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Mathematics education as sociopolitical: prospective teachers' views of the What, Who, and How

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Abstract In this article, I introduce a framework—the What, Who, and How of mathematics—that emerged from studying my teaching of prospective teachers and their views of the social and political dimensions of mathematics teaching and learning. The What, Who, How framework asks us to consider What messages we send about mathematics and the world, Whose perspectives are represented in mathematics, and How mathematical concepts and our world are related. I situate each aspect of the framework in the literature on social justice and critical mathematics and provide examples of prospective teachers' views. The What, Who, How serves as a tool to understand prospective teachers' views, to navigate a broad range of literature on social justice mathematics, and a means of informing the practice of teachers and teacher educators.

Keywords Mathematics teacher education · Social justice · Equity · Diversity · Teacher beliefs

Introduction

Discussions of teaching mathematics for social justice or critical mathematics education include consideration of a broad range of perspectives, such as connecting mathematics to students' homes, communities, and/or cultural identity (Civil and Andrade 2002; González et al. 2001; Leonard 2008); emphasizing the cultural nature of mathematics and the mathematical accomplishments of people throughout the world and history (Joseph 2010; Powell and Frankenstein 1997); the formatting power of mathematics (Skovsmose 1994b); the role of mathematics curriculum in sending hidden messages about social constructs

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such as race (Martin 2006, 2007; Tate 1994), gender (Harris 1997), class (Walkerdine 1990), and other markers of difference; and the use of mathematics for developing awareness of, critiquing, and working to change injustices in our society (Frankenstein 1995, 1997; Gutstein 2006; Skovsmose 1994b). These varying perspectives are often reflected by differing interpretations and enactments of teaching (mathematics) for social justice (Bartell 2012, 2013; Gates and Zevenbergen 2009; Stinson and Wager 2012).

There is a growing body of work focused on engaging prospective teachers (PTs) in learning to enact various aspects of social justice mathematics. A common theme in the research is that most PTs have minimal experiences with these forms of mathematics, including connecting mathematics to students' backgrounds (Ensign 2005; Turner et al. 2012a) and investigating real-world issues (Felton and Koestler 2012, 2015; Felton 2010b; Koestler 2012; Spielman 2009). While incorporating social justice perspectives into mathematics teacher education courses is often met with some resistance (Aguirre 2009; Ensign 2005; Felton et al. 2012; Rodriquez 2005), it also frequently leads to greater acceptance of these perspectives and/or a deeper appreciation of mathematics (Ensign 2005; Felton and Koestler 2012, 2015; Felton et al. 2012; Mistele and Spielman 2009). Finally, teacher educators have reflected on the challenges involved in making connections across mathematical concepts, community knowledge, and issues of social justice for both PTs (Turner et al. 2012b) and teacher educators (Felton et al. 2012).

Other research has focused on PTs' views of social justice mathematics and how these views develop in response to coursework (Bartell 2012; Ensign 2005; Felton and Koestler 2012; Felton et al. 2012; Felton 2010b; Turner et al. 2012a). I expand on this work by reporting the results from my ongoing practitioner inquiry on my teaching of mathematics content courses for PTs. My research focuses on PTs' views of social justice in K-12 mathematics. In this article, I introduce a framework—the *What*, *Who*, and *How* (WWH) of mathematics—that initially emerged from my research as a means of understanding the PTs' views and my own instruction. This framework extends the field in two key ways. First, the WWH serves as a tool for studying and understanding the complexities of PTs' views, including the interrelationships between different beliefs they hold. Second, by posing a series of questions about the nature of school mathematics, the WWH can serve as a valuable tool for reflecting on and informing the teaching of mathematics.

Framework and theoretical perspectives

The WWH focuses on the relationship between the content of school mathematics and "the world." Clearly school mathematics is an important part of learners' worlds—it will influence their future educational and professional opportunities, for one. Thus, my use of "real world" (or "the world") is meant to draw attention to the broader sociopolitical world in which school mathematics is situated. With the WWH I ask a series of questions:

- *What* (often unstated) messages does mathematics teaching send about…
  - other important social constructs such as race, gender, class, culture, and other markers of difference (the *coconstructed* nature of school mathematics)?
  - the role of mathematics in understanding, analyzing, and critiquing our world (the role of *social analysis* in school mathematics)?
- *Who*se perspectives should be represented in school mathematics and how does this relate to learners?

- *How* should mathematical *concepts* and the real *world* be related in school mathematics?

These questions are intentionally broad as they can be used to focus one's attention in a variety of research and instructional settings. However, in this article I specifically examine PTs' views regarding each question. Figure 1 shows the narrower version of each question explored in this article.

Studying teachers' beliefs is problematic for a number of reasons: (1) "beliefs" remain ill-defined in the literature (Philipp 2007; Skott 2013), (2) they are difficult to access, and (3) they are often framed as relatively stable in a way that fails to account for the social process of how mathematics is enacted (Skott 2013). Thus, what I have captured are PTs' espoused views in a particular context—their written responses to readings and reflection prompts that I have selected. While this is limiting in some ways, it is relevant to this work for several reasons. First, this work was conducted with PTs in mathematics content courses before they were enacting mathematics in classroom settings. Second, supporting PTs in unpacking their views about teaching is a key component to developing reflective practitioners (Felton and Koestler 2012, 2015; Richert 1992; Zeichner and Liston 1996). Third, this framework is intended not as a definitive accounting of PTs' views, but instead as a stepping off point for further research that examines both PTs' views in greater detail and the kinds of practices teachers engage in when teaching mathematics (Skott 2013).

General Question	Specific Question for this Study
What messages do we send about…	
…the *coconstructed* nature of school mathematics?	Do PTs endorse or resist the idea that mathematics is *coconstructed* with other important social constructs such as race/ethnicity, gender, socioeconomic status, and other markers of difference?
…the role of *social analysis* in school mathematics?	Do PTs support real-world connections, and if so what kinds of real-world connections do they advocate?
Whose perspectives are represented in school mathematics and how does this relate to learners?	Do PTs endorse or resist the idea that people may experience mathematics differently in light of their identity, including their personal interests and their broader forms of identity such as their race/ethnicity, gender, culture, socioeconomic status, and other markers of difference?
How should mathematical concepts and the real *world* be related in school mathematics?	What do PTs think the relationship should be between the *world* and mathematical *concepts* in teaching school mathematics? In particular, how much do they think each should drive instruction?

Fig. 1 What, Who, How framework operationalized for studying PTs' views

Methods

In this section, I describe my research on my own practice as a mathematics teacher educator (Anderson et al. 2007), focusing on my role in this research, the context of this work, and on my methods of data analysis.

My positionality

There are a number of reasons we might include mathematics in the school curriculum (Felton 2014). Policy documents [e.g., Common Core State Standards Initiative (CCSSI), 2010; National Council of Teachers of Mathematics (NCTM), 2014] often emphasize learning mathematics for its own sake and for career and college preparation. However, school mathematics can support students in learning about diversity; seeing the role of mathematics in their family and community practices; and questioning, critiquing, and taking action around important social and political issues in our world. While there is some evidence that this can lead to deep learning of mathematics (Civil and Kahn 2001; Gutstein 2006; Turner et al. 2009; Turner 2012), Brantlinger (2013) has also highlighted potential trade-offs between focusing on issues of equity, diversity, and social justice and learning what is referred to as classical (Gutstein 2006), academic (Brantlinger 2013), or dominant (Gutiérrez 2007a) mathematics. Ultimately, the question of whether and how to include issues of equity, diversity, and social justice in school mathematics will always largely be a question of values—a question about the purpose of school mathematics.

It is my position that learning about diversity, seeing the role of mathematics in one's community practices, and learning to question and critique one's world should be central to all of K-16+ education and should permeate all subjects. Therefore, as a mathematics teacher educator I am committed to integrating these perspectives into my courses. First, to provide my students (prospective teachers) with opportunities to experience these forms of mathematics, and second because, *as future teachers*, I want my PTs to be prepared to integrate these perspectives into their own teaching if they so choose. To me this involves providing them with opportunities to (a) experience these forms of mathematics as learners; (b) consider what this might look like in their future practice; and (c) reflect on their own views about school mathematics so they, as professionals, can make an informed decision about the form(s) of mathematics they will implement in their practice.

While I rarely explicitly state my political views in my courses, I have no doubt that my strong support of social justice perspectives is clear to my PTs through the tasks I assign and the probing questions I ask. However, I also position my PTs as professionals who must make up their own minds about the kinds of mathematics they want to enact in their classrooms. I take the fact that a number of PTs raise concerns about or reject the perspectives we explore as evidence that I have been at least partially successful in cultivating a learning environment where it is safe to disagree.

I identify as, and to the best of my knowledge am viewed by my PTs as, a white male. This is a position of privilege in general, and especially with regard to discussing potentially controversial topics such as "social justice" or "race." While I have had a small number of PTs accuse of me of pushing my own agenda, this is a rarity that occurs about as often as PTs expressing concerns that I am pushing a problem-solving agenda. I believe that because I occupy a privileged position within our society I am often protected from being viewed as on a personal crusade or being "biased" as some of my non-white colleagues have experienced.

Context

Setting

This work took place at two research-intensive universities. The first semester of this work occurred at a large, research-intensive university in the Midwest. The university is in a progressive city in a purple state with a history of progressive politics. This is where the framework was initially developed. The rest of the work occurred at the University of Arizona in Tucson, AZ. Tucson is a relatively progressive enclave within a conservative state. Arizona has dealt with a number of controversial issues, including strong anti-immigrant legislation and pressure from the state superintendent that resulted in canceling a successful and well-regarded Mexican–American Studies program in the Tucson school district. Some of the themes I ask my PTs to explore are specific to this context, but most of them deal with broader issues in the USA and in some cases the world. For instance, localized to the USA I often highlight differences in educational opportunities (Felton 2012; Flores 2007), income inequality (Felton et al. 2012), and rates of childhood poverty. More globally, we may explore the mathematics of different peoples (Perkins and Flores 2002; Zaslavsky 2001), differences in world maps (Frankenstein 1998; Gutstein 2005a), and refugee populations. While this work occurs in the USA, learning about the sociopolitical nature of school mathematics can be adapted to other contexts.

Participants

I have struggled with whether and how to discuss the demographic characteristics of the PTs I work with. It is important to understand how identity interacts with one's views. However, because this article introduces a framework that covers a range of views, it is beyond the scope of this article to investigate this interaction for each PT. In addition, while it is problematic to ignore the PTs' identities, I believe it is *more* problematic to share brief demographic information (e.g., race, gender) as a stand in for a careful consideration of their identity as this may reinforce these categories as static and deterministic (D'Ambrosio et al. 2013). Therefore, I have opted to share general demographic characteristics for my courses as a whole, but to not include this information for individual PTs. For the PTs I collected demographic data from ($n = 55$), the vast majority identify as White and non-Hispanic (76 %),[1] female (85 %),[2] are between 18 and 21 years of age (95 %), and have at least one parent/guardian with a bachelor's degree or higher (75 %).[3] The demographics of the PTs across the two institutions are quite similar.

My courses

Across both institutions, the mathematics courses I have taught are generally taken before the PTs begin the teacher education program and are for undergraduate PTs working toward a degree in elementary, early childhood, or special education. I approach these courses with two overarching goals. First, I work to strengthen the PTs' mathematics

[1] 2 % identify as White, Hispanic, 2 % as Black, 4 % as Asian, 2 % as American Indian, 11 % as other or multiple races, and 4 % did not respond; 7 % identify as Hispanic, across all races.

[2] The rest identified as male; none indicated another gender identity.

[3] 100 % have at least one parent/guardian with a high school degree or higher, and 45 % have at least one parent/guardian with a master's degree or higher.

knowledge for teaching (Ball et al. 2005, 2008). Second, I support the PTs in exploring the sociopolitical aspects of mathematics education as outlined by the WWH framework.

My courses include in-class lessons, homework assignments, a semester project (most semesters), and reflection assignments. The in-class lessons and homework assignments focus on mathematics knowledge for teaching, but also incorporate some connections to the sociopolitical aspects of mathematics. For the projects, the PTs are asked to connect mathematics to a sociopolitical issue or to explore the mathematics of a cultural group (Felton-Koestler forthcoming).

For in-class lessons, I take a problem-solving approach with a particular emphasis on exploring multiple strategies and child-invented strategies, which is unfamiliar to many of the prospective teachers. We generally begin with one or more mathematics problems that might come up in the classroom and consider nonstandard approaches to these problems (either generated by the prospective teachers or by examining examples of children's work). Much of this work focuses on mathematical knowledge for teaching, such as understanding the conceptual basis for a range of strategies for computing with multidigit numbers or fractions, or using multiple units to measure length and area before exploring why standard formulas (such as *length* × *width* for the area of a rectangle) make sense. However, some of these lessons also include connections to sociopolitical issues, such as developing strategies for measuring irregular areas in the context of measuring the amount of land American Indians have lost in the continental USA (adapted from Gutstein 2005a). Homework assignments are generally designed to reinforce and extend material learned in class, with a continued emphasis on reasoning and explanations (as opposed to computation). Taking a problem-solving approach to mathematics is one approach to broadening the prospective teachers' views about what mathematics is and can be (Felton and Koestler 2012). Based on my experiences with prospective and practicing teachers, opening up mathematics to problem-solving and multiple strategies can alter their views of mathematics as rigid and absolute and thus sometimes provides a foundation for considering the social and political dimensions of mathematics as well.

The reflection assignments provide the most sustained focus on the sociopolitical aspects of school mathematics. The following quote from a recent syllabus shows how I introduce the assignments to the PTs:

> Part of your job as a teacher is to continually reflect on your own teaching. As a teacher you will be responsible for creating a particular form of mathematics in your classroom. The reflection assignments provide you with an opportunity to reflect on what that mathematics will look like. Specifically, you will reflect on what mathematics is, what it means to do mathematics, the role of the teaching and learning [of] mathematics in our society, and the social and political nature of mathematics.

For the first reflection assignment, the PTs reflect on what it means to do mathematics; this provides a baseline for their thinking about school mathematics. On the second reflection, the PTs respond to the NCTM's five process standards (NCTM 2000, pp. 52–71) and more recently to the Standards for Mathematical Practice (CCSSI 2010, pp. 6–8). Following this, the PTs complete three to five reflections in which they respond to articles that discuss various aspects of the sociopolitical nature of school mathematics. In the final reflection, the PTs reflect back on their learning in the course.

Analysis

The data sources for this article are the PTs' responses to the homework and reflection assignments. The original development of the framework occurred following my first semester of researching my teaching of these courses. Analysis of the reflection assignments oscillated between (a) open coding a subset of the data with a focus on my two overarching course goals, (b) memoing and axial coding, in which I refined, consolidated, and operationalized codes, and considered the relationships between them, and (c) recoding the data (Strauss and Corbin 1998). While this approach to grounded theory focuses on identifying themes in the data, it acknowledges the researcher's knowledge of existing literature and its importance "as an analytic tool" (p. 47). The framework was completed when revisiting the data no longer required revisions to the framework (for additional detail, see Felton 2010b). The development of this framework has continued to inform my practice. One example is illustrated below when I discuss the How, and my attempts to better support PTs in exploring their views about this aspect of school mathematics.

Framework and results

In this section, I unpack the WWH framework by first situating each aspect of the framework in existing literature and then providing illustrative examples from the PTs' work.

The What of mathematics

In this section, I consider the PTs' responses to the idea that mathematics teaching sends (often unstated) messages about (1) how mathematics is *coconstructed* with other important social constructs such as race, gender, class, culture, and other markers of difference; and (2) the role of mathematics in engaging in *social analysis*—using mathematics to understand our world.

Mathematics as coconstructed

Hidden or unstated messages that permeate school mathematics cause conceptions of (school) "mathematics" to be coconstructed with other socially significant constructs such as race, gender, and class. Consider, for instance, the following story problem: "In a class of 40 students, 25 are boys. Express the number of girls as a fraction of the class" (Singapore Ministry of Education 2003, p. 64). This problem *relies on* the commonly held view within the USA that there are exactly two genders—boys and girls; in doing so, this problem also *reinforces* the gender binary as normative, thus reflecting what Esmonde (2011) calls *genderism.*

Harris (1997) examines the intersection of mathematics, gender, and class, by considering how practical work and traditional women's work are often ignored as sites for mathematical investigation, thus contributing to the construction of mathematics as theoretical and male while simultaneously constructing practical work and women's work as non-mathematical. Harris's attention to practical versus theoretical knowledge is echoed in Joesph's (1997, 2010) critiques of Eurocentric accounts of the history of mathematics. Joseph (1997) argues that many mathematical historians have ignored important contributions by non-European groups, often dismissing them as practical and lacking rigorous methods of proof found in Greek mathematics. This telling of history constructs a particular vision of "real" mathematics as corresponding to European (especially Greek) modes of thought.

The role of Eurocentrism in mathematics has been well explored (Powell and Frankenstein 1997), and in addition to constructing mathematics as European, it also serves to "whiten" mathematics by denying the contributions of non-Europeans and by whitening other important contributors such as the Egyptians (Felton 2010b). Joseph (2010, citing Katz and Lumpkin 1995) points out that a number of Greek mathematicians studied in Egypt and claim the Egyptians invented geometry. Further, he emphasizes that "it is important that the African roots of the Egyptian civilization be emphasized so as to counter the still deeply entrenched view that the ancient Egyptians were racially, linguistically, and even geographically separated from Africa" (Joseph 2010, p. 79). Throughout Joseph's accounts, we can see how contributions of peoples across the globe have been ignored or minimized in many histories of mathematics. More generally, a number of other authors have considered the importance of ethnomathematics and examining the accomplishments of peoples around the world (Mukhopadhyay et al. 2009; Powell and Frankenstein 1997; Zaslavsky 2001). The lack of attention to non-European mathematical contributions and the common ahistorical treatment of school mathematics can lead learners to view (school) mathematics as European, or in other cases as culturally neutral (Joseph 1997).

Exploring the relationship between race, class, and school mathematics, Tate (1994) argues "that the default position of mathematics curriculum, assessment, and pedagogy is often more closely aligned with the idealized experience of the white middle class" (p. 480). He provides an example of a district test item that involved determining whether it was cheaper to buy a weekly bus pass or pay the daily fare to go to work each day. As a test item created with a single correct answer, this question problematically required assuming the rider worked a single job 5 days a week, which did not match the lived experiences of a number of African American students in the district. Tate argues that this and other examples show how school mathematics relies on idealized White middle-class perspectives, and reinforces these perspectives as normative by treating them as taken for granted.

In similar work, Martin documents the *racialized* nature of mathematics learning in school, finding that "many African American parents situate their struggle for mathematics literacy within race-based frameworks that they believe characterize their lives and their children's lives, as both African Americans and learners of mathematics" (Martin 2006, p. 208). He provides examples of African Americans receiving the message that mathematics is not for them (Martin 2006) as well as cases where African American identity strengthened learners' commitment to mathematical learning (Martin 2007). Similar reasoning applies to the coconstruction of other racial groups within the field of mathematics education, which often constructs White and Asian students as the norm against which other groups should be compared, fails to consider the vast overlap between groups and variation within groups, and does little to illuminate the underlying inequities that lead to differences in educational outcomes (Flores 2007; Gutiérrez 2008; Martin 2009; Secada 1989).

Lubienski (2002) highlights two themes in considering differences between low- and high-socioeconomic status (SES) students' responses to *Standards*-based (NCTM 2000) instruction. First, the higher-SES students expressed greater confidence, while the lower-SES students "said they were unsure of what they were supposed to be learning" (p. 116). Second, the lower-SES students tended to focus on the real-world context in a way that obscured the overarching mathematical ideas that she intended as the focus of many of her lessons. Lubienski's research provides an example of how in her classroom a *Standards*-based approach served to construct mathematics as reflecting the "beliefs and discursive skills" (p. 117) of higher-SES students. In light of the importance of school mathematics in one's future education and career, I would argue that this also serves to construct the "beliefs and discursive skills" of higher-SES students as normative, while simultaneously devaluing the perspectives of lower-SES students.

Walkerdine (1990) focuses on wealth by contrasting examples of children and their parents discussing purchases, such as comparing the cost of a soda versus a cup of tea. For some, these items are easily affordable, allowing the calculations to be treated as a hypothetical exercise, while for others the differences in price matter, leading her to question, "what is the relationship between the classic concrete/abstract distinction and the one between a life in which it is materially necessary to calculate for survival and a life in which calculation can become a relatively theoretical exercise?" (p. 52). Building on this, she critiques a shopping trip game for students in which the children were given ten pence and had to select an item and show, on paper, the calculation for what their change would be. This differs from actual shopping because the prices were unrealistic, the students received a new ten pence for each new item, and the product of interest was the written calculation. Thus, Walkerdine concludes that "this move is not best described as a shift from concrete to abstract but as a move from one discursive practice to another" (p. 54). Therefore, as with Lubienski's (2002) case, the practices of school mathematics may reinforce some perspectives—in this case the "abstract" games of making change as a basis for mathematical activity—as normative while devaluing other more "practical" forms of mathematical activity.

In the examples above, school mathematics and a social construct(s) are mutually coconstructed in ways that reinforce status quo power arrangements in society—such as positioning Whites and Asians at the top of a mathematical hierarchy or reinforcing the gender binary. However, we can also reimagine school mathematics in ways that challenge the status quo. An explicit focus on ethnomathematics can emphasize how all peoples invent and use important mathematics (D'Ambrosio 2001; Zaslavsky 2001). In other cases, teachers and learners can unpack and question the hidden assumptions imbedded in their mathematical experiences (e.g., Apple 2000). Finally, making connections to students' homes and communities can reinforce the idea that all students have something to contribute to school mathematics (Civil and Andrade 2002; Civil 2007; González et al. 2001; Greer et al. 2009; Leonard 2008; Moses and Cobb 2001).

PTs' views of coconstruction

Next, I illustrate how PTs respond to these perspectives by first considering cases in which they agree with the coconstructed nature of mathematics. Below, a PT considers how her experience with mathematics did not connect to her racial/ethnic identity and recalls a past encounter between a teacher and a student through the lens of race.

> I didn't feel like my teachers attempted to connect my world as a Hispanic girl to math, or didn't encourage and even didn't allow a African American girl in my class to try a harder home work worksheet.

This aligns with the race-based lens discussed by Martin (2006, 2007). Below, a PT considers how problem contexts can reflect a family structure that may differ substantially from many students' experiences.

> Many times, I think people overlook how the framing of questions can send messages about "normality" and social acceptability…. Kids from single parent homes constantly hearing problems that refer to "Mom and Dad." Or what about kids that have "Mom and Mom" or "Dad and Dad"? Should kids from single parent families or those with same-sex parents be made to feel conspicuous or somehow abnormal?

Now I consider three examples in which PTs express some level of resistance to mathematics as coconstructed. In the quote below, a PT responds to three articles focused on connecting mathematics to cultural groups and practices (Powell and Temple 2001; Stevens et al. 2001; Zaslavsky 2001).

> I think that it is important to incorporate other cultures into the learning of students but I think that it should not get into the way of learning the material…. I think using these ways to learn should be a secondary source and not the primary one because after all the point is to learn the math…. Overall, I agree with the authors as long as connecting this math with other cultures does not get in the way of learning the actual math.

This reflects the idea that "the actual math" exists as a decontextualized entity separate from the social, cultural, and historical context in which it was created and is currently used.

Next, a PT responds to two articles about the relationship between gender and mathematics (Harris 1997; Vedantam 2011).

> I just don't think it is really important to address these issues today. I don't think these issues are present anymore and I don't think any subject should be gender specific. Both genders have equal opportunity to study and do whatever they want.

The PT essentially argues that we as a society have moved past issues of gender inequity, contradicting the article by Vedantam, which discusses the gender imbalance in mathematics related fields. A similar perspective regarding race can be seen in another PT's response to Tate's (1994) article on race and mathematics.

> To me, I feel as though this article is somewhat outdated because of the recent events that have rocked our country's political scene [President Obama's 2008 election]. I feel as though race is still an issue, but not as much as compared to the past. For such a large country of mostly whites to select a minority to the highest office of government really shows the steps we have taken, as Americans, to overcome this issue of race. Growing up through a mostly rural education system, we didn't necessary have to deal with the "race card." In my graduating class there were maybe only one or two African Americans, so race in the school setting is something that I really cannot connect to. So for me, Tate's definition of math truly has no meaning to me.

Here again, the PT believes that we have largely moved past issues of inequity and thus no longer need to attend to their role in mathematics. Moreover, this PT also argues that "race in the school setting is something that I really cannot connect to" because his school was predominantly white, reflecting the idea that "whiteness" is not a race (Mcintosh 1990) and therefore the issues Tate raises do not apply. These quotes about gender and race reveal how PTs' views of mathematics as coconstructed are interwoven with their views of race and gender more broadly.

Mathematics and social analysis

Koestler (2012) argues that:

> The topics teachers include (or do not include), the activities they ask students to do, and the forms of participation they demand—these all send messages to students about what is important, valid, and valued in mathematics and in school…. With respect to the ways in which teachers present the role of mathematics in the world, they can emphasize oft-used contexts in elementary school such as apples, puppy dogs, and ice cream, or they can include problems that use mathematics to understand and analyze pressing issues such as environmental issues or democratic participation. (p. 84)

Following Koestler's (2012) argument, I focus on the PTs' views about the relationship between mathematics and understanding our world. There are a number of examples of engaging students and prospective and practicing teachers in using mathematics as a tool for understanding our world. One example is Brantlinger's (2005) adaptation of Gutstein's (2005b) lesson about the density of movie theaters, community centers, and liquor stores in South Central Los Angeles at the time of the 1992 Los Angeles riots following the acquittal of four police officers in the beating of Rodney King. Although Brantlinger discusses his struggles in foregrounding the sociohistorical context surrounding these riots with his students, the use of mathematics here is intended to help illuminate underlying injustices in society (lack of public investment in some areas) that likely contributed to the riots. In a similar vein, Skovsmose (1994a) helped 14- and 15-year-old students explore the "formatting power" of mathematics over how we understand social phenomena by exploring how they would create a rule for distributing a fixed amount of money for family support. In Gutstein's (2006) teaching of middle school students, he considered issues of inequity—including racial profiling while driving, the possible role of race in mortgage lending practices, and the effects of gentrification on neighborhoods. Varley Gutiérrez (2009) engages elementary students in an afterschool program in using mathematics to collect data and make an argument, which they ultimately presented to the school board, against the proposed closing of their school. Finally, working with adult learners, Frankenstein (1995, 1997, 1998) provides numerous examples of how she interweaves political topics with mathematics—such as how unemployment is calculated, definitions of the poverty line, and the practice of redlining in which banks divest from certain neighborhoods.

These examples all emphasize the role mathematics can play in helping one understand complex social phenomena, and in particular understanding and critiquing injustice. A number of the above researchers also advocate for engaging students in taking action to change these injustices. This form of teaching is undoubtedly challenging (Bartell 2013; Brantlinger 2005; Gregson 2013; Gutstein 2006), and a number of teacher educators have begun to investigate how to support current and future teachers in this form of teaching through professional development (Bartell 2013), methods courses (Aguirre 2009; Koestler 2010, 2012), and content courses (Felton et al. 2012; Felton 2010b, 2012; Mistele and Spielman 2009; Spielman 2009).

PTs' views of social analysis

When analyzing the PTs' views, I found four types of messages about the relationship between understanding mathematics and understanding our world that the PTs endorsed:

1. *Distinct discipline:* Mathematics is a relatively self-contained discipline that has little to do with the "real world," "everyday life," or broader social and political concerns.
2. *Real world:* Mathematics should be connected to "real-world" topics that are viewed or positioned as largely "neutral" or "apolitical" in nature.
3. *Sociopolitical issues:* Mathematics should be connected to topics that are viewed as overtly political or controversial in nature.
4. *Injustice:* Mathematics should be connected to topics that are viewed or positioned as focusing explicitly on raising awareness about, understanding the origins of, and/or working to change perceived injustices.

The four sets of messages are not intended to be distinct—learners may experience a range of messages throughout their educational experiences and they may experience the same enactment of mathematics as functioning at multiple levels. In addition, as with other aspects of the WWH, the message a learner "hears" through a particular activity is subjective—some learners may view a task as neutral while others experience it as sociopolitical.

It is relatively rare for the PTs I work with to make overt statements supporting the notion that mathematics is a distinct discipline, but some do indicate aspects of this view in their writing, as seen here:

> Mathematics should not, however, be used to teach non-scientific, non-mathematical subjects. Math has the unusual quality of being unbiased and true in all cases. This quality is vital to the study and understanding of math, and thus, math should be kept separate from issues that are not truths, and which are biased, such as politics, history, etc.

Moreover, as seen above under coconstruction, many PTs differentiate between "the actual mathematics" and situating mathematics within a context, especially if that context deals explicitly with race, culture, or political issues.

A more common sentiment is that mathematics is "all around us." The PTs often highlight a broad range of "everyday" examples, but rarely explicitly discuss mathematics in political terms.

> I use math all the time on a daily basis. To start my day I need to figure out how many hours of sleep I need or what time class starts in the morning. Then later, if I am at a restaurant I need to calculate the tip for the waiter. Also, in the grocery store I add prices together before I purchase the items to see how much my total cost will be. Basically, math is a lot more then problems practiced in the classroom because it is practical to use every day.

In addition to the emphasis on "apolitical" topics, many PTs exhibit some form of resistance[4] to more overt connections to sociopolitical topics or injustice.

> Overall, I don't think I really agree with this method. I feel that mixing political issues with basic need to know curriculums would change students and have them become more biased. Students could respond negatively to learning about political views and "judge a book by it's cover" or fall into stereotypes and call them out. Another thought or argument about teaching political issues is that it almost dilutes

[4] My use of the term resistance is not intended to downplay the legitimacy of the concerns the PTs raise about these perspectives.

> math concepts and the class then changes from a math class to a political or history or english class.

As will be discussed in greater detail when considering the How of mathematics, the concern that integrating political issues "dilutes math concepts" is a significant issue in the field of social justice mathematics education. It remains an open question how to balance "social justice" goals with more traditional academic mathematical goals in the classroom (Bartell 2013; Brantlinger 2013; Gregson 2013).

Finally, the quote below reflects strong support for connecting school mathematics to sociopolitical issues and injustice.

> I definitely agree with including overtly political topics in mathematics teaching. We live in an age where we are constantly bombarded with information. I think it's more important than ever to try to instill that "skeptical intelligence" in students (as well as try to constantly pursue it ourselves). As human beings, we are all faced with very important social matters that deeply affect us and the world at large. If we can't use every educational option to explore these very things that shape our lives and our worlds, what's the point?

The quotes above demonstrate a range of views about what, if any, real-world contexts should be used in school mathematics. While most PTs embrace the idea that mathematics is "everywhere," many of them shy away from overt sociopolitical connections. The PTs frequently raise legitimate concerns about sociopolitical connections, including concerns that teachers or administrators may be upset, that students will have difficulty understanding complex social issues, and a sense that it may detract from "the mathematics."

The Who of mathematics

The Who of mathematics builds on Gutiérrez's (2007a) argument that "students need to have opportunities to see themselves in the curriculum (mirror) as well as have a view onto a broader world (window)" (p. 3). Focusing on mirrors and windows requires care; we must guard against essentializing groups in our own thinking and in the messages we send to learners (Gutiérrez 2008; Secada 1989); the goal is not to imply that all members of a single group experience mathematics or the world in similar ways, because learners' identities and experiences of tasks will vary. However, failing to think about the role of race/ethnicity, socioeconomic status, gender, language status, or other markers of difference can result in ignoring the real challenges many groups face in the educational system. Members from non-dominant social groups continue to be underrepresented in the highest levels of mathematics related fields (Herzig 2004), are dramatically underserved by our educational system (Flores 2007; Kozol 2005; Ladson-Billings 2006), and often have their perspectives ignored or erased from the classroom (Joseph 2010; Powell and Frankenstein 1997; Tate 1994).

The Bridge project provides one example of making mathematics a mirror for learners by focusing on "the development of learning environments in the classroom that allow students to participate in activities that are meaningful to them and that at the same time allow them to advance in their learning of academic mathematics" (Civil and Andrade 2002, p. 156). One such example is the creation of a gardening unit that was used to explore area and perimeter (Civil and Kahn 2001). A focus on culturally responsive mathematics (Barta et al. 2009; Greer et al. 2009; Leonard and Guha 2002; Leonard 2008) is another approach to making mathematics a mirror, which emphasizes that cultural groups are heterogeneous, but also frames students as part of broader social groups and advocates the use of "gestures, language, history, literature, and other cultural aspects of a particular race, ethnic or gender group to engage students belonging to that group in authentic student-centered learning" (Leonard 2008, p. 9).

With an emphasis on mathematics as a cultural artifact of all peoples, a focus on ethnomathematics may serve as a mirror or a window depending on how it is taken up by learners (Powell and Frankenstein 1997). Activities, such as exploring the number systems of varying cultures (Zaslavsky 2001), may be viewed as a connection to one's racial/ethnic heritage or may function as a window into the practices of those who are different from oneself. Finally, as Gutiérrez (2007b) points out, "using mathematics to analyze social justice issues might offer a mirror to students who have been marginalized by society while it provides a window to students who benefit from the status quo" (p. 3).

PTs' views of the Who

In analyzing PTs' views, I consider whether or not PTs support the view that people may experience mathematics differently in light of their identity. Some PTs reject this notion and take up the following perspective:

> *Mathematics as universal:* Mathematics is "universal" and teachers can, and should, strive to include experiences that all learners can relate to in a common way.

However, many of the PTs, either explicitly or implicitly, support the idea that mathematics may be experienced differently by learners, by adopting the following perspective:

> *Mathematics as personal:* Learners experience mathematics as reflecting their sense of identity (mirror) or as providing insight into others' perspectives (window), and teachers should actively strive to include a range of such experiences for learners.

In analyzing the PTs' views of mathematics as personal, I extended Gutiérrez's (2007b) work by differentiating between two types of mirrors and windows that the PTs endorsed:

- *Individualized mirrors/windows:* Mirrors and windows relative to a learner's individualized sense of identity, which involves attributes that learners see as individual characteristics, such as hobbies or personal interests.
- *Group mirrors/windows:* Mirrors and windows relative to a learner's sense of identity as a member of a socially meaningful group, such as their race/ethnicity, gender, culture, class, experiences with issues of inequity in our society, or other socially significant markers of difference.

While I have presented the views of mathematics as universal and personal as binary opposites, it is more appropriate to view this as a continuum of views that PTs may adopt, which is illustrated in the quotes below.

Mathematics as universal

At the beginning of my courses, a number of PTs make arguments that mathematics is a universal language, as demonstrated by the following:

> Math is like a universal language that is spoken with numbers. Unlike other subjects, it is used similarly worldwide.

In reaction to readings that highlight differences in mathematics notation and algorithms (e.g., Perkins and Flores 2002; Zaslavsky 2001) and in how learners may respond to mathematical problems (e.g., Tate 1994), the PTs often alter their perspectives. In some cases, they emphasize that despite some differences in presentation, the underlying mathematical concepts are still universal:

> Many different cultures had developed [different] gestures… while still having the same universal math concepts…. Although you may not be able to communicate in the same language, you can still communicate through math. This shows that no matter where you are, the universal understanding of math is the same.

Other PTs implicitly acknowledge that it is possible for learners to experience mathematics differently, but argue that teachers can, and should, strive to make mathematics a universal experience for all learners:

> Problems need to contain a general blueprint of what all of the kids, including all genders and races, experience in their day to day lives. [If] problems… relate to one race or gender, or bring up a social injustice that the child cannot easily relate to… the problem will not have as great an influence.

While it can be powerful to create common experiences and then draw on these experiences when doing mathematics (Moses and Cobb 2001), there is a difference between building common experiences and the notion of a universally relevant "blueprint." I attempt to problematize this notion when working with PTs because I am concerned that assuming that such a general blueprint exists will likely result in the PTs implicitly emphasizing assumptions that reflect their backgrounds and perspectives as opposed to those of their future students.

In a similar vein, some PTs acknowledge that the learners may relate to mathematics in different ways, but view it as too complex an issue to attend to when teaching:

> Adjusting the curriculum in a way that relates to all students involved is an extremely difficult task for an educator.

The quotes throughout this section indicate a preference for treating school mathematics as universal, despite a range of views about the possible interaction between a learner's identity and how they experience mathematics.

Mathematics as personal

Many PTs, however, support the view that learners' identities may influence how they experience mathematics and that teachers should attend to this. In the two quotes below, PTs implicitly endorse the view that learners may experience mathematics differently based on their individualized identities.

> I will connect math to student's interests…. To make math more entertaining, I will incorporate games and other math related activities.

> For a K-8 problem, I thought it would be interesting to have the students switch papers after they created their own numbering system. Then when their peer learned it and they learned one in return, they can see it's important to learn every "cultures" system. The[y] will love seeing someone else using their creation and it will help them grasp the idea of differences.

The second quote is in response to an examination of different number systems (Zaslavsky 2001), which focuses on group differences. The PT has refocused on differences between individual students. This is not a criticism of the proposed activity, but serves to illustrate the difference between an individual and group mirrors/windows.

Finally, some PTs support the view that a learner's experience of mathematics relates to their sense of identity as a member of a socially meaningful group—such as their race/ethnicity, gender, culture, class, or other important markers of difference—and advocate that teachers should attend to these differences. Here, a PT emphasizes the importance of mirroring all "minorities" in the classroom:

> I agree with the assumption Tate [1994] is making in which most classroom situations have biases and are geared toward specific groups of people. I also agree that these minorities need to be fully addressed and represented in the classroom so they are given the best chance to learn.

The two quotes below also emphasize the importance of windows in school mathematics regarding learners' race and culture, respectively:

> I agree that we should be using problems that relate to every minority involved in a classroom, not centered only on white middle-class families. I also think it is important to use problems like these in predominantly white schools, so the children are constantly learning about other cultures or races.

> By sometimes presenting difficult material to students in the forms of games or cultural context, they are able to better focus their attention and gain an interest on the subject. Additionally, not only do these students achieve a deeper understanding of the mathematical material, they are also able to learn about and appreciate different cultures in our world.

While the mirror quote above emphasizes providing all students with a fair opportunity to learn, these two quotes indicate an inherent value in learning to appreciate diversity.

The How of mathematics

A common tension in social justice mathematics involves balancing between:

- Focusing on *concepts:* Mathematical concepts are the primary focus of investigation, and real-world concerns are frequently subordinated to building understanding of these concepts.
- Focusing on *the world:* Phenomena in the world are the primary focus of investigation, and specific mathematical concepts are used in service of deepening understanding of these phenomena.

There are a number of examples of focusing on concepts in mathematics education literature. For instance, in Cognitively Guided Instruction word problems are used because children have informal knowledge about how to model these contexts, which can then be built on to develop more formal mathematics (Carpenter et al. 1996). Similarly, in Realistic Mathematics Education problem contexts are selected not because of how *real* they are, but whether, based on the learner's current understandings, they are realistic enough to provide meaningful opportunities for "mathematization" (Freudenthal 1968; van den Heuvel-Panhuizen 1999). In contrast, focusing on the world involves connecting mathematics to real-world contexts that are objects of investigation in their own right. This can often be seen in work focused on connecting mathematics to social justice (Gutstein 2006) and to students' funds of knowledge (Civil and Andrade 2002; Civil 2002; González et al. 2001), but it can also be found in many instances of mathematical modeling (Doerr and English 2003; English 2010; Greer et al. 2009; Lesh and Doerr 2003; Lesh and Harel 2003).

Gutstein (2006) argues that although these two foci can be mutually supportive at times, they are ultimately in tension, because focusing on mathematical concepts requires leaving "the situation in which the mathematics is embedded" (p. 108), while focusing on the world requires "studying reality and at some point leav[ing] mathematics to the side" (p. 109). Similarly, research on Funds of Knowledge has raised concerns about how on the one hand mathematizing students' out-of-school experiences may make them less appealing to students (Civil 2002), while on the other hand focusing on the world may result in superficial attention to mathematical concepts (Civil 2007).

Classroom teachers have also experienced these tensions. Bartell (2013) describes teachers working to design lessons focused on teaching mathematics for social justice, and how they struggled with "negotiating mathematical and social justice goals" (p. 159), which were often seen as oppositional. Gregson (2013) describes a similar tension experienced by a classroom teacher who struggled between providing students with *access* to the mathematics needed to be academically successful and engaging them in mathematics for social justice. Finally, I and colleagues (Felton et al. 2012) have experienced difficulties in balancing between focusing on concepts and the world when teaching of mathematics courses for PTs, due in some cases to institutional expectations and in other cases to the PTs' expectations about what school mathematics entails.

It is important to recognize that the distinction between focusing on the concepts or the world is about learners' experiences of mathematical activities, not about the activities themselves. Consider again that one of Lubienski's (2002) challenges in implementing a *Standards*-based curriculum was that she found that lower-SES students tended to focus on the real-world contexts in a way that obscured her intended focus on mathematical concepts. Thus, while Lubienski intended to focus on concepts, some of her students focused on the world instead by interpreting her tasks as real-world dilemmas to be resolved using whatever mathematical tools were appropriate and helpful.

Thus far, I have presented two opposite answers to the question of how the real-world and mathematical concepts may be related. However, the landscape is significantly more complex than this. Skovsmose (2001) suggests six milieus of learning, four of which involve a range of ways in which mathematical concepts and "semi-reality" or "real life" may interact, including using reality to engage in exercises and substantively investigating real-world contexts. In a different line of work, Palm (2009) lists a variety of ways in which a word problem may or may not be "authentic," including whether the event described is likely to happen outside of the classroom and whether the question posed might actually be posed in the real-world situation. Finally, Gainsburg (2009) considers a range of ways in which classroom teachers make real-world connections in their mathematics teaching: using word problems with realistic contexts, mentioning real-world applications, engaging in an extended project or laboratory, and asking students to create their own real-world examples.

PTs' views of the How

My PTs rarely make explicit statements about how the world and mathematical concepts should be related. This aspect of the framework emerged not only from the PTs' views, but also from my own difficulties in designing tasks that integrated real-world issues in a meaningful way, and my knowledge of the tensions highlighted in the literature discussed above. In my early attempts to take a sociopolitical stance in my teaching of PTs, I felt many of the tasks I created were superficial in nature in that the context remained underexplored and served primarily as “window dressing” (Felton 2010b; Frankenstein 2009). For instance, I have often had PTs classify CGI problem types (Carpenter et al. 2000), but instead of using problems about toys or marbles, I wrote problems about people in poverty. By considering the How, and in particular whether the focus was on the world or the concepts, I better understood why I viewed tasks like these as superficial: While this context is about a social issue, the focus in these tasks (both in how they were written and how I enacted them) was on the mathematical concepts (understanding problem structures). Recognizing this has helped me think about my teaching in three ways. First, I now view these as different forms or genres of mathematics that each belong in the classroom but have differing goals and expectations. Second, I recognized the need to better communicate with my PTs about these different genres of mathematics. Third, it highlighted the need for me to create more tasks that involved social or political issues and focused primarily on the context.

When I used this lens to examine the PTs’ reflections, and in particular the kinds of mathematical tasks they suggested using in the classroom, they frequently emphasized focusing on mathematical concepts, with very few examples of a substantive, authentic focus on the world (Felton 2010b). In this sense, the options of focusing on the world versus mathematical concepts have served as a valuable lens in exploring the views of my PTs. However, in light of the range of ways the world and mathematical concepts may be related, there is also future work to be done in finding ways to engage PTs in better exploring these possibilities.

Due to the PTs lack of explicit discussion of these issues, I have adjusted my teaching each semester to try to better draw the PTs’ attention to these different genres of school mathematics. In some cases, I have explicitly asked the PTs whether they think there should be more of a focus on concepts or on the world in mathematics teaching. In other cases, I have asked them to reflect on tasks we have completed and asked them which seemed to be “more in charge” (the world or the mathematical concepts) as a means of helping them unpack their implicit views of these issues.

A large number of PTs argue that mathematics teaching should focus primarily on concepts, often suggesting that some real-world context can be enriching, as long as it does not interfere with “the mathematics.”

> I agree support the argument in the articles. I think that the ethnomathematic thread needs to remain an ongoing process. Yet it must not take away from the main focus of the underlying math skills.

In other cases, the PTs take a stronger stance that mathematics should remain separate from real-world contexts:

> The only thing I totally disagree with is using real-world situations to understand math. I think that this just makes things more confusing and brings up talks in math that don’t belong in math.

A common theme across both of these quotes is the idea that “mathematics” exists independently from the contexts in which it is used and developed. This connects with the conception of mathematics as a distinct discipline discussed earlier.

However, the majority of PTs assert that there should be an explicit balance between concepts and the world:

> Focusing on concepts is how I was taught in school, and focusing on the context is what I am learning in this class. It is important to combine the two in order to gain the most out of your mathematics experience.

This quote is typical in that it includes minimal detail about what it would mean to focus on either the concepts or the real-world context and how one would go about combining the two. As discussed earlier, I believe this stems in large part from a lack of experience with how the world and mathematics may be connected in the classroom.

Finally, PTs occasionally indicate support for placing a heavier focus on real-world contexts. The following quote is in response to an end of semester reflection assignment in which the PTs were asked to "write a short story that illustrates how you envision teaching math as a future teacher":

> A new park is being built right next to the school the children attend. Children decide on different things they would like at the park. They then decide how much space would be needed for each object by finding different areas and perimeters… Many of the playthings put in the park will be different shapes and sizes, so many different types of perimeter would be found. The class would discuss together to come up what they think are ways to find certain perimeters of different shapes, and why they think this equation would work.

Here, the PT begins with a meaningful real-world context—designing a new park—and suggests using mathematics to facilitate that process.

The views from the PTs and in the literature about the How of mathematics often frame the issue as a tension between focusing on "mathematics" versus "the context." To the extent that school mathematics is *defined as* focusing on mathematical concepts this will remain true. Thus, I argue that we should reconceptualize this not as a difference between "mathematics" and "context," but as a difference between *different forms of* mathematics. Mathematical modeling may provide one avenue for making this shift because it involves serious attention to both the real-world context and the mathematical concepts and tools that can be used to analyze that context. Moreover, in some cases scholars have found that students learn deep mathematics while also better understanding the context (Lesh and Doerr 2003; Lesh and Harel 2003).

Discussion

A number of scholars have pointed to the (often intentional) undefined nature of teaching mathematics for social justice, critical mathematics, and other related work (Bartell 2012, 2013; Gates and Zevenbergen 2009; Stinson and Wager 2012). As I discuss below, the WWH provides one means of navigating these diverse perspectives for both scholars and practitioners. The WWH provides a lens for understanding (prospective and practicing) teachers' views of and practices surrounding the social and political dimensions of mathematics. In addition, the WWH can serve as a powerful framework for reflecting on and informing teachers' and teacher educators' instruction.

Understanding teachers' views

Very little is known about how prospective or practicing teachers' views of equity develop over time, and in particular, the learning trajectories they follow as they engage with these perspectives. Two notable exceptions are the work of Ensign (2005) and Turner et al. (2012a), both of which consider prospective teachers learning to connect mathematics to students' out-of-school knowledge bases. The WWH can serve to extend this work by focusing on a broader range of PTs' views related to equity-oriented mathematics teaching. In addition, by breaking down a range of perspectives, the WWH may help identify views that are more easily accepted by PTs. My colleagues and I are currently piloting a survey of PTs' views about connecting mathematics to real-world contexts that is informed by the WWH. This survey will serve to triangulate qualitative measures of PTs' views, will help identify which perspectives are easier for PTs to agree with, and can aid in studying how views about different aspects of the WWH are interrelated. This can inform the design of teacher education programs, as it may be more productive to begin with perspectives that are easier for PTs to engage with and then expand from there. Or it may be important to include more extensive attention to perspectives that PTs resist throughout a teacher education program.

In addition, this work must be extended to study teachers' instructional practice in the classroom. While the WWH was specifically framed around PTs' views for this article, the overarching questions asked by the WWH can be adapted to focus on the role of teachers in the kinds of mathematical practices that are enacted in the classroom (Skott 2013). For instance, instead of examining teachers' views about how mathematics and the world should be related, future research can focus on how they are related in classroom settings and how this is negotiated by the teacher, students, and other tools, such as the curriculum.

Future work can also focus in greater detail on each of the individual dimensions of the WWH. Mathematics can be coconstructed with a number of important social constructs. PTs' willingness to endorse the coconstructed nature of mathematics may vary with the particular social construct in question (Felton 2010b), and there may be specific nuances to how PTs understand each social construct that may be related to their broader beliefs about these social constructs. Similarly, PTs' views about the Who of mathematics may vary depending on the students they imagine working with, their own sense of identity, and their views about different social groups and how they are treated in our society. Finally, as discussed above, there is additional work to be done to with supporting PTs in exploring the range of ways in which mathematics and the world can be interrelated.

Relationships between the What, Who, How, and the Why

One benefit of the WWH is that it can serve as a tool for teasing out different dimensions of PTs' views about the social and political aspects of teaching mathematics. This can, in turn, support research that examines how these views are interrelated. I briefly consider two such possible relationships. First, mathematics can be coconstructed as White and middle class if it consistently serves as a mirror for learners with those backgrounds and fails to do so for other groups. Second, mathematics can function as a mirror for students either through the topics investigated for social analysis or through the mathematical approach taken. Recall Lubienski's (2002) concern that lower-SES students focused more on the world, while her higher-SES students focused more on the mathematical concepts. If one of these approaches is positioned as the official form of school mathematics, then it causes mathematics to function as a mirror for some groups and not others.

In addition to these interrelationships, future research can consider additional questions about the nature of school mathematics. An overarching question that I have begun asking my PTs to consider is "*why* should we teach mathematics?" (Felton and Koestler 2015). Continued research should examine how this is related to the other aspects of the WWH.

For instance, if a PT believes that the primary purpose of school mathematics is career preparedness, then they may see little value in engaging learners in analyzing injustice. However, when presented with new forms of mathematics, many PTs expand their view of what mathematics can be and thus what purpose it can serve (Felton and Koestler 2012, 2015; Felton et al. 2012; Felton 2010b).

Informing instruction

The WWH also provides a framework to inform instructional practice of mathematics educators. An overarching theme of this article is the recognition that there are multiple forms, or genres, of mathematics. Each genre involves a unique set of expectations for participation. Do we expect the mathematics to remain closely tied to the context or to generalize away from it? Do we recognize and discuss the sociopolitical implications of our work in the classroom or ignore it? Do we expect students to bring their outside experiences to bear on mathematics problems or to ignore them in favor of the assumptions of the text or teacher? Similarly, the WWH asks us to reconsider what it means to *know* and *understand* mathematics. Does one "know" and "understand" the so-called Pythagorean theorem if they can only apply it in school contexts and are unaware of its discovery across a range of ancient societies (Joseph 2010)? Is a student's understanding of place value complete if they cannot discuss the magnitude of the federal budget (Stocker 2008)? Have we properly supported children's learning if they cannot place mathematics in their lives and recognize its use in other cultures (Gutiérrez 2007b)?

Reflecting on these questions, and considering the WWH more generally, has been a valuable tool for reflecting on my own practice as a mathematics teacher educator. In particular, the How dimension emerged in part from tensions I experienced between focusing on mathematical knowledge for teaching (Ball et al. 2008) and integrating issues of equity into my course. By reflecting on the PTs' limited ability to articulate how mathematics and the world may be related in the classroom, I have continued to improve my own teaching by developing a broader range of mathematical tasks that can serve to illustrate different kinds of relationships between the world and mathematical concepts. Some of my future work is aimed at further unpacking these different kinds of relationships, understanding PTs' views of them, and studying their mathematical preparation for enacting them in their own practice.

In planning and reflecting on instruction, teachers might ask what kind(s) of mathematical activity they hope to engage learners in, what expectations they have for these kind(s) of mathematical activity, how they support learners in navigating these expectations, and how this relates to learners' identities. I have also found that this framework is productive in supporting prospective and practicing teachers in reflecting on the nature of mathematics and the form(s) of mathematics they plan to enact in their classrooms (Felton 2010a provides an accessible introduction to these ideas).

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