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Teacher Educators Learning with Prospective Teachers: Finding Relevant Mathematics in Our (Their) Lives

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Abstract

Two mathematics teacher educators (MTEs) discuss the mathematical contexts generated by prospective teachers (PTs) when pushed to look for relevant mathematics in their lives and communities. Through collaborative teacher action research focused on iterations of collecting, categorizing, and discussing PTs' mathematical contexts, and posing selected examples for PTs' own examination, layers of learning occurred for both PTs and MTEs. PTs began to craft more personalized, story-like contexts, seemingly noticing more mathematics in their lives. MTEs were unexpectedly pushed to clarify their thinking about what it means to develop contexts that are authentic and relevant, and to contemplate how their actions were influencing the mathematical stories told by PTs.

Keywords: prospective teachers, culturally relevant, mathematics contexts, teacher education

As mathematics teacher educators (MTEs), we aspire to support prospective teachers in developing mathematical contexts that engage students through personal connections, drawing on the mathematics used in children's homes and communities (Moll & González, 2004; Villegas & Lucas, 2002). Yet, we have repeatedly felt dissatisfied when prospective elementary teachers (PTs) created mathematical situations with superficial connections to students' lives and cultures. We also strive to better model this, connecting our PTs' homes and community knowledge to mathematical content. Based on our experiences as mathematics learners, we speculated that our PTs might not have personally experienced mathematics tasks connected to *their own* homes and community knowledge. Thus, we conducted collaborative action research (Capobianco & Feldman, 2006; Carr & Kemmis, 1986) with two goals: a) to support our PTs in generating mathematical stories drawing on their homes and community knowledge and b) to learn how we as MTEs might connect mathematics tasks to our students' (i.e., PTs') homes and

community knowledge in meaningful ways. In this paper, we discuss the evolving ways PTs responded to prompts to write about mathematical contexts in their own lives and our MTE learning that resulted from engaging in this action research.

Background: Motivation of Goals

Research has shown that mathematics-learning contexts drawing on students' cultures and community knowledge supports the needs and engagement of diverse learners and improves mathematics learning (Civil, 2007; Civil & Khan, 2001; Gutstein & Peterson, 2005; Turner et al., 2009). Innovative examples can be found where teachers have moved beyond generic "real world" contexts to connect their mathematics curriculum to real problems important to their students' cultures or interests (Gutstein & Peterson, 2005; Gutstein, 2006a, 2006b; Tate, 1995). Students who are given the opportunity to explore mathematics through such tasks have shown learning gains and increased excitement for mathematics (Civil & Khan, 2001; Turner & Strawhun, 2007).

Both authors have taught mathematics methods courses, including a series of assignments (e.g., student interviews, community walks) designed to help PTs develop lessons to engage students' out-of-class knowledge resources (Drake et al., 2015). Despite PTs' valiant efforts to design tasks meaningfully connected to their students' cultures and communities, Lindsay noticed that resulting contexts seemed superficially related to children's lives. Indeed, tasks appeared to draw on PTs' familiar knowledge (Nolan & Keazer, *in press*). rather than "mining" knowledge from their students (Ladson-Billings, 1995).

We considered how we might better model culturally relevant contexts connected to our students' (i.e., PTs') lives for use in our mathematics content and methods courses. Simic-Muller et al. (2009) described supporting their students in noticing and bringing knowledge and

experiences from the students' homes and communities. They followed the principle that "real-life problems do not have neat, predictable outcomes…and the mathematics involved is authentic and relevant to students" (p. 208). We wanted to develop authentic real-life problems that would be relevant to our PTs, connecting to their homes and community knowledge. Due to our university settings, where PTs' homes and communities are far from campus, community walks to learn about each PT's neighborhood (Drake et al., 2015; Leonard & Guha, 2002) were infeasible. Hence, we asked our PTs to practice noticing and sharing mathematics contexts from their own homes and community knowledge.

Ladson-Billings theorized three components of culturally relevant pedagogy: academic achievement, cultural competence, and sociopolitical consciousness (Ladson-Billings, 1995, 2006). While we attempt to develop all three components into our own and our PTs' culturally relevant pedagogies, we forefront cultural competence in this research. Ladson-Billings (2006) describes cultural competence as:

> helping students to recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture, where they are likely to have a chance of improving their socioeconomic status and making informed decisions about the lives they wish to lead. (p. 36)

By emphasizing the importance of finding connections between mathematics and our PTs' culture, we hope they may experience the enhanced learning resulting from cultural practices being honored and connected to mathematics. We hope they will learn to value developing connections between mathematics and culture—that of their own and their future students'.

Academic achievement and sociopolitical consciousness, the two other components of Ladson-Billings' (1995) theory of culturally relevant pedagogy, are not the focus of this

particular work though both are valued in our teaching. Academic achievement (i.e., student learning) is characterized by Gutiérrez (2012) as a part of the "dominant dimensions" of equity, due to being a component of equity most readily recognized across the field of mathematics education. Meanwhile, the "critical dimensions" of equity related to identity and power are frequently neglected. Improving the academic achievement of PTs and their future students through modeling formative assessment practices is part of our everyday practice as MTEs. Alternatively, the component of sociopolitical consciousness is one we aspire to incorporate more explicitly into our future action research, building on our learning from this project. As we learn to support PTs' in noticing how mathematics is connected to their lives, we also hope to sharpen PTs' sociopolitical lenses to identify ways to use mathematics to examine issues of justice affecting their lives.

Method: Fostering Authorship of Mathematical Contexts

We engaged in a collaborative action research model (Capobianco & Feldman, 2006), focusing on a common goal while allowing our voices, philosophies, and teaching methods to remain distinct. We align our view of action research with the original work of Carr and Kemmis (1986), who conceptualized action research as a systematic, reflective inquiry into our classroom practices with the aim of improving our teaching and understanding of our teaching. Through parallel action research projects in our unique contexts, we individually worked toward our mutually developed goals. Lindsay's context was her elementary mathematics methods course and Eryn's her elementary mathematics number and operations course. Lindsay's course served seniors one semester prior to student teaching. Eryn's course was PTs' first mathematics-for-teachers course, before PTs entered their teacher education programs. Our collaboration meant

regularly meeting as critical friends (Kemmis & McTaggart, 1988; Riel, 2019), reflecting on our learning and the results of our actions.

Action research is often described as a spiral or cyclical process through the phases of planning, acting, observing, and reflecting (Anderson et al., 2007). We developed a shared timeline for our research, simultaneously engaging in three mini-cycles of action research that were each two weeks long, with additional reflection looking across the three cycles at the completion. During each two-week cycle, we implemented our planned actions, observed their impact, and collaboratively reflected on how to use our findings to inform our actions in the next cycle. We describe each of these components below.

During each cycle, a central component of our actions was to prompt PTs to write about the mathematical contexts that they could identify in their lives, using the following prompt: "*Word problems in the classroom are not always authentic or connected to peoples' experiences. Let's look for ways to bring in math from our own culture. What math have you noticed in your home, your life, or your community?"* We collected two types of data to inform our subsequent actions: PTs' responses to the prompt and our MTE field notes and reflections recorded through email conversations and notes from virtual discussions.

At each iteration of collecting PTs' responses to the prompt, we engaged in an individual reflective process of "wandering through the data" (Anderson et al., 2007), noting elements that seemed to be significant and searching for emerging patterns. We looked across PTs' responses in each iteration, noting commonalities and divergent examples. We separated and isolated potentially interesting responses, journaling our observations through email correspondence to each other. We selected responses representative of commonalities, as well as divergent responses that might illustrate deeper connections between mathematics and PTs' homes and

communities. We then met for virtual discussions to share and discuss our selected responses, the patterns we noticed, and our developing interpretations. This collaborative component, serving as critical friends who question and provide additional perspective, pushed us to clarify and explain our thinking about similarities, differences, and strengths of PT-authored contexts. Our conversation often discussed what aspects of responses we perceived as providing superficial, unique, or deep connections to a PT's culture or community.

Our analyses and discussions played an important role in informing our decisions and actions, leading to the following cycle of action research: sharing analysis with our PTs by presenting selected examples of their peers' responses and using them to discuss how mathematics contexts connect to people's lives. After the discussion, we encouraged them to continue noticing mathematics outside of class. The next week, we repeated our initial action of asking PTs to respond to the writing prompt and the cycle repeated through three iterations.

Findings: Process of Learning to Notice Mathematics

Our goals for this action research project were to support PTs in writing mathematical contexts personally relevant and to develop our own use of mathematical tasks meaningfully connected to our PTs' homes and community knowledge. The repeated process of soliciting and analyzing PTs' responses then using sample responses to motivate class discussions about potential contexts for exploring mathematics, provided growth for both ourselves and our PTs. Growth was evidenced by two intertwined learnings that influenced each other throughout our action research: a) *PTs' learning* evidenced by changes in PTs' details and personal connections in responses; b) *MTE learning* illustrated by changes in our language in articulating differences, similarities, and strengths of mathematical contexts. Figure 1 characterizes our perception of the messy process through which these learnings occurred. Our actions as MTEs choosing responses

to praise impacted the contexts PTs produced. Our analysis of PTs' contexts impacted our awareness of biases underlying our judgments and pushed us to develop our language. Meanwhile, PT peer pressure and MTE peer pressure both fuelled changes. Next, we share our findings and offer examples to explain and untangle the changes we saw.

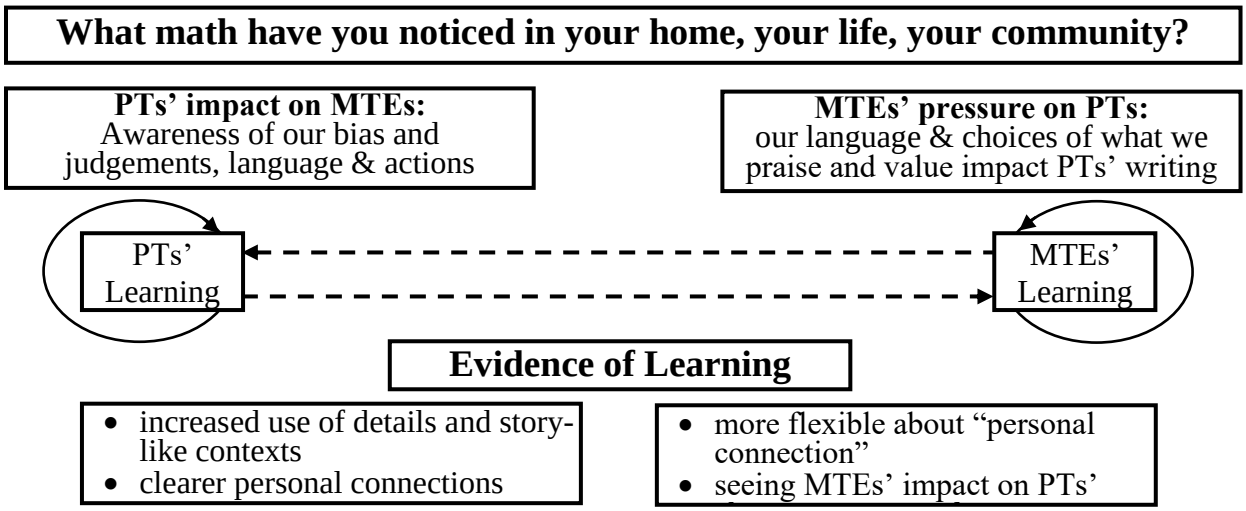

Figure 1. Model of the messy process in which learning occurred for both PTs and MTEs.

Evolutions in Mathematical Contexts

After reviewing PTs' responses from the first iteration, we initially felt disappointed. We perceived PTs' mathematical contexts as impersonal, lacking the details needed to convey personal relevance and engage a problem solver. Lindsay discovered that many (8 out of 17) of her PTs' responses were simply a list of generic contexts, such as: "Bills, amount spent on gas, car insurance, managing money, creating a schedule with times, planning out your day, planning a homework schedule" (Student A, Lindsay, Iteration 1). These responses seemed to list contexts commonly conveyed by adults or textbooks to children as examples of mathematics in everyday life. A common element of responses in both authors' courses included a focus on money, cooking, or time (contexts somewhat universal to all people) and lacked sufficient detail to convey

any obvious personal relevance. For example, "I have noticed using measuring cups when cooking" (Student B, Eryn, Iteration 1). This response lacked details regarding how or when the PT used measuring cups, information about the mathematical quantities, and type of cooking relevant to the PT.

Utilizing Peer Pressure

Only a few PTs' responses (2–3) in each class stood out to us as conveying personal relevance or a story-like nature, such as: "At the end of a movie, my family and I watch the credits to see how many Latino/as worked on the movie, and we count them. Sometimes I try to calculate what percentage of the cast/crew are Latin*"* (Student C, Lindsay, Iteration 1). In our reflective phase, we found that similar story-like responses attracted our attention and felt more compelling than other responses. We discussed how some story-like responses revealed a value or experience of an individual, conveying a personal relevance that the generic contexts lacked.

One PT included details conveying personal relevance, despite using the common contexts of money and measurement:

> At home, my parents always talk to their family in Greece + when they talk about money, they talk about Euros, so we convert Euros to dollars to make sense of the money value. We also do this with weight. My aunt always tells us how much weight my baby cousins have gained, so we convert kg to pounds. (Student D, Lindsay, Iteration 1)

These details conveyed the personal relevance of mathematics, describing the necessary conversions of weight and currency units when discussing with international family members.

Another PT wrote a story about using food to practice division concepts with her brother: "He had 9 pepperonis in his Lunchables. He had 3 pizzas … to put pepperonis on [equally]. So I

asked him how many pepperonis would go on each pizza" (Student E, Eryn, Iteration 1). While the context of eating commercialized food is arguably common to many PTs, we appreciated that the author included personal and story-like details describing specific interactions with family members.

After sorting our first iteration of PT responses according to themes, we selected and sequenced responses to share and discuss in class the following week. We sequenced their peers' responses to prompt PTs to notice and discuss similarities and differences. Eryn also shared her own example of a timely mathematical story from her life. That week, a friend had compared dollars per square inch to decide whether to buy two large pizzas or one extra-large pizza (we discuss the impacts of sharing this story in the next section). By offering PTs the opportunity to see illustrative examples of others' mathematical stories, we hoped to use positive peer pressure to help PTs see alternative images of what mathematical contexts could look like.

During class discussions, we grouped selected PTs' responses to illustrate alternative ways of seeing mathematics in their everyday lives and asked PTs what they noticed about the sample mathematical contexts that were presented for their consideration. For example, Lindsay presented a slide with a set of several list-like responses, followed by a second slide with three PTs' examples utilizing a more personal context (two were introduced above) and a third slide with one PT's example that drew on a locally relevant issue: "In my community, all of the parks in town are getting redone. …I would ask my students to design a new layout of a park that's currently under construction & include its dimensions" (Student F, Lindsay, Iteration 1). PTs were asked to consider how some mathematical contexts were different from others and the engagement potential of different mathematical stories.

PTs' responses evolved over the iterative process of writing mathematical contexts, examining and reflecting on examples from their peers, and reevaluating the presence of mathematics in their lives. The contexts developed, becoming more personal, detailed, and story-like. In the second iteration, one of Lindsay's favorite stories combined a local issue with a question of justice: "[A Hallmark Channel movie is being filmed] in two local neighborhoods & the town is talking about it a lot. Thus, it would be a great way to bridge the discussion on wage inequities of males vs. females" (Student G, Lindsay, Iteration 2). This mathematical context also allowed us to broach the third component of Ladson-Billing's (1995, 2006) theory of culturally relevant pedagogy: sociopolitical consciousness, by posing it as an example of how mathematics can be used to examine justice issues that affect our lives.

By the third iteration, Lindsay noticed that she no longer received any lists of generic contexts. Rather, PTs wrote longer, personalized responses with more specificity about their contexts. The responses from the third iteration resembled short stories expressing PTs' life experiences, such as this one from Student A, whose list-like response was shared earlier: "Each time [my dad] fills his tank he notes how many miles he's at … Then dividing the # by the amount of gas he put in. Trying to see if his [old] car is not getting as many miles" (Student A, Lindsay, Iteration 3).

Eryn also saw an increase in the frequency of descriptive, personal mathematical stories. For example, one PT wrote about their work as a dance teacher in both their first and third response (a month apart), but the mathematics that they chose to forefront had changed. In the first response, the PT wrote: "I teach dance; I wanted to give my dance kids the same amount of candy…. I used the commutative property to understand that 3 Hershey bars and 2 Reese's is the same amount… as 2 Hershey bars and 3 Reese's" (Student H, Eryn, Iteration 1). This context

holds only a surface-level connection to dance because the mathematical focus was on candy sharing, which could occur in any context. Furthermore, the use of the commutative property seemed unclear, possibly because the PT meant a different property or considered the bars to be the same weight (e.g., 1.5 ounces). In their third iteration, however, they utilized the dance context further, writing about using mathematics "to understand space needed/size of props when building them (I'm a dance teacher)*"* (Student H, Eryn, Iteration 3). Because the PT changed the mathematical focus (i.e., commutative property to measurement comparison) and further developed the use of the context (i.e., dance class), it appears that they improved in their ability to notice the mathematics already present in the context.

Recognizing Instructor Pressure at Play

In addition to PTs' mathematical stories evolving in response to positive peer pressure (i.e., the influence of discussing selected peers' mathematical stories), we noticed evidence of PTs' mathematical stories being influenced by the instructor's choices of which samples to present, emphasize, and praise. We realized that as we selected examples and presented them in class, PTs echoed our values as they tried to please us; hence, our choices became "instructor pressure" that pushed PTs in particular directions.

Eryn wrote and shared her own example of a mathematical story with the class after sharing four PTs' sample responses from the first iteration. While her goal was simply to model an example of authentic mathematics used in her own life, her sharing had unintended consequences. The story focused on a situation that came up during Eryn's weekly game night and involved comparing the best value between "two large pepperoni pizzas" (14" diameter & $9.89 each) and "one jumbo pizza" (20" diameter; $17.59).

After Eryn shared this example, she noticed many of her PTs' (23 of 61) subsequent responses followed a structure and context similar to her story, essentially using it as a template. The PTs constructed a scenario where they compared the best values. For example, one PT wrote: "A few months ago, I was sending my fiancé a package and was trying to figure out if it would be cheaper to use a flat rate box or to pay for how much the box weighed" (Student I, Eryn, Iteration 2). The situation required comparing the cost of a flat $13.65 rate versus a five-pound package at $2.40 per pound to find the best value. While this PT's response, along with those of others, seemed to offer authentic contexts for exploring mathematics, the similarities to Eryn's story were surprising. She realized that the power inherent in her role as instructor might have led PTs to prioritize her example rather than finding their own. This observation prompted Eryn to refine her goals for developing PTs' abilities to find ways that mathematics exists or could be a tool for investigating problems inherent in *their* worlds.

The following week, prior to the third iteration, Eryn shared selected examples of PTs' mathematical stories that better illustrated her goal of using mathematics to explore PTs' own curiosity in their lives. She also shared the story from Turner and Font Strawhun (2007) of students learning fraction operations while studying personal problems of concern: school overcrowding. After collecting the third iteration responses, she found more PTs seemed to describe ways they used mathematics to make sense of situations in their lives. She also noticed that the more personal mathematical stories were written in ways less likely to have "neat, predictable outcomes" (Simic-Muller et al., 2009) than a typical classroom story problem.

Meanwhile, Lindsay saw evidence of instructor pressure influencing PTs' responses. She had repeatedly praised and indicated her value for the story-like personal nature of the responses that she chose to share; consequently, she saw how PTs' responses had evolved in this direction.

While PTs' stories evolved in what she saw as a positive direction, she realized in hindsight that none of her PTs' responses included enough details to yet serve as investigatable mathematics tasks. They lacked specific quantities and solution prompts that may be needed to transform a contextual description into a task to be given to future students. For example, one PT wrote about monthly fire inspections: "We do 3 rounds…Each round, we have to count how many rooms we've done, how many rounds we've done, the time when we see the most people to start checking the rooms, and how long it will take." (Student K, Lindsay, Iteration 3). In order to transform this problem into a solvable task, more specific quantities are needed, such as the number of rooms or how much time it takes. Despite not being "classroom-ready," Lindsay reflected that learning to see mathematics in one's own life was an important first step, possibly a prerequisite skill, to developing contexts into tasks for use in the classroom. Realizing that PTs' responses seemed to evolve to reproduce what she emphasized, she decided to add this layer of work in the future.

Learning from Our PTs

Our initial goals were to support PTs in generating mathematical stories that drew on their homes and community knowledge and learn how to incorporate those contexts into our work as MTEs modeling teaching mathematics to PTs. We believe we made progress in these areas. We saw growth in our PTs as they shifted from writing generic mathematical contexts to contexts that were more story-like, personal, and distinct from typical classroom story problems. As PTs' responses became more personal, their stories provided valuable glimpses into their values, interests, and cultures. Perhaps the greatest progress made was in our own learning, in ways we didn't anticipate. Our own learning was both independent and collaborative, as we

independently explored our PTs' responses and collaboratively discussed our observations (noticing) and wonderings through virtual conversations.

Throughout the research, the process of reflecting on similarities and differences in PTs' mathematical contexts pushed us to become more aware of our internal biases that led us to judge PTs' contexts in certain ways. It also pushed us to develop our language in order to articulate the strengths we saw in some contexts over others. Initially, we felt tension over the fact that we preferred some responses over others and had difficulty justifying this preference. We recognized the inherent challenges of trying to make judgments about which contexts held personal meaning or authenticity to another's life. We pushed ourselves to broaden our views of *detailed*, *authentic*, and *personally relevant* in order to be more flexible in judging PTs' responses while still discerning how to describe what seemed to be missing. As we sorted the responses that excited us from those that didn't, we developed our ways of talking about the strengths of different mathematical contexts. Subsequently, our PTs were gaining a better sense of what we wanted and, hopefully, developing their ways of using language to connect mathematics to contexts of lived experiences. We came to recognize our desire to push PTs to find and develop contexts relevant to their own lives as personally and culturally relevant stories, unique and distinct from typical school mathematics problems.

We became more aware and cautious of the power of instructor pressure. We couldn't help but ask ourselves, "Did our students *really* learn to see mathematics in their lives, or did they simply learn to better produce what we were looking for?" We frequently discussed what we meant by "PT-learning" and what we could look for to identify it. While we had hoped to guide PTs to find their own paths, we became aware that our role as instructors, and the power inherent in that role, wielded great influence. We did not know whether our actions had actually

resulted in PT learning that would transfer beyond our classroom walls or if we had simply led PTs down *our path,* teaching them how to provide the contexts that we wanted.

Our emerging uncertainties caused tensions as we grappled with questions without simple answers. In order to determine relevance and authenticity, we looked for personal details as evidence that the mathematics had arisen from within their lived experiences. A PT wrote, "When I go to cook & I have 2 onions, I lay them out as a visual way to see my 2 onions. Therefore, I also know I have 2*"* (Student L, Eryn, Iteration 1). Student L's description seemed to be a simplistic connection to the context of cooking. We wondered whether this PT really saw mathematics in their life while cooking with onions and if they had truly paused to visually contemplate the quantity and meaning of twoness. While making these judgments, we felt the tension of interpreting relevance, recognizing that only the story's author could judge this in their own life. We discussed this example and many others as we questioned our understanding of what it meant for mathematical contexts to be relevant and authentic.

Implications

Initially, our goals focused on soliciting math tasks with greater relevance and authenticity to our PTs' lives so that they could connect to mathematics and recognize the value of bringing those experiences to their future classroom. We also wanted the opportunity to learn more about our students' lives so that we could better connect our teaching to their lives as well. As we asked our PTs to notice math contexts in their lives, we saw that we had to learn what that meant as much as they did. Our use of examples to foster class discussion supported our PTs in developing a better sense of what we were looking for, which led them to write more personal math contexts. As early career MTEs, we needed this guided and practical experience of conducting action research to develop our understanding of how to support our students in

noticing math in their lives and how to create relevant and authentic contexts ourselves for our PTs.

Possible next steps are to more directly support our PTs in noticing math in their lives. Recent action research conducted with professionals engaging in collaborative computer programming events (Nolte et al., 2020) describes the use of *sensitization kits* to support participants in realizing real-world problems to support more relevant end users' programming solutions. The sensitizing strategies, similar to community walks (Drake et al., 2015), direct participants to take pictures, respond to writing prompts, and track each time they used (or thought about using) data. Directed experiences such as these, coupled with peer sharing, opportunities to describe connections to personal relevance, and teacher-questioning and feedback loops may help our PTs similarly be sensitized to ways to connect mathematics deeper into their lives.

More work also remains to be done for us as MTEs to continue working toward our second goal: to better connect our use of mathematics tasks in the classroom to PTs' lives in meaningful ways. As our PTs change every semester, we continue to solicit PTs' ideas concerning the connection of mathematics to their lives and strive to develop and implement a repertoire of strategies for incorporating these contexts back into classroom lessons, thereby stimulating PTs to provide feedback and suggestions about the engagement potential of mathematical inquiry that acts as a "mirror" to their lives or a "window" into the lives of their peers (Gutiérrez, 2007; Styles, 1988).

Conclusion

Soliciting and analyzing PTs' mathematical stories pushed us unexpectedly to clarify and reconsider what we considered *authentic*, *relevant*, or *personal* in our PTs' lives because of their

individualized and context-specific nature. At the start of this project, we experienced disappointment as we read our PTs' first iterations of mathematical contexts. We came to realize, however, the importance of these contexts as snapshots of PTs' thoughts on mathematics at that moment in time. The contexts provided opportunities to consider how to push PTs' thinking further. As we shared alternative examples of contexts, we saw our PTs' responses gradually start to reflect more nuance and personal connections. We hope the changes meant that PTs were developing their lenses to notice mathematical contexts in their lives, but we recognize that the inherent power dynamic pressures PTs to satisfy our expectations. In that case, they may have mimicked our examples without necessarily making the connection between the mathematics in their lives and their responses.

Using our practice to learn how to support PTs to develop culturally relevant mathematics contexts may be a long and uncertain journey. Nevertheless, through this process we are better able to learn about and connect with our PTs and use those connections to improve the mathematical contexts we use in our own teaching. We see value in continuing our iterative writing prompts and analyses because developing culturally responsive pedagogies will be a lifelong process. We value continuing to elicit knowledge of PTs' lives, to support them in developing their own perspectives on mathematics in their lives, and to inquire into our motivations for the pressures we exert on them. We see a value to this work to develop PTs abilities to connect the mathematics curriculum to real problems important to students' cultures or interests, as has been modeled in the literature (e.g., Gutstein & Peterson, 2005; Gutstein, 2006a, 2006b; Tate, 1995) with benefits to student motivation, engagement, and learning. Additionally, we plan to continue our action research on our teaching and collaboration with

critical friends, because these contribute to furthering our own ongoing growth as culturally responsive mathematics teacher educators.

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