure 5. Using square tiles to show 90 percent

Reframing Mathematics

One of the most pervasive themes that emerged in analyzing word problems with children or teachers was the failure of word problems to depict realistic and relatable applications of mathematics (Yeh & Otis, in progress). Instead, math curriculum word problems often created superficial scenarios as a context for teaching the seemingly more highly valued mathematics. Take the following example found in a fifth-grade mathematics textbook:

"Jeff likes cooking with fruit and vegetables. He needs to know how much they weigh. This is what he found:

A tomato weighs between 1 ounce and 4 ounces.

An apple weighs between 4 ounces and 8 ounces.

A kiwi fruit weighs between 2 ounces and 4 ounces.

A banana weighs between 3 ounces and 6 ounces.

A carrot weighs between 2 ounces and 5 ounces.

A grape weighs between ¼ ounce and 1 ounce.

An orange weighs between 5 ounces and 10 ounces.

A plum weighs between 1 ounce and 3 ounces.

Jeff buys half a pound of grapes. What is the greatest number of grapes he can get? Explain how you got your answer. (16 ounces = 1 pound)"

Ask yourself, how could this problem apply to my daily life? When would a person weigh a single grape? Why does this problem matter? This leads to the last step: reframing. Part of examining word problems in this way involves asking our students to help us reframe word problems so that they're more relevant and realistic. Student groups collaboratively rework and reframe the problems into more relevant, socially just scenarios. This process provides opportunities for students to examine the often unnamed layers of power, positionality, and privilege that form the context of mathematics scenarios in textbooks and then to use these insights to consider ways to challenge and disrupt current narratives of mathematics that are removed from lived experiences.

Follow this weblink to view three groups' recreated word problems and their justifications for changes: **https://youtu.be/zeLEpdMnabk.** In our experiences with students, their reframings—similar to the recreated word problems seen in the video—often focused on shifts in the identity of the protagonist so that the word problem better represents the diversity of children and families in our schools and community: *Juan is cutting ribbon to make a pink bow or Molly's dad knits a scarf for his husband.*

The Journey of Teaching (and Learning) Mathematics for Social Justice

Recent events in US politics have led to a renewed urgency to examine the role of education in the lives of our children. Educational inequities are systemic and pervasive. Education, including mathematics education, is implicated in various forms of broader interpersonal dominance and ideological struggles. Institutional tools that implicate mathematics, like standardized tests, prescribed curricula, and curricular tracking systems, perpetuate inequities in mathematics and have led to increased pressures of accountability and performativity for teachers—making the process of teaching mathematics for social justice both challenging and rejuvenating.

One of the greatest challenges in learning to teach mathematics for social justice is the negotiation of mathematical goals and social justice goals. In our desire to support and foster students' sociopolitical and critical consciousness, it is always necessary to ensure that our students use, apply, and learn new mathematics (Bartell, 2013; Gutstein, 2006). As such, we have found that it's important to not only examine curriculum text, but also to closely examine our own implementation of math lessons. Critical mathematics education should not only raise students' awareness of social issues, but also develop their power with mathematics and their sense of themselves as mathematics thinkers and doers. In our work as teacher educators, we ask our teachers to consider how lessons, from their design to their implementation, can leverage the community and classical mathematical knowledge students bring to class and to find ways to connect students' funds of knowledge (Gonzalez et al., 2005) to new mathematics concepts.

As teacher educators, we have had the privilege to work with hundreds of pre-service and in-service teachers. Although mathematics education is one of the powerful institutional discourses that help to create and maintain prejudice, many educators, students, and school professionals consider textbooks and curricular materials to be objective transmitters of truth (Yeh, 2017; 2018b; Yeh & Rubel, under review). Teachers and students typically do not question the context of word problems presented to them. Instead, they initially accept the text as truth, and they often view mathematics and mathematics teaching as universal, neutral, and uninfluenced from the social realm. Only after some period of time do they feel compelled to engage with the question, "Why does this matter?"

Cochran-Smith (2004) uses the metaphor of traveling—or walking the road—to make the case that the work of social justice in education is "an ongoing, over-the-long-haul kind of process" (p. xvii). Education, including mathematics education, is intricately linked to power structures that perpetuate inequities in both schools and society (Bartell, 2013; Frankenstein, 1983). Mathematics learning experiences in most schools still require students to perform mathematics using algorithms that are not their own, in a language different than their native tongue (emergent bilinguals are now the fastest-growing student population in the United States) and to solve mathematics problems irrelevant to student interests and experiences (Aquino-Sterling, Rodríguez-Valls, & Zahner, 2016; García, Kleifgen, & Falchi, 2008). As such, we've found this work to be a collective journey in which we walk with teachers and students to "unlearn" the mathematics we have experienced as students and to relearn the possibilities to teach mathematics for social justice.

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Elementary Mathematics and #BlackLivesMatter

Theodore Chao and Maya Marlowe

> *Children, not yet aware that it is dangerous to look too deeply at anything, look at everything, look at each other, and draw their own conclusions. They don't have the vocabulary to express what they see, and we, their elders, know how to intimidate them very easily and very soon. But a black child, looking at the world around him, though he cannot know quite what to make of it, is aware that there is a reason why his mother works so hard, why his father is always on edge. He is aware that there is some reason why, if he sits down in the front of the bus, his father or mother slaps him and drags him to the back of the bus. He is aware that there is some terrible weight on his parents' shoulders, which menaces him. And it isn't long—in fact it begins when he is in school—before he discovers the shape of his oppression, (Baldwin, 1985, p. 326).*

Welcome (Some of You) to Peace Park

Maya, a veteran elementary educator, talks to her first-graders as they sit on the carpet. Maya's class is comprised entirely of Black and Latinx children. Maya asks her students to partner up and discuss "What do you think the word 'fair' means? What do you think it means to be fair?" After the children talk for two minutes, they share that fairness means "equal," "you get the same number," "everyone gets the same amount," and "sharing." Maya writes these ideas on the front board, helping her students expand their thoughts about fairness to include "treating everyone with honesty and respect," "cooperating with people," and making sure "others are not treated poorly."

Maya then reminds her children of a prior mathematics lesson on Rosa Parks and the Montgomery bus boycott (Chao & Jones, 2016), in which, as a way to explore how mathematics can be used to confront unfair treatment, they counted up how much money Montgomery lost as a result of the boycott. Today's lesson moves to modern times, exploring the mathematics involved in the formation of the #BlackLivesMatter movement so that her children can see themselves as citizens who are empowered by mathematics and who recognize that our struggle for justice is far from over.

Over two decades of teaching, Maya has learned how to curate a classroom space safe for all voices to engage in discussions about the importance of diversity, restorative justice, empathy, loving engagement, and Black families — some of the guiding principles of the #BlackLivesMatter movement (Watson, Hagopian, & Au, 2018; "What We Believe," 2018). She is extremely sensitive to the emotional and psychological well-being of her children and makes sure her students and families always have a safe space to voice opinions and concerns, particularly when connecting her teaching to topics that could trigger violent and traumatic feelings. For instance, before delving into this lesson about #BlackLivesMatter, Maya engaged in conversation with her students' families about how they speak about the #BlackLivesMatter movement with their children at home. The #BlackLivesMatter movement is especially pertinent in our community, as the police murder of 12-year-old Tamir Rice at a public park took place only a two-hour drive away. Maya's dedication to her students' safety and well-being mirrors Leonard's (2018) warning about precautions to take when teaching mathematics for social justice.

Maya often launches her lessons using a picture book or a story. Today, she starts with *The Three Billy Goats Gruff* (Galdone, 1973), a tale about a mean troll who prevents billy goats from crossing a bridge to get to some sweet green grass on the other side. Children giggle as the troll tries to stop each billy goat, finally bursting into a chorus of laughter at the end, when the biggest billy goat rams the troll off the bridge. After reading the story, Maya asks the children to talk to their partners about how the troll was not being fair, reminding them to align their discussion with the ideas about fairness they generated earlier. Using evidence from the story, children point out that the troll was not being fair because it did not treat the billy goats with honesty and respect.

Next, Maya walks to the side wall and introduces Peace Park. Children giggle with excitement as she tells them about Peace Park's amenities: swings, water slides, free popsicles, basketball courts, a bubble area, an outdoor skating rink, live music, and a swimming pool! Maya points to two signs reading, "Yes" and "No" (see Figure 1). Just like the mean troll who stops the billy goats from crossing the bridge, something can stop the children from entering Peace Park. This obstacle, however, has a mathematical form: the probability of landing on blue, depending on which one of two spinners a child uses, that determines if the child can enter Peace Park ("Adjustable Spinner," 2016).

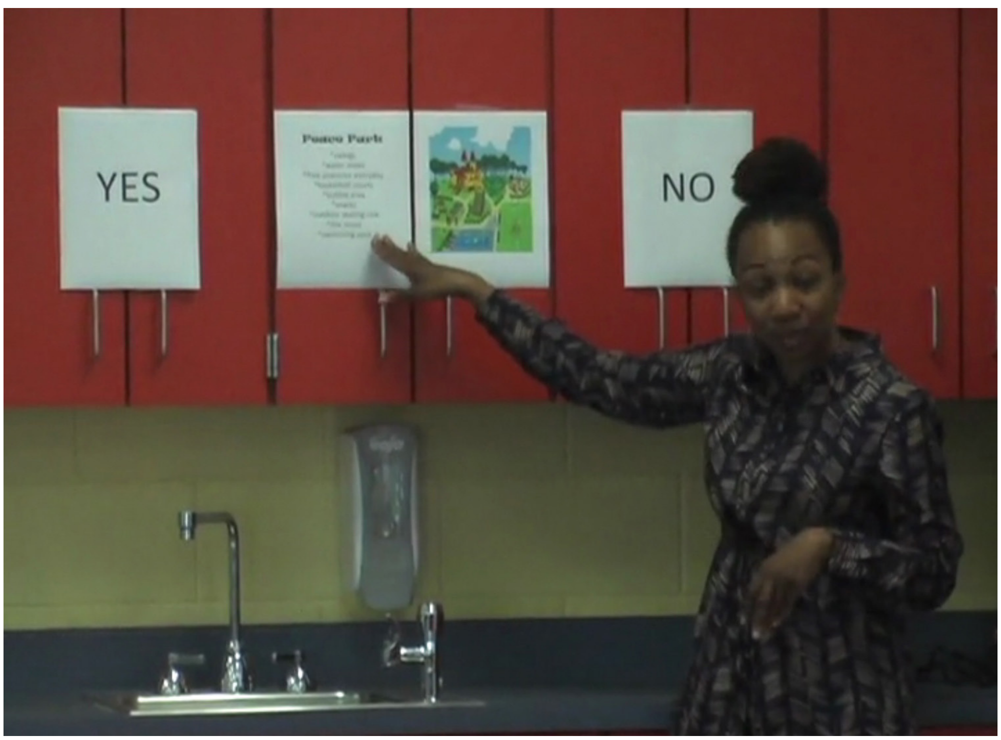

Figure 1. Maya introduces Peace Park to her students

Without explaining what the spinners mean, Maya helps the children choose which one they want to use. The students giggle as they approach a computer with two spinners displayed on the screen, one of which they'll spin to find out if they are allowed into Peace Park (see Figure 2).

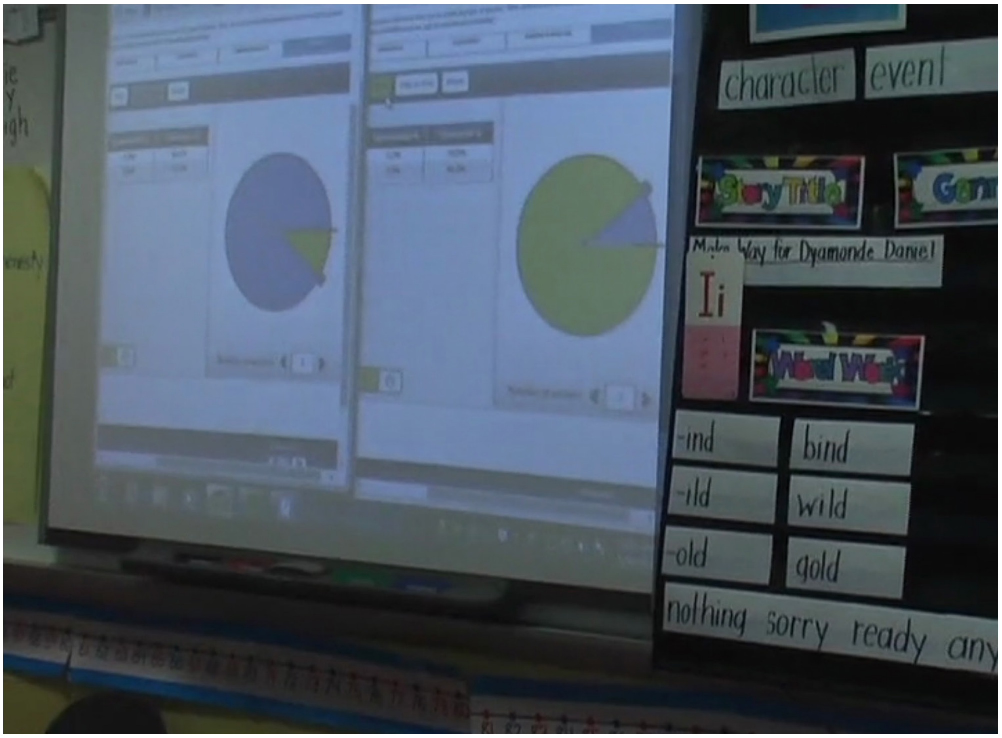

Figure 2. The two different spinners used by children to determine entry into Peace Park

Children must spin onto the blue color to be let into Peace Park. The left spinner is 86 percent blue, while the right spinner is 14 percent blue. Before the students take their turns, Maya asks, "Do you think these spinners are fair? Who do you think will get into the park?" Students shout out various answers, eager for an opportunity to spin. Then, one by one, the children approach the spinners and choose one to spin. When a child spins onto blue, Maya high-fives them, shouting, "Welcome to Peace Park!" and directs the child to the "Yes" sign. If a child spins onto yellow, Maya directs the child to the "No" sign.

After every child has taken a turn, Maya asks the children to count who entered Peace Park and who did not. Together, they count that five children entered Peace Park, while 13 did not. The students then count who spun the left spinner and who spun the right spinner. They determine that none of those who spun the right spinner entered Peace Park and that six of the 11 children who spun the left spinner didn't get into Peace Park either.

Maya asks the children who did not get in, "How do you feel that you didn't get into Peace Park?" A child raises their hand and says, "I feel sad because I didn't get to come in." Maya asks the student to explain why and to connect their reason to one of the definitions of fairness from earlier. The child replies, "I was being treated badly."

Another student raises their hand, "I think it's unfair because there's only five people over there [in Peace Park] and more over here." Maya responds, "So you think more people should be able to get in?" "Yes," says the child.

Maya then turns to the five children that did enter Peace Park and asks, "How does it feel to get into Peace Park?" One child shouts in excitement, "Cool!" Another child raises both hands, yelling "Whoo!" A third child gestures with a wavering hand, "I feel bad that other people didn't get to come in."

Next Maya arranges the students in small groups to discuss and then journal about (a) who got into Peace Park, who didn't, and why; (b) how the two spinners were different and what fair spinners would look like; and (c) how the children felt about having two different spinners. After journaling, students share their thoughts. One child says, "None of [the people who used the right spinner] got to go in and I think I know why. The [right spinner] got a lot of yellow, and the [left spinner] got a lot of blue. So, we [right-spinner group] automatically got all no. That is not, not, not, no, no fair."

Maya then asks the children how they would make the situation fairer. Students share various suggestions, such as making sure the spinners have the same amount of blue and yellow, requiring everyone to use the same spinner, or doing away with the spinners entirely and letting everyone into Peace Park. Maya then orchestrates a discussion about what it feels like for those who were restricted from entering Peace Park and how we all heal when we listen to those who are not being treated with honor and respect. Maya connects the conversation back to the lesson on the Montgomery bus boycott and the ensuing protest marches of the Civil Rights movement, leading to a classroom discussion during which children decide that they could lead a march to let people know about how the spinners are not fair. Maya finishes the lesson by revealing that the unfairness represented by these spinners was one reason why three Black women—Alicia Garza, Patrisse Cullors, and Opal Tometi—started the #BlackLiveMatter movement (Watson et al., 2018), specifically to show everyone how some people were not being treated with honesty and respect.

In this lesson, the spinners mirror actual racial profiling traffic statistics from Ferguson, Missouri, in 2013 (Madrigal, 2014), shortly before the police murdered Michael Brown and subsequent protests crystallized the national #BlackLivesMatter movement (Hill, 2016). In this activity and its discussions, children confront the statistics from Ferguson County, in which Black citizens in 2013 accounted for 86 percent of the traffic pull-over stops and 92 percent of the car searches, even though Black citizens made up only 67 percent of the population of Ferguson County.

Maya has also taught this lesson to fifth-graders, extending the context and the mathematics in age-appropriate ways. When working with the older students, Maya replaced *The Three Billy Goats Gruff* (Galdone, 1973) with *Ghost Boys* (Rhodes, 2018), which details how a community and a ghost deal with societal anti-Blackness after a police officer murders a 12-year-old boy holding a toy gun. During the final discussion, Maya reveals that these spinners represent the difference in being pulled over by police officers in Ferguson, Missouri, depending on whether you were Black or not Black, shortly before Michael Brown was murdered. Maya orchestrates that discussion around the use of rational numbers and probability to describe whether a situation is “fair” or not, having students compare the 86 percent-blue spinner to the 14 percent-blue spinner. Maya then makes the connection to the mathematics of the use of economic boycotts—such as the Montgomery bus boycott the class had studied earlier, the #NotOneCent boycott of Black Friday shopping, and the boycott of National Football League games—as a form of protest. Children finish the lesson by writing in their journals about ways they can use mathematics to describe when a situation is unfair and, furthermore, how they can use mathematics in collective economic protests.

Origins of the Peace Park Lesson

The vignette presented above details a lesson based on an activity that a group of elementary pre-service teachers in a Master’s degree teacher licensure program created. The group was mentored by the authors: Theodore, who instructed them in an elementary mathematics methods course and Maya, who served as a cooperating teacher to one of the pre-service teachers. On November 25, 2014, the day after police officer Darren Wilson was found not guilty of the murder of Michael Brown, the group decided to develop a mathematics-related activity for young children to explain what was happening in Ferguson. The teachers wanted to create a role play of the daily unfair experiences with racial profiling that the #BlackLivesMatter protests in Ferguson centered upon, using racial-profiling statistics in Ferguson in a way that children could understand. Maya and Theodore guided the teachers toward adapting an activity called “Driving While Black or Brown” (Gutstein, 2013), a middle-school lesson that appeared in *Rethinking Mathematics* (Gutstein & Peterson, 2005), a volume of social justice-themed mathematics lessons and commentary. “Driving While Black or Brown” explores the different statistical probabilities of someone being pulled over by police officers, depending on whether the driver is White, Black, Latinx, Asian, or Native American. Because practices such as racial profiling are inequitable and perpetuate race-based differences in access, they are strongly connected to modern social justice movements and demonstrations. As Leonard (2018) states, “Teachers of mathematics can build student awareness of #BLM by using data collected on traffic stops” (p. 202).

Together with the pre-service teachers, we found publicly available police arrest records from the state of Missouri (Madrigal, 2014), and then connected them to the first- and second-grade Common Core State Mathematics Standard of learning to represent and interpret data (CCSS 1.MD.C.4, 2.MD.D.9, and 2.MD.D.10). In order to adapt this middle-school lesson for elementary grades, we had to (a) modify the mathematics so that it was less about proportional reasoning and rational numbers and more about understanding probability, (b) introduce an age-appropriate role-play context for early elementary students—such as crossing a bridge to a park—that was not as terrifying as racial profiling or murder by the police, and (c) consult with a child psychologist about avoiding and mitigating potential trauma invoked by the lesson. We then revised the activity so it fit within the context of Maya’s classroom community, Maya’s pedagogical practice, and the guiding principles of #BlackLivesMatter: diversity, restorative justice, empathy, loving engagement, and Black families (“Herstory,” 2018; Watson et al., 2018).

Preparing the Classroom Space for Children's Emotional and Psychological Well-Being

I, Maya, use the first-person voice here to speak specifically about how I prepare my classroom for lessons such as this one.

I want the children in my classes to learn about themselves by studying Black people, places, and events of the past and of the present and also to understand the social and racial issues impacting our Black community. My goal as an elementary educator is for my children to create counter-narratives to the racist and damaging stereotypes about Black people that permeate our community. I want my teaching to instill an awareness of social issues impacting Black people, helping my children find their voices to challenge social and racial injustice. Education is emancipation. My children learn to embrace their own culture and history with pride, to learn to be unapologetically Black, and to engage in true empathy and loving engagement with Black villages and Black families. These experiences lay the foundation for them to give back to the Black community and empower it when they become adults. While not all of my students are Black, the lessons everyone in the class learns from understanding the magnificent struggle from emancipation to civil rights to ending mass incarceration connect to the history of all oppressed peoples, particularly the history of my Latinx students, who face similar struggles in our community.

There are five established principles in my classroom that highlight Black culture and the evolving nature of racism. First, every month (not just Black History Month), we focus on specific Black role models and display images of them (e.g., Kings and Queens of Africa, Black authors, and #BlackLivesMatter activists) on our bulletin boards. Second, our classroom library is stocked with books written by and about Black people (and other authors of color). Third, every topic of study is aligned or connected with Black culture. For instance, when we study fairy tales, we include fairy tales that connect to African or Black American culture. Fourth, we integrate modern Black popular culture into our activities through popular songs, trends, and dances. For example, we are currently studying the lyrics of J. Cole's *Be Free*, a tribute to Michael Brown, in our poetry unit. Finally, our classroom walls, anchor charts, and teaching examples always include images of Black people so children see representations of themselves everywhere in my classroom. As the Latinx population in our community is growing, I create the same amount of representation of Latinx role models and authors (and other people of color) in my classroom library and on my walls, too.

I used these principles to incorporate the Peace Park lesson into our ongoing classroom discussion. For background, we discussed the history of the Civil Rights movement and role-played how Rosa Parks used bravery and non-violent methods to start a boycott of an unfair bus system that denied seats to Black people (Chao & Jones, 2016). We studied the terms racism, segregation, prejudice, and social justice. Then, to connect these ideas to the current #BlackLivesMatter movement, we discussed the lives of Trayvon Martin and Tamir Rice (Watson et al., 2018). We discussed the norms of compliance with the police, how to handle things when you are not treated fairly, how to avoid using violence, and how to speak up. We discussed how we cannot succumb to violence despite the fact that fear and intimidation have been tools used to attack the Black community. We discussed how people rose up to protest unfair ways police treated Black people using the slogan #BlackLivesMatter to organize these protests through social media throughout the country.

I am fortunate to have a respectful relationship with many of the families in my community. This relationship is built upon trust and enables my administration and (usually) my families to know that I have the children's best interest at heart and not to challenge what I am doing in the classroom. Occasionally, parents will object to my classroom practices as inappropriate or not educationally sound, but my administration has always supported me and my pedagogical decisions.

It is critically important to have established these relationships of trust with the community I work with before formally connecting social justice constructs to my mathematics lessons. Because I am also my children's literacy teacher, I have more freedom in engaging them in ideas about fairness and the historical oppression of our people. But I also want to warn teachers who want to do this work that they must take caution. In my experience, it has been important to let the guidance counselor and the district child psychologist know what I am doing, to first talk to families about the nature of the conversations they are having at home, and to make sure that in all my teaching, I am aware of the emotional and psychological well-being of my children. Some of them have already been traumatized, and because of the color of their skin, they will continue to be traumatized for the rest of their lives by our nation's anti-Black violence. My classroom is not a place where I want to induce more trauma, but rather a space of loving engagement in which my children learn about their power and about ways to continue to grow this power through love, empathy, and the growing of their Black villages. My classroom is a space where all my children can breathe.

Equity, Power, and Creative Insubordination in Elementary Mathematics Teaching

Mathematics teaching for social justice at the elementary and early childhood level must connect formalized mathematics to the complex and sophisticated mathematics already present in children's histories and communities (Civil, 2007, 2009; Turner, Gutiérrez, Simic-Muller, & Díez-Palomar, 2009). For young children, stories and play are real-world situations (Parks, 2015; Wager, 2013). We situate social justice mathematics at the elementary level by connecting to and honoring children's histories, stories, and fairy tales that highlight mathematics and ways children can use mathematics to recognize and confront the injustice they notice (McCormick Smith & Chao, 2018; Parks & Wager, 2015; Wager, 2013; Ward, 2017) .

Our work in teaching mathematics for social justice revolves around the following ideas. First, all children are capable of sophisticated mathematical thinking, which develops as we listen to and pay attention to children as well as to the social identities and cultures that children use to position themselves (Hand, 2012; Louie, 2018). Second, children have the capacity to think in sophisticated ways about fairness (Chao & Jones, 2016; Tan, Barton, Turner, & Gutiérrez, 2012). Third, children bring a wealth of mathematical knowledge from their communities and families with them into the classroom (Aguirre &

del Rosario Zavala, 2013; Civil, 2007; Turner et al., 2009). Children live in spaces in which mathematics is often used—they see it, they observe it, and they know it. Fourth, connecting this knowledge to the formalized mathematics in the classroom helps children develop strong mathematical identities (Aguirre, Mayfield-Ingram, & Martin, 2013). Fifth, any form of mathematics teaching for equity and social justice is posturing if it does not attempt to empower the global collective Black, a term used by Bonilla-Silva (2004) to describe the dark-skinned populations often placed at the bottom of racial stratification systems (Martin, 2015). Sixth, for young children, expressions of unfairness ("It isn't fair!") are routinely dismissed by the adults around them as infantile complaints. Yet when an expression of unfairness is followed up with a mathematical explanation ("It isn't fair because they used a spinner with less blue"), adults are forced to evaluate the legitimacy of the claim. Seventh, recognizing injustice through using mathematics is not enough; children must also use mathematics to confront injustice by what Gutstein (2006), in reference to Freire (1970), calls writing the world with mathematics and what Gutiérrez (2013) calls creative insubordination. While Gutiérrez frames creative insubordination as something that teachers and administrators do, Maya believes that children are also capable of creatively insubordinate thoughts and actions. Finally, in recognition of the collective action happening around the world as the #BlackLivesMatter movement, we see that mathematics teaching for social justice is incomplete if it does not touch on the guiding principles of #BlackLivesMatter: diversity, restorative justice, globalism, queer affirming, unapologetically Black, collective value, empathy, loving engagement, transgender affirming, Black villages, Black women, Black families, and intergenerational (Leonard, 2018; Watson et al., 2018). Therefore, teaching mathematics for social justice to children revolves around empowering children of the collective Black—particularly by using tools of loving engagement, restorative justice, and empathy—to use mathematics to call out and confront unfairness in their lives so that adults in power around them recognize that unfairness.

Maya's Growth through the Peace Park Activity

I, Maya, again use the first-person voice here to reflect upon my growth through this lesson.

While I have learned to connect issues impacting the Black community to my language arts and social studies lessons, exploring social justice through a mathematical lens was something I only started to do through this activity. After this lesson, my children "felt" unfairness and learned how to highlight social injustice using mathematical data. In our first enactment of the lesson, the children who did not get to enter Peace Park were genuinely upset; their negative emotions were real. Some children bordered on crying, some children pouted, and others were just plain mad. We addressed this anger and other emotions through class discussion, connecting again to our lessons on the history of Black struggle and to how we can take action against unfairness and racism. Having an opportunity to journal and discuss what we had just experienced allowed the children to reflect on how they could move beyond anger to take action. In subsequent lessons, I have tried to better reflect real-world situations by randomly giving students stickers labeled "Black" or "Not Black" in order to create more empathy and understanding over the arbitrary and violent use of race as a category.

Closing Thoughts

We end with our reflections and suggestions from teaching and revising this activity in our classrooms and various professional development presentations over the past four years. While we enjoy sharing this activity, we still find that because of the very real and scary implications of the statistics revealed in the lesson, self-reflection is absolutely necessary every time we teach it—particularly as the #BlackLivesMatter movement grows stronger, more vital, and more indispensable. This self-reflection works well when we include parents and community members in dialogue about how this lesson went and how we can support these ideas throughout the school year.

After the first time we taught this lesson, we felt satisfied with how it connected to social studies and language arts. However, we are aware of the tension in engaging children in doing and learning mathematics through using data as a means of discovering, sharing, and confronting problems in the community. We note that this content goes beyond what is proposed in the first-grade content standards. As we explained earlier, teaching mathematics for equity involves viewing children's strategies through a lens of culture and identity; recognizing children's sophisticated ways of thinking about fairness; valuing community and family funds of knowledge; helping children develop strong identities as mathematical thinkers; empowering the collective Black; engaging children in using mathematics to justify to adults the children's expressions of unfairness; and employing the guiding principles of #BlackLivesMatter. We feel that our evolving Peace Park activity as presented here still only touches upon some of these principles. We continue to work on how to empower the collective Black, engage children in using mathematics to justify their expressions of unfairness, and create mathematics lessons for children who are queer and transgender affirming.

In the future, we would like to place more emphasis on using data to highlight classroom issues (positive and negative) as well as on supporting children in understanding that social justice begins with individuals and their treatment of others. Therefore, we suggest the following extensions to this activity that more formally connect to mathematics.

1. *Having children create their own story problems/situations.* To increase their ownership of the story context, children should create their own mathematics story problems, extending from the story used at the beginning of the lesson, from the role-play, or from the experience of unfairness in general. Their final product would include a mathematics story problem or picture; a written component explaining why the situation is not fair; and mathematical data to support their position.

2. *Having children use their own data.* Children should gather their own data. For example, if the classroom encounters trouble finding healthy options during snack time, students can compile data showing the number of times healthy snacks are available versus the number of times they are not available. Children can chart this data in order to highlight problems involving food

justice and to spark dialogue in their classroom and community about solutions. This connects to the Common Core State Standard for Mathematics of learning to represent and interpret data (CCSS 1.MD.C.4, 2.MD.D.9, and 2.MD.D.10) as children create simple bar graphs to represent the data they have gathered.

3. *Reflecting real-world situations.* We have experimented with having children wear "Black" or "Not Black" labels to make the lesson more realistic, yet not based on students' self-identified racial categories. We find that when this activity is presented in child-appropriate ways, the inclusion of race as a factor is something that children realistically engage with critically and mathematically. We caution readers again about the dangers of introducing emotional and psychological trauma into their classrooms. But we also encourage readers to engage in school-wide dialogue about ways to speak about race in ways that engage Black children in feeling proud and unapologetically Black in and out of school.

4. *Modeling fairness through teaching about division.* In introducing fractions and other rational numbers, the concept of fairness can be aligned with the fair sharing of finite resources (Empson & Levi, 2011). When sharing materials, do children feel they are treating each other with respect and that everyone has the same amount? Extending the activity to incorporate ways to express how the billy goats would share the sweet green grass or how children would share a finite number of snacks (e.g., slices of cheese) or a finite amount of materials (e.g., modeling clay) connects ideas of fairness to multiplication, division, and rational number concepts.

5. *Connecting to families.* Family members are always present in Maya's classroom as volunteers, which helps connect classroom experiences to the discussions that children have at home. More explicit connections to families can be made through letters and emails home and questions related to fairness that children can ask their families. These connections can be further strengthened when families are present to participate in the lessons.

6. *Adapting scenarios for older children.* We continually see ways to extend this activity to connect to the concept of (dis)proportionality for higher-level grades. For instance, we can incorporate recent statistics from Baltimore, Maryland, where Freddie Gray died in police custody (Hill, 2016) or general statistics about police violence toward Black men. These statistics focus on the mathematics of *drawing comparative inferences between two populations* (CCSS 7.SP.B.3, 7.SP.B.4), *investigating chance processes*, and *developing, using, and evaluating probability models* (CCSS 7.SP.C.5, 7.SP.C.6, 7.SP.C.7). We use these examples only with older children, as we feel direct discussion of murders committed by police is too traumatic for younger children. We again warn that these statistics are horrifying; they provide mathematical depictions of the epidemic of police-led violence against our Black communities.

   a. We can use statistics to highlight the tremendous amount of undue force used in Baltimore, a majority Black community (Hill, 2016). We can extend our activity using one spinner that shows that 39 percent of the time, an encounter with a police officer in Baltimore involves force or the threat of force (Puente & Perna, 2014) while using another spinner that shows that an encounter with a police officer nationally involves force or the threat of force only 1.4 percent of the time ("Bureau of Justice Statistics (BJS) – Use of Force", n.d.). In our discussion, we would ask older students, "What inequities do these statistics unveil? How can these statistics lead to empowering the collective Black and strengthening the guiding principles of #BlackLivesMatter, such as empathy, restorative justice, and Black families?"

b. Another extension of our activity can focus on the statistic that Black males are murdered by police at a rate of 21 times more than white males (Gabrielson, Sagara, & Grochowski Jones, 2014). We can have students mathematically model this alarming statistic. In a discussion about it, we could ask what could possibly account for this statistic and how it can be used to motivate collective action.

The Peace Park activity and the ensuing discussion are continual works in progress for us. We are excited to share our experiences with this activity and how we have tried to incorporate the guiding principles of the #BlackLivesMatter movement into elementary-school mathematics lessons to engage children not only in their mathematics thinking, but also in their global citizenship and empathy.

Reflection and Discussion Questions

1. How do you explore issues of social justice in your teaching, particularly issues that might be controversial but are pertinent?

2. How are your children exposed to mathematicians and role models who look like them? Are there only predominantly white and male representations of mathematicians and role models in your examples, books, or wall art?

3. How do you integrate your children's pop culture (i.e., current songs, fashion, or social media) in your teaching?

4. How does your teaching connect to your children's communities and families? How do your children talk about or include their ancestors into their mathematics talk? How do members of your community know about what your classroom is doing? How have you incorporated the history of the community into your teaching?

5. How do you incorporate real statistics from your children's communities and families into your mathematics lessons?

6. How can you do this while still maintaining a playful environment?

Acknowledgements

We are thankful to Sarah Dodson, Krystin Burgess, Stephanie Tape, Angela Tolbert, Brittany Bader, Lauren Woeste, Jessica James, Britni Boyer, Mallory Loless, and Amber Gregg for the ideas, plans, and revisions of the activity this manuscript is based upon. We are also very thankful for the guidance of Dorothy White, Marta Civil, Sylvia Celedon-Pattichis, the National Council of Teachers of Mathematics, and numerous anonymous reviewers for their caring and thoughtful feedback, which helped us further develop and reflect upon this activity and manuscript.

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The “Soft Bigotry of Low Expectations” and Its Role in Maintaining White Supremacy through Mathematics Education

Laurie Rubel and Andrea McCloskey

Introduction

The articles in this volume of the Bank Street *Occasional Paper Series* document successes and struggles in supporting the teaching and learning of mathematics as critical mathematical inquiry (CMI). CMI efforts range from teaching mathematics for social justice to broadening school mathematics to making mathematics classrooms places where people want to participate, and more. CMI challenges systems of power and oppression, such as white supremacy, that exist in and operate through mathematics education (Battey & Levya, 2016; Martin, 2013, 2018). Any initiative that demands transfer of power away from those who possess it will always be countered by hegemonic forces that seek, instead, to maintain the status quo (Guinier & Torres, 2002). This means that those who engage with or advocate for CMI are vulnerable to forces whose expression can range from negative feedback from parents, students, or colleagues; disciplinary action from a school or district; or even targeted harassment on social or other media by white supremacists. Indeed, fears about such pushback are a known deterrent to CMI efforts (Simic-Muller, Fernandes, & Felton-Koestler, 2015).

We have identified a central ideology that is used to maintain the status quo of white supremacy in schools and schooling in the United States, an ideology captured by the phrase “soft bigotry of low expectations” (SBLE). In this paper, we explore its origins and analyze various ways that it is employed in current discourse about mathematics education. We begin with a vignette that contextualizes the motivation for our analytic interest in SBLE. Next, we present the origins of SBLE and its supporting ideologies. Then we analyze[1] how SBLE is used by media aligned with the political far right and its readers in recent attacks on mathematics education researchers and their CMI scholarship. We present an analysis of this thread of discursive backlash at a national scale, as expressed across television, blog posts, and social media. We then shift our analytic focus to examine the role of SBLE ideology in mainstream discourse about education and by mathematics education organizations. Finally, we conclude the paper with an analysis of how certain language is appropriated by others to marginalize or exclude CMI and support SBLE ideology, thereby maintaining the status quo and reifying whiteness.

Vignette

At the end of 2017, the *Journal of Urban Mathematics Education* published a paper by Rubel (one of this paper’s authors) that focused on a set of four equity-directed instructional practices in mathematics.

1 Like Valero (2017), we use a rhizomatic (Deleuze & Guattari, 1987) approach, with its focus on multiplicity and connections. In this spirit, we cite evidence from academic scholarship, as is traditional, but also from popular television and Twitter.

Rubel synthesized those practices using Gutiérrez's (2007) equity framework to delineate dominant dimensions of equity from critical ones. Rubel identified two of the featured equity-directed instructional practices as conforming to the dominant axis in Gutiérrez's (2007) framework: teaching for understanding, a component of standards-based mathematics instruction (National Council of Teachers of Mathematics, 2000); and fostering multidimensional participation, a feature of complex instruction (Cohen & Lotan, 1995). These practices map onto dominant dimensions of equity in mathematics education in that their focus is on access to and achievement in mathematics. Rubel showed how the other two equity-directed practices—connecting mathematics content to students' experiences, an aspect of culturally relevant pedagogy (Ladson-Billings, 1995) and providing opportunities for using mathematics to "read and write the world," a feature of teaching mathematics for social justice (Gutstein, 2006), conform to the critical axis in Gutiérrez's (2007) equity framework because they directly address issues of identity and challenge systems of power. Rubel then presented a case study of three white teachers who teach in hyper-segregated schools in underserved sections of New York City, analyzing their struggles with the two critical equity-directed instructional practices in comparison to their successes with the two dominant ones.

Because of the significance of whiteness in reproducing subordination and widening opportunity gaps in and through mathematics education in the United States (Battey & Leyva, 2016; Martin, 2009a, 2009b, 2012; Stinson, 2006), Rubel affirmed, as part of the paper's framing, that whiteness tacitly positions white people, their experiences, and their behaviors as superior (Battey & Leyva, 2016; Martin, 2009b). Citing Picower (2009), Rubel elaborated on a pair of ideological principles that function as ideological "tools of Whiteness" (Picower, 2009, p. 204). First, Rubel argued, as many others have before, that the rhetoric of meritocracy implies that success results from hard work or talent and is not a function of the myriad of institutional structures that mediate opportunities and distribute rewards according to race and social background (Bowles & Gintis, 2002; McIntosh, 1988). The rhetoric of a meritocracy inversely implies that any *lack* of success results from a *lack* of effort or ability (Martin, 2009b) and is not an outcome of "systemic barriers and institutional structures that prevent opportunity and success" (Milner, 2012, p. 704). A corollary is the valorization of "colorblindness" for teachers and schools, another "tool of Whiteness" (Picower, 2009, p. 204). Colorblindness, or the avoidance or denial of signifying students' races in curriculum, classrooms, and schools, ignores the causes and impact of enduring racial stratification (Martin, 2008).

Possibly notified by search engine alerts programmed to detect phrases related to whiteness, white supremacists found Rubel's message sufficiently threatening to be newsworthy. They twisted its framing and blasted hyperbolic, misleading, and inaccurate headlines such as "Meritocracy Is a Tool of Whiteness" (Cicotta, 2018); "Working Hard in the Classroom Is Now Racist" (Arie, 2018); "Lib Prof Just Said Teachers Who Grade Based On Merit Are 'A Tool Of Whiteness,'" (Reynolds, 2018) or "Merit and Math Are Tools of 'Whiteness." (2018) We share the preceding vignette as a way to contextualize our noticing that as these stories spread across white nationalist news sites, blogs, and social media pages, a recurrent comment surfaced: a calling out of "the soft bigotry of low expectations." As we have come to learn, this phrase is one that is dog-whistled,[2] repeated, and nodded at across national discourse about mathematics education (and in other spheres of social concerns).

A Historical Perspective: Origin of the "Soft Bigotry of Low Expectations"

The phrase "the soft bigotry of low expectations" was coined by President George W. Bush[3] in 2000 in a speech to the NAACP that marked the launching of the No Child Left Behind (NCLB) Act. Bush asserted, "Discrimination is still a reality, even when it takes different forms. Instead of Jim Crow, there's racial redlining and profiling. Instead of separate but equal, there is separate and forgotten" (George W. Bush's Speech to the NAACP, 2000). After promising that his administration would enforce civil rights, Bush announced that he would be confronting "another form of bias: *the soft bigotry of low expectations*…" (George W. Bush's Speech to the NAACP, 2000). He acknowledged that educational achievement gaps fall along socioeconomic and racial lines, but evaded discussing any systemic causes of these gaps. Instead, Bush argued that it is these school achievement gaps that produce discrimination, as if their direction of causality pointed in only one direction. Through this logic, fundamental and underlying systemic inequities are overlooked by a focus that is limited to the outcomes of those inequities. Bush then offered a prelude to his vision for NCLB, as a

> great movement of education reform [that] has begun in this country built on clear principles: to raise the bar of standards, expect every child can learn; to give schools the flexibility to meet those standards; to measure progress and insist upon results; to blow the whistle on failure; to provide parents with options to increase their option, like charters and choice; and also remember the role of education is to leave no child behind. (George W. Bush's Speech to the NAACP, 2000)

The NCLB Act passed in 2001 as federal legislation with broad, bipartisan support and heralded the current era of high-stakes accountability in education. Positioned as a way to identify teachers and schools "in need of improvement," at its core is a vision about standardization of curriculum and assessment that requires districts to disaggregate and report testing data in terms of race and socioeconomic status. The logic of accountability is that educational equity and justice can be achieved by holding school districts accountable in this way, using performance as measured by standardized tests. Effectively, standardized test scores were legislated to be the most significant measure of learning. Differences between racial groups on those tests are viewed as products of ineffective schools or as evidence of low expectations of individual teachers—all forming "soft bigotry." An essential problem with this orientation to education is that it sidesteps any discussion of broader, systemic, structural racism and thereby fails to acknowledge or address the role of white supremacy in US education systems. Beyond its fundamental role in the articulation of NCLB, the term "soft bigotry of low expectations" and its ideology continue to be at the heart of discourse about education and US schooling. We will show how this ideology is used by the

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2 Dog-whistling is the practice of sending a message that takes on a different or additional meaning for a specific subgroup. Just as dogs can hear sounds at frequencies that humans cannot, the targeted subgroup is meant to hear something different in the message than other readers do.

3 Michael Gerson, Bush's head speechwriter, is credited with penning phrases such as "the soft bigotry of low expectations" and "axis of evil." He is also credited as having been highly influential in developing the direction of Bush's policies in addition to their accompanying rhetoric. Gerson described the governance strategy of Bush's administration as an "activist approach," and described the No Child Left Behind initiative as activism focused "on minority education problems" (Baker, 2006).

American political far right and, perhaps surprisingly to some readers, by the political mainstream, as well as by mathematics education organizations. In all cases, as we will demonstrate, SBLE ideology is ultimately used to defend or maintain white supremacy in mathematics education.

SBLE and White Supremacists in the United States

As described above using the example of Rubel's (2017) paper, recent scholarship that challenges the role of white supremacy in mathematics education has, at times, been met with intense backlash from the political far-right media and its white supremacist readership, as well as with violent, misogynistic, racist, anti-Semitic, and homophobic personal attacks on the scholars themselves (Gutiérrez, 2017b, 2018). This accompanying violence attests to the deeply political and controversial debates around mathematics education and to the personal risks inherent in challenging the status quo. Our analysis reveals examples of how white nationalists use accusations of SBLE to defend white supremacy through two central tactics.

Tactic 1: The Racist Pot Uses SBLE to Call the Kettle Black

One way that white supremacists counter critiques of racism is through a tactic known as "blame-shifting." This tactic is a self-defense maneuver in which white supremacists defend themselves against the charge of racism by shifting that charge onto the critique itself. Consider the example of the November 2017 attack on mathematics education scholar and activist Rochelle Gutiérrez. Gutiérrez (2017a) presented two ways in which school mathematics operates in US society as whiteness: (a) when the mathematics created by white people is the only mathematics that is taught in school and (b) when mathematics is used as a way to sort, filter, and judge people (see Gutiérrez, 2017b, 2018 for her analyses of this attack). One strategy used to attempt to delegitimize these arguments was to blame-shift by asserting that Gutiérrez's resistance to white supremacy was itself racist and an example of SBLE. Figure 1 shows a representative example. Gutiérrez's critique was that mathematics operates as whiteness in that only what is seen as European or White mathematics is valued and taught in schools, even though a myriad of cultures produced significant mathematics. Referencing SBLE here implies that Gutiérrez's thesis of mathematics operating as whiteness instead *underestimates* Black students, lowers expectations in mathematics for them, and is an indicator of implicit, "soft" bigotries. Thus, a "reverse" charge of racism is used to redirect Gutiérrez's critique of racism, a blame-shifting process that may represent an effort to distract many social media readers.

Blame-shifting in general is a known manipulative psychological tactic that can evoke defensiveness or even a mistrust of one's own intentions and judgment.[4] Consider the image selected to accompany the charge in Figure 1. In relationship to the text that accompanies it—the explicit deployment of SBLE in the context of a Twitter discussion about mathematics education in the United States—an image of cheerful Africans in ethnic dress, is placed inappropriately. The image at once evokes an array of negative stereotypes about African Americans and distances African Americans as *others* from an American belongingness; along with the accompanying charge of SBLE, the image of Black people who are smiling and cheering casts African Americans as somehow gleeful yet duped. As a rhetorical move, this blame-shifting is a dog whistle to other white supremacists, messaging that functions to stoke collective racial anxiety (Boyce, 2017). This kind of blame-shift maneuver, using accusations of

4 In the psychological literature, this is referred to as "defensive projection" (Newman, Duff, & Baumeister, 1997).

SBLE, is used by white supremacists to stifle any attempts to redress past and current racism by asserting that the plea for justice is racist itself.

Figure 1. Tweet as part of attack on Gutiérrez

In Figure 2, we show a second example of purported SBLE being used to delegitimize resistance to white supremacy in mathematics education by blame-shifting charges of racism, this time directed at Rubel.[5] The tweet's author does not accept Rubel's (widely accepted) critique that the narrative of the United States functioning as a meritocracy is a myth. Instead, its author premises that there is meritocracy in mathematics and a single, agreed-upon way to "do math correctly," as well as that white people achieve greater success in mathematics because they are "inherently intellectually superior." Again, we see here a blame-shifting of the critique of white supremacy ("you believe black people are too stupid to do math correctly" and "this is really disappointing"), concluding in the accusation of SBLE. This inversion not only redirects Rubel's critique but also reinforces the very tenets of white supremacy in mathematics.

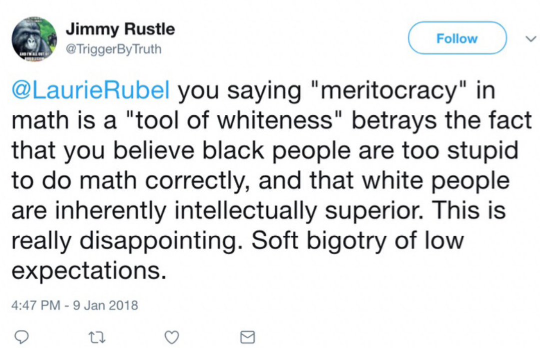


Figure 2. Tweet as part of attack on Rubel

5 As with the tweet in Figure 1, we have excerpted this tweet from a longer stream or thread of a kind of Twitter conversation or exchange. We have no way of knowing whether the tweet's authors in fact align themselves with white supremacy/nationalism or even if these tweets were generated by actual human beings, so we make no claims about the tweet's author. Our analysis in this section is focused on the discursive function of SBLE to further or reinforce white supremacy/nationalism, which does not depend on any kind of assignment of membership, kinship, or association to the tweets' authors.

Tactic 2: Using SBLE to Reinforce Math as Colorblind and Meritocratic

A second way that SBLE is used by white supremacists is to reify one of the ideological "tools of whiteness" (Picower, 2009), namely the claim that the United States functions as a colorblind meritocracy. That view in turn implies that mathematics, as well as systems of mathematics education learning in the United States, are colorblind, neutral, and meritocratic. To demonstrate this tactic, we present **a video segment** that aired on national television as a commentary on Rubel's (2017) journal article.[6] The show's white male host began by presenting another instance of the same blame-shifting tactic, asserting that "to deem achievement-based reward as racist suggests that certain students can't handle academic effort" ("Gutfeld," 2018, 00:52–1:00). The host then pointed blame at "teachers who seek to reduce education to mere identity politic[s] algebra" (1:08–1:13), showing a photograph of Rubel. The panel's two white women responded that "math is math" (1:37) and "math is hard" (1:41), promoting a view of mathematics as colorblind ("math is math") and at the same time attesting to the privilege afforded to it in our society ("math is hard"). The host and panelists are using the "tools of Whiteness" critiqued in Rubel's paper to defend white supremacy.

Next, the second white male panelist continued to defend white supremacy by making the following argument: Societal systems and the distribution of rewards and opportunities in general are clearly just. How else could we explain that Blacks dominate the NBA? The NBA is "mostly Black," he said, "because Blacks are the best players" (2:08–2:17). Instead of considering the array of societal systems that have led to Black preeminence in the NBA, his reasoning that Blacks dominate the NBA because they are naturally better athletes insidiously justifies white dominance in every other arena, including the ownership and management of sports leagues. By analogy, according to the panelist, the people who are at the "top" of mathematics and mathematics education domains are there because they are naturally superior in those areas. Although Rubel's (2017) argument that race plays a significant role in mathematics education was summarily dismissed, the show's host then claimed that short-statured people experience discrimination. This claim is not refuted or ridiculed, effectively further trivializing Rubel's argument. To conclude the television segment, the male panelist of color cautioned against (presumably Black) students being cast as incapable by teachers or schools, a threat he described as "the bigotry of low expectations" (03:52–3:54).

As yet another example, we turn to Figure 3, a screenshot of part of a stream of 865 comments on Breitbart's story in response to their coverage of Rubel's (2017) paper. The discussion demonstrates a prevalent misinterpretation of Rubel's critique of the rhetoric of meritocracy. To these commenters, the notion that there is inequitable access to opportunities to learn mathematics is untenable. Instead, comments such as those by "Mojave_Forks" and "GoodToHateEvil" interpret the charge of inequitable access to mathematics education as a critique of what they view to be a fair and meritocratic opportunity and rewards systems. The affirmation of the rhetoric of meritocracy is then quickly used to justify blame-shifting the charges of racism ("Seems like she's suggesting blacks can't compete based on merit"), expressed, again, as SBLE. The final comment in this stream, by "VetMike," claims that "the Left" uses SBLE to continue to marginalize and oppress Black people, a line of thinking that we examine later.

6 Skepticism about our thesis that white supremacists found this message threatening should consider the question of how many and which mathematics education research articles are covered by Fox News.

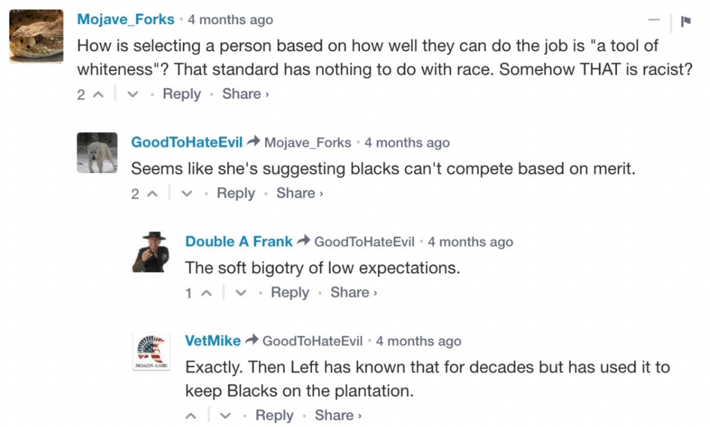


Figure 3. Discussion on Breitbart comment board about Rubel's article

Viewing the processes that lead to achievement in mathematics as meritocratic allows for a reaffirmation and reinscription of the tenets of white supremacy. In the tweets in Figure 3, this leads to the claim that Rubel (2017) is suggesting that we should *lower expectations* of mathematics proficiency for children of color, which is, in the white supremacist/nationalist view, akin to affirmative action in mathematics education. This then leads to rhetoric about whether it would be desirable for society to condone the licensing of doctors or other professionals who have performed poorly in school mathematics. Interestingly, it is occupations that are seen as directly related to public health (rather than the work of teachers or urban planners or even mathematicians) that are put forward as professions that are seen to fundamentally rely on success in mathematics. This argument, of course, presumes that creating more equitable opportunities for children of color to learn mathematics would result in anything but excellence. And, as readers can see through the emblematic examples in Figures 4 and 5, selected from the same Breitbart comment stream, the defense of white supremacy is expressed with aggression, using thinly veiled personal threats of violence.

Figure 4. Tweet by "Oceandiva" on Breitbart

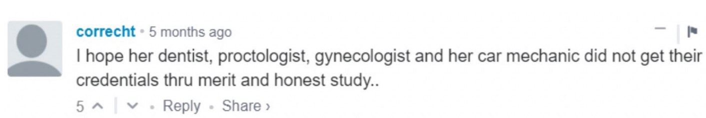


Figure 5. Tweet by "Correcht" on Breitbart

How SBLE Is Used by the Mainstream: Less Overt, Just as Dangerous?

We now turn our attention to the political mainstream[7] in the United States. While references to SBLE are used as a dog-whistle discursive weapon by white nationalists, as demonstrated above, we argue that SBLE ideology also undergirds "education reform" efforts put forward and supported by the mainstream, including those who may identify as "liberal" or "progressive." These efforts propagate a widespread belief about education that centers on standardized testing, accountability, school choice, and the support and growth of charter schools. Although NCLB was introduced by a Republican president, the Democratic party's enthusiastic support of NCLB led to an expansion of its associated policies through both terms of the Obama presidency. NCLB's casting of high-stakes standardized testing and standardization of curriculum as civil rights initiatives has been shown to be deceptive, to narrow conceptions of teaching and learning, and ultimately to reinforce the rhetoric of the United States as a meritocracy. NCLB did not improve test-score gaps; instead, it led to a "curricular and pedagogic squeeze" (Au, 2016, p. 51) that has differentially impacted low-income children of color. Further, NCLB's promotion of a "no-excuses" mentality about learning has led to an overemphasis on compliance and discipline, resulting in an over-policing of students of color, most notably in underserved communities (Battey & Levya, 2016).

NCLB's classifying and sorting processes around accountability initiated upheaval and instability in schools through closures, reopenings, and renamings, instead of seeking or implementing other options for supporting struggling schools (Lipman, 2012). Parents are accorded "school-choice" to opt out of so-called low-performing schools, under the neoliberal logic that market forces will pressure struggling schools to improve and, at the same time, create additional school options for families. However, few families actually take advantage of these choices (Vernez, 2009), perhaps because the market model ignores the fact that schools are rooted in neighborhoods and communities.

President Obama and his education secretary, Arne Duncan, continued the NCLB trajectory for US schools by introducing the Race to the Top initiative in 2009. Race to the Top incentivized the use of student scores on standardized tests as part of evaluating teacher and principal effectiveness. This practice was part of Secretary Duncan's commitment to "data-driven education reform," an approach to education that involves firing large numbers of teachers, closing schools, expanding charter schools, and promoting school choice. And finally, the widespread and pervasive concern with "gap gazing" (Gutiérrez, 2008), mandated by NCLB, has been widely taken up in educational research and policies with its logic rarely questioned, thereby constricting visions of teaching and of learning as well as imaginings of educational justice. Just as the ideology, laws, and policies of the mainstream Left have contributed significantly to mass incarceration of Black people (Murakawa, 2014), we posit that the ideology, laws, and policies of the mainstream (including the Left) around education, although expressed as intending to *improve* racial justice, have expanded and further entrenched inequities in education. The ideology of SBLE has been fundamental to the appeal of NCLB to politicians and voters from *both* sides of the political aisle and has remained fundamental to the ensuing and ongoing movement of "education reform."

7 By "mainstream" we are referring to neighbors, colleagues, programs, and organizations who would likely distance themselves from the types of beliefs espoused by white nationalists/supremacists. Individuals in the mainstream might identify as "politically left," "liberal," "progressive," or even "fiscally conservative" and would find the hateful rhetoric in the alt-right Twitterverse to be racist and highly objectionable.

Even Closer to Home: SBLE Ideology Within Mathematics Education

Here we draw heavily on the work of our colleagues, especially Rochelle Gutiérrez and Danny Martin, trailblazers in theorizing about and documenting systemic inequities in US mathematics education. Gutiérrez and Martin have called for professional mathematics education organizations, like the National Council of Teachers of Mathematics (NCTM) to acknowledge their participation in maintaining an inequitable status quo (Gutiérrez, 2017a; Martin, 2015, 2018; McCloskey, Lawler, & Chao, 2017). One way that NCTM has been complicit in using and propagating the ideology of SBLE is through rhetoric that confines determination of success in mathematics to individuals, teachers, or schools. Prominent across documents from NCTM's *Principles and Standards* (2000), as well as their more current *Principles to Actions* (2014), is rhetoric that emphasizes individual students and their teachers with a focus on productive beliefs, high expectations, and effort.[8] Such rhetoric has largely ignored systemic inequities and injustices in education in general and, in mathematics education in particular (Emdin, 2018). We interpret this positioning of the path toward equity in mathematics education as one that relies mainly on raising teachers' expectations for students of color, implicitly nodding once again toward SBLE.

Ignoring systemic injustices and inequitable learning opportunities while focusing only on individual teachers' expectations or on student psychology (for example, by fostering attributes like growth mindset, or grit) reifies the ideology of a color blind, politically neutral, and meritocratic system of mathematics education (Gutiérrez, 2017a; Ladson-Billings, 2017; Zavala & Hand, 2017). This was the heart of Martin's (2015) critique of *Principles to Actions:* that despite the repeated calls for equity contained within the document, it continually asserts that the primary obstacles to equity are the "unproductive beliefs" (National Council of Teachers of Mathematics, 2014) held by stakeholders, such as teachers, students, or administrators. In *Principles to Actions*, NCTM continued the trend of placing the "blame" for and the "solution" to inequities within individual people's sphere of influence without sufficient acknowledgement of systematic, historic, and institutional patterns of oppression. Such denials converge with the same set of ideologies that support white supremacy and protect and promote the use of accusations of SBLE against advocates of CMI.

SBLE and the Mathematics Education Research Community

Our final group of interest here is the mathematics education research community. In our own experience, both as researchers and as providers of professional development for and with teachers around CMI, we have often faced the pointed question, "Where is the math?" When posed by parents, teachers, or principals, this question is usually part of a concern that classroom CMI learning goals are not focused enough on mathematics. When posed by journal reviewers or editors, the "Where's the math?" question

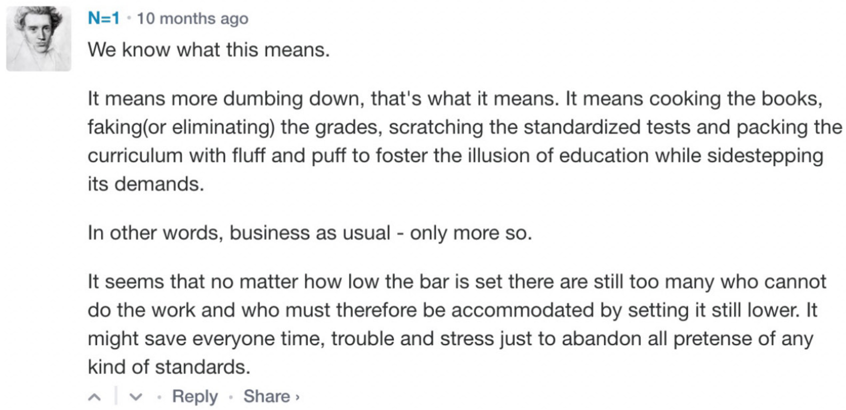
8 Here we follow Martin's (2015) "more critical look at NCTM's equity-oriented message and politics" (p. 19). Martin observed that NCTM has been calling for equity in mathematics teaching for many years, but that in *Principles to Actions*, as in others of its documents and statements, NCTM framed its vision of "Mathematics for All," in part, in terms of "beliefs and expectations" (National Council of Teachers of Mathematics, 2014). In this particular framing of the problem of inequity, the beliefs of individual people (teachers, students, etc.) are at once the cause of and a solution to racism. At the same time, in *Principles to Actions* NCTM did not acknowledge the systemic and historic nature of persistent inequities in conditions and outcomes, nor the role that "neutral" fields, like mathematics, or "well-meaning" institutions, such as NCTM, have played in perpetuating these inequities.

is usually part of a critique or rejection of a study that claims to investigate mathematics learning but seemingly without enough specificity or attention to the discipline of mathematics. In general, the "Where is the math?" critique is usually used to signal either that mathematics is not foregrounded enough among social phenomena or that the mathematics is not rigorous enough. "Doing mathematics" and "doing critical inquiry" are sometimes positioned as a zero-sum pair because it is argued that when trying to do both, one must either overly simplify the social phenomenon or trivialize the mathematics (Dowling & Burke, 2012).

We agree with the commitment to the position that mathematics should remain central in mathematics education research (Harel, 2010). However, we also take seriously the ideas of Pais and Valero (2012), who cast doubt on the often unquestioned premise that rectification of a social injustice will occur solely through the application of better or more mathematics and who suggest that we instead consider how the (mis)use of mathematics often *exacerbates* injustices. We identify at least two problems with the "Where's the math?" query. First, the article "the" in that question reinscribes the fallacious notion that there is a single mathematics when, in actuality, every culture has produced and continues to produce mathematics; even "school mathematics" is its own particular type of mathematics that is distinct from the academic mathematics practiced by professional mathematics (Bishop, 1988; Gutiérrez, 2017a). Second, implicit in the "Where's the math?" question is an over-privileging of mathematics-related concerns about students' material and social selves, even in the context of a scholarly focus on mathematics learning environments or as part of working in mathematics classes toward achieving equity and social justice.

The reflexive questioning from within our mathematics education research community of "Where's the math?" is connected to SBLE and its ideologies in how the question is readily recruited and then mis-appropriated by other groups in service of their arguments for marginalizing critical inquiry in mathematics education. Consider the example presented in Figure 6, a tweet on Breitbart in response to the white nationalist coverage of Rubel's (2017) article on equity-directed instructional practices. The tweet's author warns that equity perspectives about mathematics education imply a watering or "dumbing down … to foster the illusion of an education while sidestepping its demands." In other words, critiquing and trying to redress unjust educational systems around mathematics education are positioned as equivalent to a "dumbing down" of mathematics. Similarly, in Figure 7, we see "Alyzza" posing the question, "What … kind of math is that?! How about this: 1+1=2," another often repeated attack across these comment streams. The "Where's the math?" or in this case, "What kind of math is that?" question expresses the belief that the recommendation of engaging in CMI implies that there is some kind of other (presumably incorrect) mathematical logic.[9]

9 The idea that one plus one is two is a tautology is challenged by Fasheh (1982), who aptly points out that "one equals one" might be a mathematical fact, but that its "description and interpretation and application differ from one situation to another and from one culture to another. A fresh and delicious apple is not equal to a rotten apple. . . . One dollar in 1970 is not equal to one dollar in 1980. And so on. Strictly speaking, then, 'one equals one' does not have true instances or applications in the real world" (p. 5).


N=1 · 10 months ago

We know what this means.

It means more dumbing down, that's what it means. It means cooking the books, faking(or eliminating) the grades, scratching the standardized tests and packing the curriculum with fluff and puff to foster the illusion of education while sidestepping its demands.

In other words, business as usual - only more so.

It seems that no matter how low the bar is set there are still too many who cannot do the work and who must therefore be accommodated by setting it still lower. It might save everyone time, trouble and stress just to abandon all pretense of any kind of standards.

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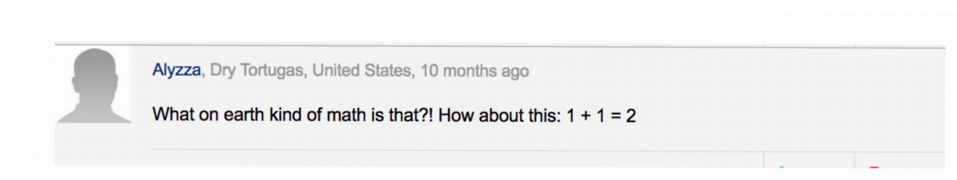
Figure 6. Comment by "N=1" on Breitbart


Alyzza, Dry Tortugas, United States, 10 months ago

What on earth kind of math is that?! How about this: 1 + 1 = 2

Figure 6. Comment by "Alyzza" on Daily Mail

Conclusion

In current US education rhetoric and practice, neoliberal values and corresponding mechanisms, such as those listed above—accountability, school choice, and standardization—are viewed as the appropriate and exclusive means to improve and measure public schooling, and even to frame discussions of it. Furthermore, as race scholar DiAngelo has described, the neoliberal legacy in Enlightenment thought has sustained the pillars of individualism, independence, and self-determinism that are the hallmarks of the US origin story (General Commission on Religion and Race of the UMC, 2017). The Enlightenment's hyperrationality and ahistoricity are still with us when we find ourselves trapped in the binary thinking that has characterized much discourse about mathematics teaching and learning and that has served to limit all of our students. Accordingly, "skills" and "understanding" have been framed as polar opposites (or at least as conflicting values), as have other pairs of terms, such as "concepts" and "procedures," and—relevant to those of us who have tried to speak and work for CMI—"rigor" and "equity" (Blintz & Moore, 2011). As we have shown in this article, any time we make reference to the historical, cultural, and political conditions that shape *all* of our conditions and expectations, we are vulnerable to inquiries from members of our own mathematics education research community, who ask, "Where's the math?"; to cautions from mainstream mathematics education organizations that we are sacrificing mathematical "rigor"; or to accusations from all sides that we are perpetuating the "soft bigotry of low expectations."

At a basic level, we believe that our analysis of the origins, underlying ideology, and various current uses of the concept of SBLE—whether they are expressed in word, belief, or practice—should serve to contextualize its meanings and diffuse its potency in instances of future attacks on mathematics educators. More broadly, we believe that this analysis further specifies how concepts like SBLE are seeded and then recruited in various ways and serve to maintain the status quo of white supremacy in and through mathematics education. We hope that bringing our analysis into mainstream discourse about education, into the discourse of mathematics education organizations, and into the mathematics education research community extends the understanding that SBLE rhetoric and ideology are not limited to those who brazenly align with white supremacy and white nationalism. While we agree with Audre Lorde (1983) that "The master's tools will never dismantle the master's house," it is necessary to take an honest look at the bricks used to construct that house and on whose backs the house is built.

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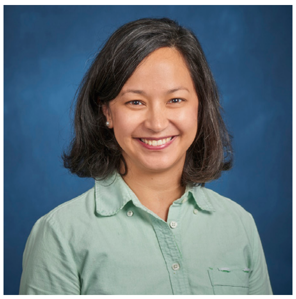

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