"YOU CAN'T GO ON THE OTHER SIDE OF THE FENCE": PRESERVICE TEACHERS AND REAL-WORLD PROBLEMS

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Our study investigates preservice teachers' perceptions of real-world problems; their beliefs about teaching real-world contexts, especially ones sociopolitical in nature; and their ability to pose meaningful real-world problems. In this paper we present cases of three preservice teachers who participated in interviews that probed their thinking about real-world problems, and asked them to create problems they would consider using in their future classrooms. We use the three cases to propose a potential trajectory for preservice teachers from ambivalence to certainty about teaching mathematics through real-world and controversial contexts.

Keywords: Teacher Education-Preservice, Equity and Diversity, Problem Solving

Introduction and Review of the Literature

In this paper we present work that is part of a larger study investigating different aspects of preservice teachers' (PSTs) relationship to real-world problem solving and problem posing. Here we place an emphasis on PSTs' problem posing and draw on their thinking about contexts they would (and would not) use in their teaching to inform the steps that we, as mathematics teacher educators (MTEs), need to take in order to prepare teachers to teach through real-world and controversial issues. The border-crossing metaphor applies to our work in at least two ways: we want PSTs to cross from posing superficial real-world problems to posing authentic ones; and we want them to cross from "safe" topics that do not challenge unjust systems to those that draw from sociopolitical and potentially controversial contexts.

Real-world problems have recently come into the spotlight in mathematics education due to their treatment in the Common Core State Standards for Mathematics (CCSSM) (CCSSI, 2010). The CCSSM introduced modeling not only as a content strand in high school mathematics, but also as one of the eight essential mathematical practices to be developed in all mathematics classrooms at all grade levels. According to the document, "mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace" (CCSSI, 2010, p. 7). However, the types of problems recommended by the CCSSM are not the norm in school mathematics, where real-world problems are frequently understood to mean textbook story problems, with contrived contexts and neat solutions that combine the numbers given in the problem in an algorithmic manner. Verschaffel, Greer, and De Corte (2000) describe textbook problems as "routine applications without judgment or any higher level thinking skills" (p. xiii) and "artificial, puzzle-like tasks that are unrelated to the real world" (p. xv). As an alternative to scripted textbook problems, researchers suggest realistic real-world problems, as they can enhance student performance (Boaler, 1993; Verschaffel, Greer, Van Dooren, & Mukhopadhyay, 2009) and contribute to a bigger picture of mathematics (Blum, 2011).

These real-world contexts recommended by research (and the CCSSM) are rich and varied, and include examples from science, engineering, and business among others (Common Core Writing Team, 2011), but do not explicitly include applications of mathematics that emphasize (a) connecting mathematics to students' lives and backgrounds in meaningful ways and (b) using mathematics to critically analyze our world and challenge injustice. Real-world applications that exclude the aforementioned (a) and (b) can certainly improve student access to rich mathematics and their academic achievement, but do not help develop their identity or empower them as citizens

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(Gutiérrez, 2007). Frankenstein (2009) argues instead for *real* real-world problems, which "use mathematics ideas in struggles to make the world better" and, along with Gutstein (2006), promotes mathematics as a tool for reading the world, explicitly focusing on issues of social justice, including, but not limited to, income inequality, education funding, homelessness, institutional racism. The use of critically oriented real-world problems is essential in mathematics teacher education, as it helps PSTs see mathematics as a window into the worlds of their future students and a mirror into their own (Gutiérrez, 2007). Through engaging with *real* real-world problems, PSTs gain an understanding of the circumstances students live in, the relevance of mathematics to their own lives, and the power of mathematics in reading the world and developing agency.

In addition to solving real-world problems, PSTs need to be able to write them as well (Gonzales, 1994). Because problem posing is typically not emphasized in mathematics education, PSTs encounter difficulties when posing real-world problems for the first time. They typically create problems that can be solved in only one way and in a single step (Crespo, 2003); limit contexts to time, food, and money (Gainsburg, 2008; Lee, 2012); and are unrealistic and can even include objects like unicorns and aliens (Lee, 2012).

Our work investigates real-world problem solving and posing in the context of PSTs' beliefs and knowledge about connecting mathematics to students' lives and about using mathematics to critically analyze the world. We have developed a survey that measures preservice teachers' beliefs about engaging in mathematics teaching based in real-world contexts (Simic-Muller, Fernandes, & Felton-Koestler, 2015); and have conducted interviews in the first author's mathematics content courses for K-8 PSTs, investigating their thinking about different types of real-world contexts. In this paper we focus on examples of real-world and controversial issues that PSTs were asked to create in the interviews. In particular, we present cases of three PSTs and propose a trajectory, based on their interview responses, towards competency in teaching mathematics through authentic problems about complex issues.

Methods and General Observations

Our 35-item survey investigates PSTs' beliefs about teaching through real-world problems (6 items) as a whole, as well as three other subscales: controversial issues (8 items), injustices (11 items), and family backgrounds and community practices (10 items). We used a 1 (Strongly Disagree) to 5 (Strongly Agree) Likert scale for each item. These categories are present in a survey we have created and conducted with 127 PSTs thus far. The survey design was informed by literature and our experience working with preservice teachers (see, in particular, Felton-Koestler, 2015). We also sought comments from seven experts in the area to ensure content validity. We highlight a few items in Table 1. The questions corresponding to the other three sub-categories closely match the ones in Table 1.

Table 1: Sample Survey Questions

1.	When I teach mathematics, I will make connections to REAL-WORLD SITUATIONS.
2.	I am interested in learning how to make connections to REAL-WORLD SITUATIONS.
3.	When I teach mathematics, I will focus on mathematical concepts (e.g., addition and subtraction, geometric shapes, etc.) and not worry about using REAL-WORLD SITUATIONS.
4.	When teaching mathematics, REAL-WORLD SITUATIONS can distract students from learning the important mathematical concepts.
5.	An advantage to teaching mathematic with REAL-WORLD SITUATIONS is that they help students learn about the world around them.
6.	Teaching mathematics with REAL-WORLD SITUATIONS helps students learn the mathematical concepts better.

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In the survey and interviews, we explained controversial issues as "topics that will likely be viewed as contentious or debatable. Not everyone agrees on what topics are controversial, but some examples might include the costs of the war on drugs, government spending, funding for schools, or climate change."

We have been recruiting preservice teachers nationwide for the survey, but have currently mostly collected data from the first author's two-part mathematics content course for K-8 PSTs. In the course, PSTs see some examples of contexts investigated in the survey prior to responding to it (e.g. they might have investigated the affordability of housing by minimum wage-earners, or the gender wage gap), and after the survey is administered (e.g. the racial make-up of the Congress or the interest rates when renting to own); but the primary focus of the course is on developing mathematical content knowledge.

Based on the 127 survey responses, 96% of the respondents agree or strongly agree with making connections to real-world contexts in their teaching. Unsurprisingly, it is much more difficult for PSTs to agree with using controversial topics, with only 24% responding with "agree" or "strongly agree." However, both the survey and interviews indicate that PSTs are generally curious about controversial issues: in the survey 64% (agree or strongly agree) said they were interested in learning how to make connections to controversial issues.

In order to better understand survey responses, the first author also interviewed nine students who were, with one exception, taking a class with her for the first time, and had had no known prior exposure to issues of social justice in the context of mathematics. The interviews took place after the end of the semester. PSTs volunteered for the interviews, and represented a wide range of interests and openness to mathematics teaching and social justice. The interviews varied in length, and followed a semi-structured format. The interview questions investigate survey topics at more length, for example:

> Some people think it is important to teach mathematics by making connections to **real-world situations**. What does that mean to you? [Can you give me some specific examples? Can you give me more specifics? How would you teach it? Which mathematics would you use? What issues are relevant to you?]

The interview protocol contains similar questions about controversial issues, injustices, and family backgrounds or community practices. For the purposes of this paper, we will consider questions related to real-world situations and controversial issues, as defined above. The first two authors coded the interviews for common themes.

While all interviews provide valuable insights, we decided to focus our attention to three PSTs: Mirinda, Briana, and Laura (pseudonyms). We began the data analysis for this paper by looking at the codes related to mathematics content present in the interviews, and extracting all relevant quotes from all nine. While rereading and organizing the quotes, we noticed that Briana's statements often emerged as significant; she was therefore the first PST chosen for a case study. We next included Laura, who we identified in prior research (Simic-Muller et al., 2015) as more advanced in her thinking about real-world and controversial issues than her peers. We realized, when comparing their responses, that there was a progression from Briana's to Laura's responses, and finally decided to include Mirinda's case to complete the progression. We identified four common themes that emerged in all three interviews: the ability to imagine relevant contexts for real-world problems, perceptions of children's ability to engage with complex real-world contexts, beliefs about the role of controversial issues in the classroom, and interest in teaching through real-world and controversial issues. We describe the range of views among the three PSTs in each of the four themes through quotes from their interviews and our interpretation of their quotes, and hypothesize that these may be a potential trajectory for PSTs engaged in course work emphasizing real-world and sociopolitical connections in mathematics.

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Three Cases

Mirinda: Beginning the Journey

Mirinda is a quiet student who wants to teach third grade, and who performed well in the course, but seldom made contributions to class discussions or approached assignments in original ways. Her interview is not a departure from her typical classroom demeanor. Mirinda's interview displays characteristics we think of as emergent in the development of a positive disposition toward teaching through real-world and controversial issues. The four themes in her interview are discussed below.

Imagining relevant contexts. Mirinda thought that third-graders should encounter real-world mathematics problems, but had difficulties coming up with examples. The ones she picked were standard ones: sharing food fairly and shopping at a store. Other PSTs had similar difficulties in the interviews, and in particular also chose similar contexts: six out of nine mentioned food, and three mentioned money. The following exchange shows Mirinda proposing a promising context based in students' communities, but then turning it into a static story problem.

> *Mirinda*: For third grade, they are old enough to go to the store and buy snacks and they know how much to pay and if they are getting the right amount of change.
> *Interviewer*: How would you do that in your classroom?
> *Mirinda*: I would say word problems once more. So I would give them a scenario. They go to a store and they buy a certain item, and give them the cost, and ask them how much will the total cost and how much change with they get back.

When asked for an example of a controversial issue, Mirinda shared an example from an assignment completed earlier in the semester, and otherwise responded, "I can't really think of anything."

Perceptions of children and controversy. Mirinda seemed to believe that children cannot understand complex real-issues, stating that "it would be difficult for younger students to understand." Other PSTs in the interviews also stated that children are too young to understand issues or to care about them, even if those children live in circumstances investigated by the real-world problems.

Controversy in the classroom. Mirinda did not see a need for teachers to teach through controversial issues, saying that "it should be optional for teachers to teach it." Of course teaching controversial issues cannot and should not be mandated, but in this statement made by Mirinda we also see a relinquishment of responsibility for teaching for change to a self-selected group of teachers, instead of being distributed to all.

Interest in teaching with controversy. Mirinda also did not feel too much curiosity about teaching through controversial issues. She responded to the question of whether she was interested in learning more about the topic with, "If I find content and issues that go with it, maybe…" This was not the case with other interviewed PSTs, who all expressed interest, if accompanied with doubt, in learning more about controversial issues.

Briana: Eyeing the Line

Briana is a PST from the campus' low-income neighborhood who has lived in different parts of the city and has attended some of the highest- and lowest-performing schools in the region. She wants to teach first grade, and is an average mathematics student. Because of her background she has a greater awareness of neighborhood and community issues than most of her peers. Briana was also concerned about the effect that teaching controversial issues might have on others. In the interview she made references to borders by expressing concerns about "staying on one side of the fence" and making sure not to "cross the line." The four themes emerge in her interview as well.

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Imagining relevant contexts. Briana had difficulties coming up with real-world contexts, and her mathematics examples were not particularly rich. While she said she wanted to bring children's lives into mathematics teaching, she was unable to come up with an example beyond counting, for example suggesting that "they could go outside for a homework assignment and they could count how many bikes they see and things like that. However, despite these difficulties, Briana believed that "it's not very hard to incorporate math into real world situations."

Perceptions of children and controversy. Briana believed that children should be aware of the world around them. She had some reservations about their ability to comprehend the issues, but to a lesser extent than Mirinda. For example, when discussing recycling, she noted:

> I think it is good for students and children to know what is going on around them, it may be on the broad spectrum and they may not get the whole picture but it's still important for them to know… [T]hey may not know everything about one thing that you are trying to get the point across, like recycling they don't need to know the pros and cons but they can get the point of, "Oh it's good to recycle, I recycled 10 bottles this week."

We would advocate extending this reasoning to most controversial issues: even if students do not understand it fully yet, there is usually an entry point for discussing it. We should not prevent young children from thinking critically about the world just because they will not be able to understand all its workings.

Controversy in the classroom. Briana wanted to know where to set a limit and how not to go beyond it, because "we don't know where to draw the line, or what's appropriate for what age necessarily." She also briefly mentioned that parent resistance might get in the way of teaching controversial topics to young children. Like other PSTs we interviewed, she was concerned about offending someone by teaching topics some might find inappropriate. This is understandable, and points to the need for MTEs to support PSTs in learning to navigate these complex spaces so that they and their students can learn to both play the game and change it (Gutiérrez, 2007).

Interest in teaching with controversy. Briana was open to and aware of controversial issues, but preferred safer ones. She was interested in the environment, but would pick recycling over climate change, because the latter could "start to get controversial." Similarly, if she talked about the military, it would have to be in a positive light:

> You can't go on the other side of the fence but you have to stay on one side if you talk about that with all the military families, that's where all the controversy comes in, you so you have to be very positive about it, like how many people have family in the military, so let's make them thank you cards.

While this could be viewed as backing away from controversy, it can also be seen as recognition of the local context – criticizing the military is widely unpopular in the area where Briana lives. Briana's concern about not offending people is common, and we as MTEs need to develop tools to help PSTs develop the courage to cross to the other side of this fence, i.e., be critical of and challenge the status quo, and not only help their students succeed academically, but also empower them to challenge inequity and injustice (Gutiérrez, 2007).

Laura: Over the Line, Looking Back

Laura is also White, and wants to teach upper elementary school. Her responses to the interview prompts show deeper thinking than those of her peers, and we have conjectured (Simic-Muller et al., 2015) that this is due to three factors: (a) her mathematical knowledge, as she is getting a middle-level mathematics endorsement; (b) her background, as, like Briana she grew up in the neighborhood surrounding the campus and is aware of its strengths and challenges; and (c) her position on campus as a residence assistant, in which she participated in a variety of social justice programming. We will

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compare and contrast Laura's characteristics pertaining to our four stated themes to those of Mirinda and Briana, hoping to understand what sets PSTs like Laura apart from her peers.

Imagining relevant contexts. Laura had no difficulties creating real-world examples for various grade levels. For a real-world context, she gave examples of whole number and percent problems about the numbers of children who speak other languages in order to celebrate bilingual children. For a controversial issue she proposed investigating how many school lunches a favorite celebrity could buy for students with her income, with the purpose of "realizing how do we make it fun but also relate it to our own lives," and noting that "it's not just me compared to them, but our whole society compared to them [which is] easier to look at rather than me compared to you." She claimed that she is "always thinking of things in [her] daily life in math ways," and as she is "pretty confident in the content [she will be] teaching, and the standards [she will be] trying to meet," it is "easier to relate those on the spot to different things and come up with things on the spot."

Perceptions of children and controversy. Laura did not dismiss younger students' ability to deal with real-world, issues, though, like the other PSTs, thought that in-depth conversations are easier to facilitate with older students, partly because younger students do not have as many mathematical tools available to discuss complex issues. She also explicitly discussed children's backgrounds, which she believed should be celebrated, such as the number of languages a child speaks or the number of people living in his household; and she believed that even the basic data collection questions, such as recording how many pets each child has, is a "way to create a community in the classroom and have students learn about other students."

Controversy in the classroom. Laura was confident that she would teach through real-world issues. Although she too had concerns that the administration and student might disapprove of discussions about touchy subjects, she offered strategies for turning these stakeholders into allies. She built on her experience as resident assistant to describe that, when discussing a potentially touchy subject, she would explain to students who might be impacted by it that "it's great for people to be aware … of all these things going on people's lives." Similarly, she said she would "would like to be able to do what I want in my classroom with math" but would ask her supervisor, "I am interested in using these types of situations, how would you suggest, or could you suggest a different way that I bring these up in the classroom?"

Interest in teaching with controversy. Finally, although she did not explicitly say it, her entire interview indicates her openness to learning more about teaching through real-world and controversial issues.

Discussion

The three case studies show a range of beliefs and knowledge related to real-world connections. While additional research is needed to better understand how PSTs' beliefs and knowledge develop, we hypothesize that the cases may represent a possible progression that PSTs first developing familiarity with these ideas may follow.

First, mathematical content knowledge is important for problem posing (Gonzales, 1994), but it is not sufficient. Although Mirinda possessed reasonably strong mathematical knowledge, she was unable to come up with a rich context on the spot. Laura, on the other hand, talked about "always thinking of things in my daily life in math ways," and we believe that the ability to view the world through a mathematical lens, along with content knowledge, can support PSTs' problem-posing skills. A question for our consideration, then, is how to help develop a mathematical lens in all PSTs, especially those who see themselves as bad at math.

Second, if PSTs do not believe that students are capable of engaging with real-world and controversial contexts, then they will not feel compelled to think about these contexts. Doubts about children's interests or abilities repeatedly occur in the interviews, yet we know from research and our

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experience that young children do possess the capacity to engage with complex contexts and mathematics (e.g. Turner, Varley Gutiérrez, Simic-Muller, & Diéz-Palomar, 2009; Murphy, 2009; Varley Gutiérrez, 2013). Many MTEs already challenge PSTs' perceptions about children's ability to develop their own strategies, and it is important to challenge their perceptions about children's ability to engage with real-world contexts as well. We need more accessible examples of young children being successful at grappling with complex real-world problems that deal with their lives or the world at large.

Third, PSTs are hesitant to introduce controversial topics into their teaching. With the current climate of excessive teacher evaluation and diminished autonomy, these concerns are far from unfounded. However, Laura's approach, which seeks to turn students and administrators into allies, is a promising one. MTEs need to provide positive examples of communities and schools working together to enact change and to support PSTs in learning to successfully navigate these complicated political spaces.

Finally, as obvious as it may seem, it is essential that MTEs provide PSTs with ample opportunities to learn about real-world mathematics problems and controversial topics. In our survey, though few PSTs readily agree to teach using controversial issues, many more are at least curious about this approach. We will also encounter PSTs like Mirinda who do not yet see its point, but may begin to do so through appropriate and relevant examples. We need to better understand pathways to creating curiosity in PSTs who come to us with little prior experience with social justice in order to help them develop interest in teaching mathematics to critically analyze the world.

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