Preservice Teachers' Understanding of 'Real world': Developing a Typology

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This study examines the beliefs of 33 preservice teachers (PSTs) from the U.S. have about using different types of real-world contexts in the mathematics classroom. Qualitative data about the participants' reactions to specially designed word problems that varied in contexts from "neutral" to controversial were collected. A thematic analysis of the responses indicated that they could be arranged into three typologies on a continuum based on their openness towards the use of controversial issues in the mathematics classroom. Drawing on the analysis of PSTs' responses and the literature, a fourth typology was inferred. The typologies can be useful to teacher educators and education programs as they seek to prepare PSTs to work with increasingly diverse students in their future mathematics classes. The study also highlights the potential of using word problems as a tool to understand PSTs' beliefs.

Mathematics is a powerful tool for understanding the world, yet discussions of the sociopolitical realities of children with diverse ethnic, racial, gender, socioeconomic, and other identities (Aguirre, Mayfield-Ingram, & Martin, 2013) are generally avoided by mathematics teachers as they are viewed as complex, controversial, not relevant to the content, or not relevant to their own experiences. Increasing inequality, racialized outcomes, and shifting student demographics, among other factors, make discussing these issues necessary; while the increased reliance of our world on data makes the connection of these topics with mathematics even more salient. In the last few years, we have seen issues of power, oppression, and identity become more central in the mainstream mathematics education. The 2018 volume of *Annual Perspectives on Mathematics Education* published by the National Council of Teachers of Mathematics (NCTM) is dedicated to humanizing practices in teaching Black, Latinx, and Indigenous students (Goffney & Gutiérrez, 2018). Gutiérrez argues in the introduction that access to high-quality mathematics instruction is not enough, and that additionally, "a student should be able to feel whole as a person—to draw upon all of their cultural and linguistic resources—while participating in school mathematics." (Gutiérrez, 2018, p. 1).

There is a push for real-world problems in the Common Core State Standards in Mathematics (CCSSM) (Common Core State Standards Initiative (CCSSI), 2010). The terms "real-world" and "real world" come up 52 times in the standards document (CCSSI, 2010) and 13 times in *Principles to Actions* (NCTM, 2014). While the CCSSM emphasize real-world problems, they deemphasize any critical analysis of power and oppression (Bartell, Wager, Battey, Foote, & Spencer, 2017). Moreover, what we consider real-world also varies. For example, it is common to think about real-world problems as synonymous with word problems, especially those found in textbooks. Realistic real-world problems, recently becoming more prominent owing to the modelling standards in the CCSSM, still typically consider contexts that are perceived as neutral, but which privilege dominant identities (Bright, 2016; Rubel, 2016), and likely do not allow students to feel whole as a person. Less is also understood about how future teachers conceptualize "real-world." Given the disparities between the backgrounds of teachers and public school students (e.g., Aguirre, Mayfield-Ingram, & Martin, 2013; Castro, 2010; Gay & Kirkland, 2003) and PSTs' general lack of exposure to, awareness of, and interest in the communities they will serve (Castro,

2010; Martin, 2012), there is need to align what it means to be real-world with the need for critical awareness in teachers in order to rehumanize mathematics for their students. The *Standards for the Preparation of Mathematics Teachers*, created by the Association of Mathematics Teacher Educators (AMTE) identify equity as central to all mathematics teacher preparation, and state that well-prepared beginning teachers of mathematics "can apply their mathematical knowledge to real-world situations by using mathematical modelling to solve problems appropriate for the grade levels and the students they will teach." (AMTE, 2017; p. 9) Furthermore, well-prepared beginning teachers of mathematics:

> embrace and build on students' current mathematical ideas and on students' ways of knowing and learning, including attending to each student's culture, race/ethnicity, language, gender, socioeconomic status, cognitive and physical abilities, and personal interests. They also attend to developing students' identities and agency so that students can see mathematics as components of their cultures and see themselves in the mathematics. (AMTE, 2017; p.13)

Real-world for many public-school students could mean challenges faced by their families like racial profiling by police, gentrification, access to nutritious food and clean water, and predatory loans, to name a few. For teachers who will work with students who may be from marginalized backgrounds, it is important that they understand the meaning of "real-world" from their students' perspective so they can build on students' ways of knowing and learning. As mathematics educators seek to prepare PSTs for their future teaching, it is important to understand the PSTs' current perspectives about the real world so that mathematics educators can build on them and bring them closer to the perspectives their future students might bring. In other words, if we wish teachers to connect mathematics with real-world issues, especially the issues that are important to students belonging to marginalized groups, it is important to make sense of their understanding of what "real-world" means and which contexts they consider relevant and appropriate.

In this study, we designed and tested a framework that examines PSTs' beliefs about using real-world contexts in their future classrooms. We investigate how PSTs relate to different real-world contexts presented to them and propose a typology that can help gauge their openness to using similar contexts in their own teaching. Understanding the current conceptions of the PSTs and building a possible strategy for growth can help better prepare teachers to work with the growing population of students holding complex, diverse, and often marginalized identities in their future classes. We agree with Mamolo (2018) that helping prepare teachers to incorporate authentic real-world contexts is an important yet understudied problem that needs further attention. It is therefore helpful to provide examples for PSTs of what this looks like, and to provide spaces for reflection on which contexts they deem appropriate and why, and how to incorporate them into their teaching.

A note on the language: there is no satisfactory umbrella term to describe students of colour, immigrant students, working-class students, students living in poverty, LGBTQ students, and others whose experiences are not considered the norm in traditional classrooms. We will mostly use terms *minoritized* and *marginalized*, noting that "minoritized" primarily refers to populations of colour, and that both are passive terms that do not reflect the agency that these groups display in the educational systems and elsewhere.

Theoretical Framework and Literature Review

According to Philipp (2007), beliefs are "psychologically held understandings, premises, or propositions about the world that are thought to be true. Beliefs might be thought of as lenses that affect one's view of some aspect of the world or as dispositions towards action" (p. 259). Teachers' beliefs about mathematics and mathematics teaching influence their

practice in the classroom (Richardson, 1996; Pajares, 1992; Thompson, 1992, 1984). Aguirre and Speer (1999) found that teachers' beliefs go further to influence even the moment-to-moment actions of teaching. Beliefs are context-dependent, and the context can also influence how teachers approach teaching mathematics. For example, even though teachers may believe that students learn mathematics through engagement and discussion, they may not adhere to this approach when working with students with non-dominant identities, believing that these students benefit from direct instruction. Sztajn (2003) illustrated case studies of two teachers who shared the same beliefs about mathematics and mathematics education, but who implemented the mathematics curriculum differently based on the backgrounds of their students. The teacher whose students came from middle-income backgrounds engaged them with problem-solving. The teacher whose students were from low-income backgrounds taught basic facts and engaged with repeated practice. Zevenbergen (2003) also found in a study in Australia that the socio-economic status (SES) of the students influenced the curriculum that the students received. Students from high SES engaged in problem solving, while students from low SES engaged with routine practice problems. Villegas (2007) reported results of numerous studies that found that PSTs believed that diversity was a problem to overcome, not a strength to build on and that students with backgrounds different from theirs are deficient in some way. In a review of studies related to millennial PSTs' views on diversity, Castro (2010) found persistent lack of complexity in understanding of multiculturalism, belief in meritocracy, generic support for multicultural education with no critical reflection, deficit thinking, and lower expectations.

In light of these challenges, Bartolomé (1994, 2004) discussed the need for teachers to have political clarity in their teaching. Political clarity refers to:

> the process by which individuals achieve a deepening awareness of the sociopolitical and economic realities that shape their lives and their capacity to recreate them. In addition, it refers to the process by which individuals come to better understand possible linkages between macro-level political, economic, and social variables and subordinated groups' academic performance at the micro-level classroom. This, it invariably requires linkages between sociocultural structures and schooling. (p. 178).

Bartolomé argues that currently there is too much emphasis on the methods for teaching students who are viewed as "at risk," with little attention paid to the sociocultural awareness of the teacher. As this approach does not address issues such as the origins of terms such as "at risk," "urban," "minority," and other deficit-oriented terms, teachers still retain deficit beliefs about their students. Bartolomé argues that teachers with a political clarity are able to deploy methods with students in ways that will negotiate unequal relations and discriminatory structures and practices in the class and improve the quality of instruction for the students typically marginalized by schooling. Gutiérrez (2013) references the idea of political clarity, argues that all teaching is political, and specifically argues that mathematics teachers need political knowledge in order to "challenge the powerful messages and policies being enacted by those outside of education" (p. 12). Having written elsewhere about the need for teachers' creative subordination in order to advocate for their students (2016) and the need to help students both play the game and change the game of mathematics (2009), Gutiérrez writes:

> Given the current context of high-stakes education, I seek to help teachers build the knowledge and stances required to creatively resist a definition of the profession that unnecessarily limits the relationship between mathematics and historically underserved and/or marginalized youth (p. 14).

Gutierrez and others (e.g., Gregson, 2013; Gutiérrez, 2000; Gutstein, 2006; most chapters in Gutstein & Peterson, 2013; Ladson-Billings, 1994; wealth of examples in

Leonard, Brooks, Barnes-Johnson, & Berry, 2010) have written about successful examples of mathematics departments and teachers who helped their students achieve academic success (play the game), and celebrated their lives and communities in the classroom while addressing oppression they faced (change the game); though not without tensions and challenges. For example, Ladson-Billings (1994) documented practices of successful teachers of African American children. When she coined the term "culturally relevant teaching" (currently the more commonly used terms are *culturally responsive* and *culturally sustaining teaching*), she stipulated that it must satisfy the following three criteria: 1) experiencing academic success; 2) developing and/or maintaining cultural competence; and 3) developing critical consciousness with the purpose of challenging the systems of oppression (Ladson-Billings, 1995, p. 160). It is this last point that Bartolomé calls political clarity and that is often forgotten in current conversations about culturally responsive teaching. The teachers in Ladson-Billings' (1994) study who engaged in culturally responsive pedagogy were not reluctant to introduce the political aspects that related to the students' communities. The teachers also allowed the students to draw on their community knowledge as official knowledge in the classrooms. Related to the notion of culturally responsive teaching is the idea of "windows and mirrors." Originating in literacy research (Style, 1996), the term is used to argue that children need books that serve as mirrors into their own lives, and those that are windows into the lives of others. The term has also been used in mathematics education (Gutiérrez, 2018). In the narrowest understanding of culturally responsive teaching, it corresponds to the idea of a mirror: children must experience mathematics curriculum that is relevant to their lives. But if we are also to heed Ladson-Billing's third stipulation, then children need mathematics curriculum that is a window into others' lives, the hardships they encounter, and triumphs they achieve. Furthermore, what is a window to one child is a mirror to another, and it is dangerous to narrowly understand culturally responsive teaching as that which matches current interests of individual students in a class.

Gutstein (2006) based his work on the ideas of Freire (Freire & Macedo, 1987) about reading and writing the world with mathematics. Reading the world relates to "understanding the sociopolitical, cultural-historical conditions of one's life, community, society, and world," (p. 24), while writing the world simply means "using mathematics to change the world" (p. 25). Once again, this connects to Bartolome's idea of political clarity. The middle school students in Gutstein's class examined the housing prices in their neighbourhood to see if racism was a factor in the prices. Some other examples included wealth inequality and racial profiling during driving. The activities generated interest in mathematics, rich mathematical discussions, and allowed the students to use mathematics to read and write their world. Of course, the teacher in this case, Gutstein, was one with the appropriate political clarity with specific goals about the students' developing a political consciousness.

While teachers often have concerns about using this approach with younger students (McCormick Smith & Chao, 2018; Simic-Muller, Fernandes, & Felton-Koestler, 2015), there are examples of educators engaging in deep and productive conversations related to mathematics and justice with children as young as preschool (Chao & Jones, 2016; McCormick Smith & Chao, 2018; Murphy, 2009; Turner, Varley Gutiérrez, Simic-Muller, & Diéz Palomar, 2009). For example, Chao and Jones (2016) documented a deep and productive conversation about fairness and mathematics in context of Black History Month that took place in a Pre-K classroom.

Despite some exemplary cases in literature, it is not common for teachers to implement these ideas in the class, and even if they do, it is not clear that they will focus on getting

students to develop their sociopolitical consciousness. This should not be surprising. Political clarity does not develop overnight. Due to factors including barriers for prospective teachers of colour that exist at all levels (Carver-Thomas, 2018); and the diminished appeal of the profession due to lack of respect and resources, and focus on accountability and testing (Carver-Thomas & Darling-Hammond, 2017), the teaching profession remains predominantly White and middle-class. These teachers were raised in a society with a long history of housing (Rothstein, 2017) and school (Kozol, 2006) segregation and may therefore have limited experience with people of different backgrounds. Teachers are also a product of an educational system that discourages conversations about "controversial" topics, and even civics education in the United States is increasingly rare (Shapiro & Brown, 2018). Coupled with the persisting belief in the myths of meritocracy (Castro, 2010) and colour blindness (Sensoy & DiAngelo, 2011), it is understandable that prospective teachers do not come to education programs with political clarity, and that an education program by itself can only contribute so much to its development (Equity Alliance Blog, 2019). Furthermore, even if teachers do develop political clarity, Gutiérrez (2013) highlights how operating with political clarity could lead to the teachers facing obstacles in the school and the classroom. As such, teachers will need to find ways to subvert the system in their quest to support their minoritized and marginalized students in engaging in high level mathematics and bringing their whole selves to the mathematics classroom (Gutiérrez, 2016). To further complicate matters, given that it is mathematics, PSTs tend to believe that it is neutral and universal (Gutiérrez, 2013). Thus, even though they may believe in social justice, they may not believe that the mathematics class is appropriate to discuss these topics.

The larger goal of our study is to understand how PSTs can develop political clarity. To do so, our first step was to understand where the PSTs were currently and see if we could isolate the stages of progressions to develop into a mathematics teacher with political clarity. We conjectured that there was a continuum in the PSTs' beliefs as they traversed from a novice PST to one with political clarity. It was our goal in this study to understand the stages the PSTs passed through. We created this assignment in order to examine PSTs' beliefs and to gain insight into them. We conjectured that an important aspect of developing a political clarity in the mathematics class would be their openness in using problems that look at aspects of inequities experienced by minoritized and marginalized populations.

There are numerous studies that examine the beliefs that PSTs have about diversity and multiculturalism (e.g., Flores & Smith, 2009; Milner, 2005; Mills & Ballantyne, 2010; Molto, Florian, Rouse, & Stough; 2010; Siwatu, 2011; Tatto, 1996), instruments that measure these beliefs (e.g., Larke, 1990; Pettus & Allain, 1999; Pohan & Aguilar, 2001; Ponterotito, Baluch & Greig, 1998; Spanierman, Oh, Heppner, Neville, Mobley, Wright, Dillon, & Navarro, 2011), studies that investigate the change in multicultural beliefs (e.g., Garmon, 2004), and the impact of courses and experiences on multicultural beliefs (e.g., Bodur, 2012; Tatto, 1998; Wiggins & Follo, 1999). Despite the extensive literature related to diversity and multiculturalism, there are few studies that examine the beliefs of PSTs within the context of teaching mathematics for social justice, specifically, beliefs about the use of controversial issues in the mathematics class. Some notable exceptions are Simic-Muller et al. (2015) and Mamolo (2018). Mamolo examined the perceptions of learning and teaching mathematics using social justice contexts of 29 secondary mathematics PSTs in Canada. She designed three contexts - retirement, nutrition, and fair trade, and allowed PSTs to choose one to investigate. Some PSTs chose contexts because they were familiar, and others chose novel contexts to bolster their own learning of something new. The PSTs engaged with the retirement activity as they were personally interested and were familiar

with the mathematics. They were also interested in the nutrition and fair-trade activities as they felt that they learned about a new context. Besides their own learning, some PSTs believed that their students would benefit from similar activities that tied to social justice contexts. The activities would allow students to make connections to real-life and social issues. The majority of the PSTs in the study were open to the problems, but a few were openly resistant (6 out of 29). Some expressed beliefs about mathematics being unambiguous and politics-free, and some had difficulties dealing with problems that did not have a definite right answer. In terms of the constraints, the PSTs felt that the activities would take up too much class time, and some thought they were not mathematical enough. Mamolo suggests broader exposure to these types of problems if teachers are to develop an understanding of teaching mathematics with social justice.

Simic-Muller et al. (2015) used a mixed methods approach to examine the beliefs of 92 PSTs about using real-world contexts that related to injustices, controversial issues and cultural backgrounds of the students. Though open to the use of real-world contexts in the class (97% agreed that they would make connections with real-world issues as they were teaching mathematics), the PSTs were not sure about using controversial issues as a springboard for problems (61% were neutral; 27% agreed). However, 67% of the PSTs responding to the survey indicated that they were interested in learning how they could make connections to controversial issues in their teaching of mathematics (21% were neutral on the issue). In the interviews, PSTs generally drew on their everyday contexts like food and money as they provided examples. Some PSTs also thought that controversial topics were appropriate within certain classes with a particular racial and ethnic breakdown. Many PSTs were reluctant to discuss controversial issues with younger children. Further, they were concerned that the students would experience discomfort with these topics.

In this study, we decided to look at PSTs' beliefs about using real-world contexts related to controversial issues. We need a different approach of providing PSTs with the contexts within the problems, getting their reactions, and gauging their openness to implement the problems in class. While the literature on incorporating issues of equity, justice, power, and oppression in mathematics education is growing, there is still little literature on incorporating these issues in K-8 content classes (Felton-Koestler, Simic-Muller, & Menéndez, 2017; Martin, 2012; Mistele & Spielman, 2009). In this manuscript, we aim to fill the gap in the literature, and note that more work in this area is needed.

Measuring Beliefs

Beliefs are challenging to measure directly. Instead they need to be inferred from teachers' actions or their dispositions to act in certain ways. Ambrose, Clement, Philipp, and Chauvot (2004) underscored the challenge of measuring beliefs about teaching mathematics through surveys. Instead they had the PSTs interpret scenarios through a free-response format. The PSTs' responses were graded using a rubric that classified the responses based on the degree of evidence that was provided by the PSTs. Ambrose et al. (2004) developed inferences about the PSTs' beliefs based on their responses to the belief items. We took a similar approach to draw inferences about the PSTs' beliefs about real-world problems in the curriculum and the implementation of the problems in the classroom. We conjectured that the PSTs' beliefs about these contextual word problems would not be all or nothing, instead, the PSTs' beliefs would lie on a continuum that went from being closed to the use of these tasks in the class to being open to implementing tasks that were connected to the lived experiences of their students and could be controversial.

In this study we used the popular genre of word problems to draw inferences about PSTs' beliefs. Word problems have existed in mathematics for over 4000 years (Gerofsky, 2001). Even though word problems cannot be considered real-world, our interactions with PSTs indicate that they may believe that they are (Simic-Muller et. al, 2015). Given the PSTs' familiarity with word problems, we introduced the real-world contexts as the only new feature within the problem, in an attempt to prompt a reaction from the PSTs. Pilot tests with some of the word problems indicated that inserting a real-world context invariably led to the PSTs commenting about the nature of the context without much prompting during interviews. Under the umbrella term "real world," we identified sub-categories of injustice, controversial issues, and family background (Simic-Muller et. al., 2015).

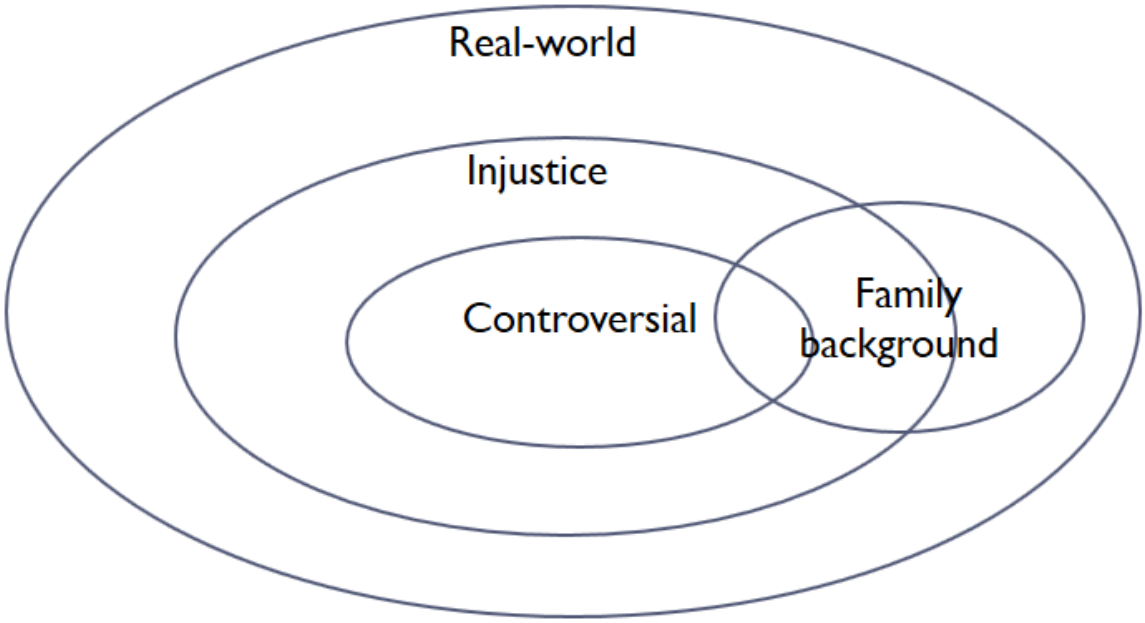

Figure 1. Types of real-world problems.

As seen in Figure 1, family background intersects all other categories. We conjecture that injustice is a broader category than controversial issues, as there are some injustices that are not controversial and others that are; though we do not expect that there will be agreement on which injustices are and are not controversial, especially in the current political climate.

Setting

This study took place in the first of two mathematics content courses for K-8 PSTs at a medium-sized private liberal arts university in the Pacific Northwest that the first author teaches almost every semester. The university has a stated commitment to social justice, and students encounter social justice issues across the curriculum, though not necessarily in other mathematics courses. Students enrolled in the course are typically first- and second- year students who have not yet entered the education program. A few are seniors who are majoring in a different discipline but will be getting a Master's degree in teaching at the university. However, most students in the course intend to teach K-5, with few interested in middle school mathematics. The first part of the course, which this study was conducted in,

focuses primarily on numbers and operations. Most work in the course is done in groups and PSTs (re)discover concepts of elementary and middle school mathematics through open-ended problems, work with manipulatives, and discussion. The PSTs vary in numbers and levels of prior mathematics courses taken and in beliefs about mathematics, and the course is designed as a safe space for those dealing with math anxiety to improve their relationship to the subject. Because we did not collect demographic data, we are unable to make accurate statements about the students' race, ethnicity, or socioeconomic status and do not wish to draw conclusions based on our own observations. All but three PSTs identified as female: we have chosen to use "they" pronouns throughout both to preserve anonymity and to deemphasize gender in our analysis.

In order to encourage PSTs to grapple with issues they have never considered in a mathematics class, it is essential to provide a safe and respectful classroom atmosphere (Oslund, 2012), and much class time is spent building relationships and helping PSTs overcome their prior negative experiences in mathematics. The course incorporates issues of equity and justice, though most take place after this assignment is administered, in the second half of the course.

Task Design and Data Collection

The assignment (see Figure 2) engages PSTs in problems that can all be solved using division, and which include decontextualized problems as well as different real-world contexts. It is aligned with Villegas' (2007) recommendation that PSTs be given opportunities early in the teacher preparation program to critically examine their beliefs. The assignment was adapted from Gutstein and Petersen (2013), Tate (2013), and Trexler (2013). In the introduction to *Rethinking Mathematics*, Gutstein & Petersen (2013), building on the work of Freire and Macedo (1987), and in line with Bartolomé (1994, 2004) and Gutiérrez (2013), reiterated that all teaching is political. They used two word problems as examples: one about purchasing candy and the other about the wages of a sweatshop worker, both solved by multiplying 43 and 12. Even though one might refer to candy purchasing as a neutral context, according to them, "[t]he first example has subtext of consumerism and unhealthy eating habits; the second has an explicit text of global awareness and empathy. Both are political, in that each highlights important social relations" (p.6). For this reason, we refer to the so-called neutral contexts in quotation marks, to denote that these contexts are not neutral and promote a particular set of values.

Trexler (2013) used these two problems to create a similar assignment that she used in her classroom: she kept the same contexts of candy and sweatshop labour, but the operation used is division. Our assignment contains the same problems with different numbers, updated based on our research on the actual pay of sweatshop workers in Honduras. The third problem, the "bus pass problem," was also taken from Trexler. This problem was popularized by Tate (2013), who wrote about it as an example of curriculum that treats experiences of White middle-class students as central and typical. We added one more problem that was initially about the U.S. war spending between 2001 and 2017. Because the university where the study was conducted is in an area with a large military and Air Force base, we chose to change the context of that problem to the war on drugs instead. We also added a decontextualized problem with the same numbers as the word problems, to gauge whether PSTs prefer one type of problem over the other. The problems were selected to represent our four categories of contexts: "neutral," injustice, family background, and controversial issues. By design, some problems were mathematically equivalent but presented different contexts (i.e., candy and sweatshop labour, decontextualized problems

and word problems). We wanted to see if the PSTs would see the problems as same or different, and whether the injustices and controversial topics would evoke any emotion from them.

Problem 1. Find the values of the following expressions as decimals:

13.50/12=

16/1.50=

1000/47=

Problem 2. Several students go to the store. They buy 12 candy bars that all cost the same and spend $13.50. How much does each candy bar cost?

Problem 3. A factory worker in Honduras works 12 hours a day and earns $13.50 in daily wages. How much does she earn per hour?

Problem 4. It costs $1.50 each way to ride the bus between home and work. A weekly pass is $16. Which is a better deal, paying the daily fare or buying the weekly pass?

Problem 5. The U.S. has spent $1 trillion on the war on drugs since 1971. How many billions has it spent, on average, per year, since 1971?

Figure 2. Problems in the Assignment

The assignment was first given in Spring 2016, and 75 PSTs participated over five semesters, concluding with Fall 2018. In the latest two iterations, the assignment has become more elaborate, is worth more points, and includes a second part in which PSTs suggest contexts for word problems that they would use (see Appendix for full assignment). The PSTs' written responses to the questions in Figure 2 form the data corpus considered in this study. Furthermore, we only considered 33 PST responses, from Spring and Fall of 2018, for our analysis. Each PST's work received a simple code, a letter and a number. The letter designated the semester the assignment was collected (S for spring and F for fall), and the number represents the ordering of the assignments as we analysed them. The assignments were not arranged in any order.

Data Analysis

We examined the written responses individually and wrote memos as we compared the PSTs' responses to the same questions. We were interested in how the PSTs discussed the contexts of the problems. As mentioned in the data collection, the problems were supposed to evoke a feeling among the PSTs, especially with the contrasting contexts that went from just numbers and "neutral" contexts like buying candy, to the more controversial ones of government spending on the war on drugs. We wanted to see what the PSTs would notice about the problems. Would they just notice the numbers and the operations, or would they notice the contexts of the problems? In reading and contrasting the PSTs' responses to the tasks we observed patterns that helped us group the PSTs' responses. This classification, through discussion and refinement, eventually led to the development of the framework.

Each researcher did an independent analysis of the student responses and thought about possible categories (Patton, 2002). Based on our independent analysis, we designed three and four categories for the responses respectively. We agreed on the beginning and end of the continuum of beliefs and had a discussion about whether there was one category, or two categories of beliefs, in the middle. We agreed that the first category consisted of PSTs who

did not like any controversial context and wanted to implement the candy problem since this would be a familiar activity for the students, or who expressed no interest in any of the contexts. On the other hand, the PSTs in the other extreme category were open to getting their students, no matter how young, exposed to controversial contexts. There was some debate about the PSTs who were interested in broader issues referred to in the problems, though they were reluctant to implement these in the class. For example, the PSTs would often mention that they were interested in the tasks and felt that they learned a lot about the world. However, some stated that even though the problems were personally interesting and useful, they would not implement some of them in their class (e.g., wages problem). We paid attention to the reasons that the PSTs stated to help our classification. In response to the question which problems they would modify and how, some PSTs mentioned that they would change the problem to something that was relatable to their students, with the unstated assumption that all their students would relate to the new context. There were other PSTs who noted the low wage in the task. Thus, they suggested that the context could be changed to a student mowing the lawn with an hourly wage. In our discussion we noted that these features were important in the overall analysis.

Results

After examining the responses across the students in Spring 2018, we developed three typologies - Not yet interested, Interested and reluctant, Ready to engage, as well as a fourth, aspirational one - Fully developed. The common characteristics of each type are given in Table 1. We elaborate on the variations and give examples for each type below.

Table 1
Common Characteristics of Each Category

Type	Characteristics
Type 1: Not yet interested"	Little writing
	Little personal interest
	Depoliticizing contexts
	Would use problem 2
Type 2: Interested and reluctant	Personally interested
	Would use problem 2
	Reluctant to use some or all problems 3-5
Type 3: Ready to engage	Personally interested
	Comfortable with mathematics
	Not as enthusiastic about problem 2
	Would use most of the problems 3-5
	Do not dismiss 5 as inappropriate

Type 1, "Not Yet Interested"

Twelve out of the 33 PSTs were categorized as Type 1. These PSTs did not elaborate on their responses. Their assignments expressed little or no interest in the problems, and there was no visible emotional response to any of the contexts. Three explicitly stated that the

problems did not interest them while others wrote brief, general responses about why they might be interested in the problems, but with little conviction. Seven out of the twelve thought that the problems were relevant because they dealt with money. None were openly resistant to these problems, though one wrote, "I am not really interested in the problems. If it is a real-world problem or a fake problem, it doesn't really matter to me." The written responses were typically short, and sometimes discussed only the mathematics and not the contexts of the problems. While their responses about which problems they would use in their classroom varied, all twelve agreed that they would not use problem 5, six because of the mathematical content ("because it's challenging to work with such a huge amount, never really happens in math"), and six because of the "too mature" or "too invasive" content that "children would not understand" or because "that is inappropriate for young children." Another common feature among the 12 responses was the push to depoliticize the context of the Honduras factory worker problem: those who would use it stated that it was useful because wages were pertinent, "important to know [how] much one gets paid for working" but did not mention the injustice implicit in the problem, and the PSTs who would not use the problem did not explain why. Three would change the context to mowing lawns, a librarian, or a place that would be familiar to children. Though not all the PSTs specifically discussed the candy problem, those who did, held it up as an example of a problem that is "relatable" to children; stating, "because kids are interested in food." None of the PSTs had any concerns about the context of candy. We would like to know how these PSTs' beliefs about the nature of mathematics, their perceptions of themselves as mathematics learners, their prior experiences with word problems, and their beliefs about the roles of teachers impact their response to this assignment. We speculate that their responses stem from limited interest either in mathematics or in the world outside their immediate personal experience, and that experiences outside of mathematics classes might be necessary in order to help PSTs in this group to move to Types 2 and 3.

Type 2, "Interested and Reluctant"

The 12 PSTs placed in this category had an emotional reaction to the problems and were personally interested in them. Some wrote that the problems made them sad, or more aware of the world. One wrote, "The math felt like it was something important being calculated rather than a pointless math problem." There was a greater variety of responses in this category, in particular on their openness to using these problems in the classroom. Based on their openness, we placed 12 PSTs on a continuum, and found that they fell into three distinct areas (see Table 2). All the PSTs stated that they would use the candy problem, and only one PST mentioned that the problem was not particularly interesting. A small subset (four PSTs), while personally very interested in the problems, stated with little uncertainty that they would only use the candy problem in their classes. For example, one wrote that Problem 5 was the most realistic, but that they would use the candy problem in the classroom "because it is easier for the student to understand, rather than the war on drugs problem which I would not use in a classroom because it is more complicated for students." Others were more open and would use additional problems. Many of them showed awareness of unethical labour practices. Only two PSTs changed the third problem from being about a sweatshop worker to "someone students would know," or doing a familiar task like mowing a lawn. Only one PST did not discuss the problem at all, and six found it relevant and wanted to use it in their classrooms, not just as a word problem, but to raise awareness of issues. For example, one PST wrote, "This problem helps when thinking about the wages that I make as a teenager versus adults working in a factory in Honduras (differences in labour)," and another, noting

that children might not know much about Honduras, said that "it would be cool to do a mini lesson about the location and then several problems that involve Honduras" and also suggested comparing the sweatshop workers' wages to those of minimum wage earners in the U.S.

Some PSTs in this category made assumptions about what children would and would not know: that "the kids would be uninterested" in Problems 3-5, as "it is unlikely for them to work a factory job or know about the finances of the United States or how to spend their money," and that candy "is what the students know." These were the four PSTs we placed at the initial end of the continuum, as similar to Type 1 but expressing more interest in the context (see Table 2). Their justifications for avoiding these contexts included "I would not want to ruin students' innocence" or "students would not know/care." These responses are problematic because they assume as "normal" the experience of White middle-class students whose families have not experienced visible hardship. Furthermore, they assume knowledge about what students know or care about, without considering the variations in student experiences. Another common response related to the previous responses was that they would only use issues that were relevant to kids. While this is definitely commendable and shows that some version of culturally responsive teaching is gaining traction in education, it is important to recall Ladson-Billings' (1995) definition of culturally responsive teaching, which places critical awareness as central and to note that many PSTs in this category depoliticize the contexts. While primarily focusing on mirrors, PSTs are missing out on the opportunity to use mathematics as a window into the world.

Table 2
Sample Quotes of PSTs in Type 2 Based on Their Location in the Continuum

Location on continuum	Sample quotes (each PST has a code that consists of a letter (S for spring and F for fall) and number between 1 and number of students in that course
Like Type 1 but more interest	S3: "The candy bar problem in a classroom because it is easier for students to understand, rather than the war on drugs problem which I would not use in a classroom because it is more complicated for students." (interested, would only use candy problem) F6: "The candy bar and bus ones to introduce the concept of decimals but the other two eventually because it's important to show children how the real world is" (minimal information, but interested and open) F7: "I would use the chocolate problem because it would interest 3-5 and 6-7 year olds… I wouldn't use the Honduras worker or drug wages because the kids would be uninterested as well as the drug problem has numbers, they probably couldn't count up anyway." (interested, would only use candy problem) F8: "The US treasury problem was the most interesting to me. I would use the question about candy in my class because it's what the students know." (interested, would only use candy problem) F16: "I would not use questions 3-5 because my students would not be able to relate to them. In elementary school it is very unlikely for them to work a factory job or know about the finances of the US and how to spend their money." (would only use candy problem)

Ambivalent	S9: "Out of all the problems, the war on drugs problem will likely be the problem I leave out. I feel this issue is unnecessary for students to be learning at the age I plan on teaching" (will not use problem 5) S10: "In my classroom I would probably use problems 2 and 4 because they are real world problems, but they are also relatable… I would probably not use problems 1 or 5… Problem 5 would probably be too hard for younger kids…" (will not use problem 5) F5: "1-4 are very relevant & interesting to solve & consider. I would not use 5… because I wouldn't want students looking into drugs & getting involved negatively in any way." (will not use problem 5, protecting student innocence) F12: "I will say though that I wouldn't give a problem with that context until fourth or fifth grade, because I feel like introducing how much the world sucks that early in life would take away their childhood innocence a bit too early." (protecting student innocence) F15: "I'd use problems 2 + 3 because they address problems and situations that are real life/applicable to real life; and may give students insight into real world issues" (will not use problems 4, 5)
Similar to Type 3 but more reluctant	S5: "I think I would possibly use any of them, but maybe with some changes. …I think I could modify 5 for use by changing the topic, unless there had been a conversation about the topic already." (prefers not to use 5) S12: "I would use [1-4]. Because the numbers are manageable, there are scenarios that connect math to real life applications, and many of the story problems could lead to good conversations… I suppose if the students seemed interested in big numbers a problem like [5] or similar would work." (prefers not to use 5)

Six PSTs specifically identified Problem 5 as very interesting or most interesting ("I find this problem very interesting because I am interested in our government spending"), yet only two stated that they might use it, and only if students were interested but not otherwise. We do not suggest that all teachers should discuss the war on drugs with students, regardless of age and interest. Rather, we believe that teachers should be open to discussing all topics using sound judgment, with the understanding of students and their communities. We use the war on drugs as a proxy for controversial topics, and the reluctance to use this particular topic could suggest that these PSTs are generally reluctant to address controversial topics. Because the problem uses large numbers, which made some PSTs quite uncomfortable, we are unsure whether the resistance in some cases comes from the context or discomfort with the numbers. We have addressed this issue in the most recent version of the assignment by including related controversial topics that do not require dividing trillions of dollars.

Consistent with our prior findings, PSTs in this group were more comfortable with contexts dealing with injustice (sweatshop wages in Honduras) than controversial ones (war on drugs). This indicates that mathematical conversations about injustice, such as unfair labour practices or lack of representation by people of colour and women in positions of power, may be good topics for introducing PSTs to issues of social justice in mathematics content courses and a starting point for helping them develop political clarity.

Type 3, "Ready to Engage"

There were eight PSTs in this category. While there was variation in their openness to the different contexts, there were some traits they all shared. The PSTs in this group were generally comfortable with mathematics. They did not think that the problems were confusing and only one commented on the fact that the answer in the second and third problems had three decimal places and had to be rounded, while PSTs in other categories were more likely to express discomfort with this fact. While we did not look at this more closely, we are interested in exploring the connection between PSTs' mathematical identities and their openness to more controversial contexts for problems.

The PSTs in this category were generally not interested in the candy problem: five stated that it was uninteresting and that they might not use it, and one even wrote that the problem has "few positive outcomes"; the others mentioned that they would use it but did not express as much enthusiasm as PSTs in the previous two categories. Four explicitly said that the sweatshop problem was important to discuss due to its global and human rights implications, and that "it isn't too deep for children," while only one wrote that she would avoid it as it was too sad (this is also one of the PSTs where we had initial disagreements on whether to place in Type 2 or 3). About this problem, one of the PSTs wrote that it was "age appropriate, challenging," and that it was also "letting them test their moral compass. What is wrong? What is right? You decide!"

Another shared characteristic in this type was lack of outrage over the mention of the war on drugs. Whereas in other categories PSTs dismissed the entire problem, usually because drugs were not an appropriate topic to discuss, in this category, there was a much more nuanced discussion of the problem. All the PSTs pointed out that this was an important issue. One expressed interest in learning more about the subject; another commented on the damage that the war on drugs has done and the financial resources it has taken away from other government programs. Another PST wrote, "How much our government is spending is something real and something we should look at more." Out of the seven, five stated they would use the problem; though one was worried that they would not be allowed to do so by school administration, adding, "which breaks my heart because I think kids have the right & obligation to know about what's going on in the world." The other two did not entirely dismiss the problem but thought it would be a complex topic better left for middle school.

The PSTs in this category also expressed humility and willingness to learn. One response in particular stood out. In response to the question of how the problems help make sense of the world, this PST wrote, "I don't think they help me understand the world better than before. If anything, I feel more confused. Problems 2 and 4 fit my current model of the world. However, Problems 3 and 5 show the unfairness that exists in our world." We did not see similar disequilibrium between prior understanding of the world and the information that the problems presented in PSTs from previous categories; yet disequilibrium is needed for learning and growth. PSTs in this category also realized that these problems are just that: word problems with minimal context. Five out of the eight explicitly mentioned this. For example, one would have a class discussion about Problems 2 and 3 and how they relate, another noted about Problem 5 that "students would likely need significant background information in order for it to make sense." and another wrote, "If I used 3&5, I would connect lessons to it." This is important because if social justice contexts are brought into the classroom but treated as regular word problems without proper reflection and background information, then they are just like other word problems.

The changes PSTs in this category suggested for the problems were also generally different than those in the other two and were more realistic. For example, one would change

the candy problem to one about food waste, one would add the sales tax to the candy problem, and another would compare the Honduras wages to the wages in the local area.

While certainly farther along on the continuum, these PSTs also shared some characteristics with the PSTs in previous types. For example, they might still make assumptions about children's' interests. One wrote about the bus problem that "kids probably wouldn't be interested in the subject matter." While insisting that children should learn about these and other related contexts, none referred to specific groups of students, for example students of colour being most impacted by the war on drugs. However, this is not surprising since none of the PSTs are in a formal practicum yet. Finally, one PST wrote about the Honduras problem, "This problem helps me understand just how hard others have it and how blessed I am," showing that the PSTs' political clarity is nascent, with room for further development.

Type 4, "Fully Developed"

While all responses we received fit into three types, the data suggests a fourth. In this type, PSTs would go beyond reading the world with mathematics to also writing it (Gutstein, 2006). A PST in the fourth type would seek to understand the students in the class and the unique experiences that these students bring as resources. The PST might say that choosing the contexts to study would depend on children's experiences and lives. While acknowledging that children may have some seemingly universal interests (e.g., playing, dancing, singing), it is important to note that no experience is truly universal: children play different games, sing different songs, and celebrate different holidays at home, or they may be left out of these experiences; and the "universal" culture of school is often the culture of the dominant group (Tate, 2013). Therefore, while teachers should seek to create a common classroom culture, they should also not assume that they know their students' interests before getting to know them. The PSTs would also seek to engage the students in understanding macro conditions that impact the lives of their students and their communities. For example, teachers might help students use mathematics to investigate issues in their school and even present to the school board with the hope of improving conditions such as overcrowding (Turner & Strawhun, 2013), proposed closure (Varley Gutiérrez, 2013), or the proximity of liquor stores (Brantlinger, 2013). With their political clarity, they would explicitly talk about using the contexts to empower students to change the world. It is possible that the questions in the assignment in this study, or the prior experiences of the responding PSTs, precluded PSTs from giving such responses, and we hope that the distance between Type 3 and Type 4 is short and easy to cross.

Limitations

The problems we used in the assignment are artificial in that they provide no context for the exploration. Furthermore, they all deal with money, thus reinforcing the common belief that real-world mathematics mostly deals with money or time (Lee, 2012). We used these problems because they are a genre that is familiar to students (Gerofsky, 2001), but they are not necessarily as rich as we would like them to be. They do not, as presented, allow for "understanding, unpacking, and critiquing social issues and their implications" (Mamolo, 2018). It is worth noting that these problems were followed up by an assignment where the PSTs created their own mathematical problems where many of them investigated realistic contexts, though related to the ones typically used like cooking and baking, travel, and spending. Presented by themselves, these problems would not be sufficient to offer insights

into the type of real-world mathematical explorations that are possible, but in context of a course that also introduces such contexts, they offer valuable, though limited, insights.

Because of how some of the problems were worded, it was difficult to distinguish between resistance to the context and discomfort with the mathematics. This was especially the case with the problem dealing with the cost of the war on drugs. Some PSTs commented that the problem was inappropriate because of the very large numbers, which is a fair concern, especially for those teaching younger grades; we allow for the possibility that the same context with smaller numbers might get different responses and have adjusted the assignment accordingly. We are also aware that some PSTs like to write more than others, and that a short response cannot always be distinguished from lack of interest. Even though we paid more attention to the wording of responses than to their length, it is possible that some PSTs might express more interest in the contexts in a one-on-one conversation than in a written assignment. Because the first author interacts extensively with the PSTs, and because the categorization matches their other work and interactions, we think that the miscategorization due to brief responses is possible but unlikely.

Furthermore, although the assignment includes each of the types of real-world problems from our characterization, because each type is only represented with one problem, all of which have its challenges, it may not be possible to fully understand the PSTs' relationships with these problems. For example, a PST may be opposed to discussing the war on drugs in class but may be more willing to talk about other controversial issues. As mentioned earlier, we are not proposing that all teachers discuss the war on drugs in their classrooms, but are instead looking for openness, interest, and awareness that this is an issue that already affects children; and in that sense we believe that the problems provide a good approximation for the PSTs' opinions and beliefs.

Finally, we acknowledge the unique nature of our context: The Pacific Northwest if considered to be a more politically progressive part of the United States, and the beliefs expressed by these PSTs cannot simply be generalized to the entire country. The university's proximity to a large military base, as well as PSTs' backgrounds that include small towns, rural areas, cities, and progressive and conservative parts of the state, necessarily influence their interest in and openness to different contexts. This is a limitation and an opportunity for being more culturally responsive in teacher preparation and considering PSTs' own backgrounds in the curriculum.

Discussion

In this study, we used word problems to understand the PSTs' beliefs about real-world problems and their views about implementing these in their future classrooms. Based on the responses, we developed three typologies that reflected a progression towards openness to the use of different types of real-world contexts in their future classrooms. The analysis of the typologies suggested a fourth typology that would include PSTs with a high degree of political clarity. While this is a preliminary study, it does provide some indication of the nuances in the beliefs that PSTs have about real-world problems. Based on our analysis of the data and considering existing literature, we make some conjectures and general recommendations for teacher preparation related to the PSTs' understanding of mathematics, the world, and children and communities.

Understanding of Mathematics

The participants in our study were primarily first- and second-year students who had not yet entered the education program and had little prior experience thinking about real-world mathematics problems that did not have "neutral" contexts. PSTs will be resistant to such contexts if they never experienced them as learners, both in K-12 and college (Rodriguez & Kitchen, 2005). Further, even if they were familiar with injustices, they could consider it inappropriate to discuss issues like unfair labour practices with young children, for example. Content courses for K-8 teachers can play an important role in exposing PSTs to not just simple word problems like the ones we used for this study, but rich investigations that help read the world with mathematics (e.g., Felton-Koestler et al., 2017; Gutstein & Peterson, 2013). Even if PSTs investigate multicultural issues in other courses in their teacher education programs but get messages from mathematics content classes that mathematics is neutral, then they will continue to perpetuate this message. Content courses need to engage in a sustained conversation about the culture of institutional mathematics that has served as a gatekeeper and kept out many and needs to provide examples of how mathematics makes sense of the real world with a range of contexts. While there is a place for "neutral" contexts, in order to educate a mathematically literate and informed citizenry in the era of disbelief in facts, we need teachers with a political clarity who will not be afraid to use mathematics as a powerful tool that it is to investigate the world and develop students' critical consciousness with the purpose of challenging the systems of oppression (Ladson-Billings, 1995). In addition to exposure to the use of controversial topics in their content courses, the PSTs need guidance in developing their beliefs about implementing controversial contexts within problems in their own classes. This is especially important for future teachers of younger children, as they are the ones in our study who were most likely to say that children would not know or be interested in these issues. Providing examples of successful teachers of young children engaging in conversations about controversial issues, especially in relation to mathematics is needed, but such examples are rare (Chao & Jones, 2016; McCormick Smith & Chao, 2018; Murphy, 2009; Turner et al., 2009).

While it is not within the scope of our paper, it is worth noting that PSTs had differing opinions on Problem 4. While some identified it as their favourite, others disliked its open nature and the fact that it had more than one correct answer. This is like Mamolo's (2018) findings that some of the participants in her study were uncomfortable with problems that did not have a definite answer.

Understanding of the World

One way to normalize the injustices and controversial topics in mathematics courses is to normalize them in all conversations. We conjecture that, due to the nature of our educational system, many of our PSTs are not sufficiently informed about issues like the historical oppression of communities of colour or limited upward mobility in the U.S. society. We believe that more exposure to these issues across the curriculum would be beneficial.

We have informally observed that particular prior experiences have a positive impact on PSTs' understanding of and openness to issues. Many of the PSTs who we placed in Type 3 had extensive prior coursework on these issues, were politically active, had related lived experiences, or campus positions in which they received significant training about issues of social justice. In addition to developing strategies for recruiting teacher candidates of colour

(Carver-Thomas, 2018), teacher education programs should pay attention to co-curricular activities that PSTs participate in and connect them to the curriculum.

Knowledge of Children and Communities

As many PSTs have had limited experiences with students who have backgrounds different from theirs (Castro, 2010; Martin, 2012), it is not surprising that they do not necessarily make the connection between the contexts and students' lives. For example, the war on drugs has had a devastating impact on all communities, and especially communities of colour: it is estimated that 1 in 28 U.S. children and 1 in 10 African American children has an incarcerated parent on any given day in school, and 1 in 4 will have a parent incarcerated during their time in school; and the majority of the offenses are for drug possession (Morsy & Rothstein, 2016). Yet, PSTs in this study thought that children would have no knowledge of or experience with the war on drugs, and many instead assumed that candy would be the context most familiar to children. Presumably, they view candy as a neutral context. The PSTs need experiences with students during their preparation so that they can understand the students' perspectives and use this insight as a resource in their teaching (Fernandes, 2012). Participants in our study frequently talked about the need for problems to be relatable to students, showing that they understand the significance of culturally responsive teaching. However, in alignment with Villegas' (2007) and Castro's (2010) findings, their understanding of what is relevant to children might not be very deep. Some ways in which they modified problems are relatable to middle class students, such as allowance for mowing lawns. It was also common for participants to depoliticize the contexts. For most PSTs, it was not a conscious decision, or at least not a stated decision, which they defended with the desire to make contexts relevant to children. But how will they know what is relevant to children if they have not interacted with them? And even when they interact with children in their field placements, how will they view the interests of the students as assets rather than deficits (González, Andrade, Civil, & Moll, 2001)? Does focusing on what is relevant to students also mean that children should only see mirrors in the math class, or is there a place for windows, especially as mirrors for some are windows for others and vice versa? Should teachers not discuss sweatshops because children do not know where Honduras is? Like Mamolo (2018), we found that some PSTs found it essential that contexts should be familiar to them and their theoretical students, while others considered the problems an opportunity to learn more about the world. This is exactly the tension between windows and mirrors, but we strongly believe that in order to develop informed citizens, we need both.

In order to be well-prepared beginning teachers of mathematics who attend to students' lives (AMTE, 2017) and uplift all their identities (Aguirre et al., 2013), PSTs need multicultural experiences and they need spaces to reflect on these experiences (Gay & Kirkland, 2003). Just putting PSTs in diverse environments is not enough and may in fact only exacerbate the issue by reinforcing deficit beliefs about children and making them blind to their own privilege (Fernandes, 2012). Mathematics content courses also have a part to play by giving PSTs multiple opportunities to engage with authentic real-world contexts that investigate topics related to students' lives, injustices, and controversial issues and that serve as windows into the lives of their future students.

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Appendix

Full Assignment

Part 1

Find the values of the following expressions as decimals:

13.50/12=
16/1.50=
1000/47=

Several students go to the store. They buy 12 candy bars that all cost the same and spend $13.50. How much does each candy bar cost?

A factory worker in Honduras works 12 hours a day and earns $13.50 in daily wages. How much does she earn per hour?

It costs $1.50 each way to ride the bus between home and work. A weekly pass is $16. Which is a better deal, paying the daily fare or buying the weekly pass?

The U.S. has spent $1 trillion on the war on drugs since 1971. How many billions has it spent, on average, per year, since 1971?

Part 2

What are your thoughts and feelings about each of the problems?
How real-world is each problem?
How much does each problem interest you?
How does each problem help you make sense of the world you live in?
Which, if any, of the problems would you use in your classroom? Why?