From "Eye-opening" to Mathematical: Helping Preservice Teachers Look for Mathematics in Stories of Oppression

Ksenija Simic-Muller
Pacific Lutheran University

Abstract

This article analyzes preservice teachers' reflections about a visit to a campus event focused on injustice and oppression that they were required to attend as part of an assignment in a mathematics content course for preservice K-8 teachers. Prior to the assignment, the preservice teachers had had limited exposure to social justice-based mathematics contexts and extracting mathematics from the real-world. Their reflections provide valuable information about the types of social justice contexts preservice teachers find relevant, and the mathematical possibilities they see, on their own, in events such as this one.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. What real-world contexts are appropriate and relevant for preservice teachers to investigate in a mathematics content course?
2. Should oppression be discussed in teacher education? If so, how?
3. Should oppression be discussed in a mathematics class? If so, how?
4. How can campus and community events be brought into the mathematics classroom?

Ksenija Simic-Muller (simicmka@plu.edu) is Assistant Professor at Pacific Lutheran University in Tacoma, Washington. She primarily works with preservice K-12 teachers, and is especially interested in issues of equity and social justice. She has been focusing recently on the use of social justice-based real-world mathematics problems and mathematical modeling in preparing preservice teachers to teach mathematics.

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Ksenija Simic-Muller
Pacific Lutheran University

Real-world mathematics contexts and social justice issues, highly relevant but not necessarily well-known to preservice K-8 teachers (PST), are closely connected through a pedagogical approach usually referred to as *teaching mathematics for social justice*. This approach is not uniformly defined in literature (Gonzalez, 2009), and in fact some authors prefer to leave the term undefined, highlighting its complexity and nonlinearity (Bartell, 2013; Wager & Stinson, 2012), but most authors agree that an essential component is "the use of mathematics as a critical tool for understanding social life; one's position in society; and issues of power, agency, and oppression" (Gonzalez, 2009).

The scholarship of teaching mathematics for social justice has significantly grown in the recent years (e.g. Bartell, 2013; Gonzalez, 2009; Gutstein, 2006; Gustein & Peterson, 2013; Wager & Stinson, 2012), as more educators see the potential for empowerment that social justice-based curriculum brings. My work is particularly influenced by Gutstein (2006) and Frankenstein (1998; 2009), who in turn build on the work of Freire (1985) when they write about "reading the world with mathematics." Reading the world with mathematics is a widely-encompassing term, which implies, among other things, using authentic real-world mathematical contexts to understand the social and political forces that shape our lives and our societies. Mathematics content courses for preservice K-8 teachers provide a convenient setting for reading the world with mathematics, since the mathematics content often used to analyze social justice issues, such as algebraic reasoning, rational numbers, proportional reasoning, probability, and statistics, is part of the standard curriculum in these courses.

This manuscript provides an analysis of PSTs' reactions to a campus event featuring a variety of social justice topics through a mathematical lens. The PSTs' reflections about the event offer insights relevant to mathematics teacher educators, about social justice contexts PSTs consider relevant and about their interpretations of mathematics connected to these contexts.

Context and Data Collection

I teach a two-part mathematics content course for preservice K-8 teachers at a medium-sized liberal arts university. The majority of students intend to teach lower elementary school. They fit the profile of a typical student in a teacher education program: the vast majority are white females from suburban and rural areas (National Center for Education Statistics, 2011; Zumwalt & Craig, 2005), and, likely because I teach at a private university, many come from wealthier backgrounds. Research shows that PSTs who fit this profile are often unaware of issues faced by a large and growing number of public school students who deal with racism and poverty in their daily lives, are food insecure, have incarcerated parents, have no access to resources, or are homeless (Hollins & Guzman, 2005; Milner, 2006). In fact, PSTs may even have deficit views of these students, and believe them to be at fault for their circumstances (Castro, 2010; Gay, 2010; Ladson Billings, 2006; Villegas, 2007). These views should be addressed in every aspect of an education program, including in mathematics courses. In particular, a mathematics content course can raise PSTs' awareness of issues that affect their future students and their communities, while showing them the power of reading the world with mathematics.

Because the primary focus of the course is developing mathematical knowledge needed for teaching (Ball, Thames, & Phelps, 2010), I am unable to give the social justice content a central place in the curriculum. Instead, I create occasional problems, lessons, and assignments about topics that vary from semester to semester, often following current and campus events, and have included sweatshops, homelessness, income inequality, incarceration, and sustainability as topics. Due to past instances of resistance to social justice contexts, I align assignments as much as possible with the social justice efforts taking place at the university. In particular, I have created an assignment around an event titled *The Tunnel of Oppression* (referred to as "the Tunnel" throughout). The Tunnel is an annual, student-created event that takes place on college campuses nationally, and on our campus every spring, featuring a tunnel-like setting with scenes portraying different forms of oppression or injustice, through spoken, written, or acted-out information. I require PSTs to attend this event; write a reflection about their experience; and create a report, based on additional research, about a scene of interest (the detailed instructions are included in the Appendix). I have chosen the Tunnel as a topic for an assignment because of its inherently mathematical nature, as almost every scene features numerical and graphic data, typically obtained through mathematical processes. For example, some facts that have occurred in the Tunnel in the past have included the percentages of rapes in the military that are reported and prosecuted, the difference in employment rates between Black and White college graduates, or differences in graduation rates between school districts.

While the reports are much more structured, incorporating mathematical content addressed in the course, and requiring PSTs to submit multiple drafts, the reflections are deliberately open-ended. The prompts require PSTs to describe their reactions to the scenes and the mathematics they saw in the event, and to give examples of situations in which mathematics was absent but could have been beneficial. Their purpose is for PSTs to look for mathematics in new places, and for me to better understand what they see as mathematical.

I have used the Tunnel assignment for three consecutive years. The work collected includes reflections, reports, responses to the assignment, and some problems posed by PSTs, who are aware that their work is the focus of my research. This manuscript focuses solely on the reflections, 109 collected over three years. My purpose in analyzing the reflections is to investigate what mathematics PSTs notice on their own, having had little prior experience with similar assignments; and it is in no way intended as criticism of PSTs' perceived limitations. Prior to this assignment, PSTs will have encountered a few problems or assignments that deal with social justice, but this is the first assignment that requires that they look for mathematics or pose mathematical questions.

All the reflections were coded for themes after being collected, using a method most closely resembling the constant comparison method (Merriam, 1998): reflections were repeatedly read, and new codes were added in the process, uncovering themes related to mathematics and oppression, which became the categories in the data analysis. For this manuscript I focused on the codes related to the contexts PSTs found relevant, the mathematics they recognized in the event, and the mathematics they thought was missing.

Results

Oppression: Moving, but Is It Relevant?

In the reflections, 75% of the PSTs have used an emotional term such as "moving" or "shocking" to describe their experience at the event, and some variation of the term "eye-opening" is used in the reflections 48 times; only eight PSTs expressed disappointment at the event, and only one had a strong negative reaction to the Tunnel, which clashed with her personal beliefs. Assuming PSTs were truly moved by the event as they claim, an important question to ask is which contexts had the greatest impact on them, and why.

The Tunnel topics change every year, but issues related to education and youth are always present in some form, including scenes about high school graduation rates or negative stereotyping of local youth. Many other scenes have addressed issues relevant to large numbers of public school students, including ones about racial profiling, immigration, poverty, or access to health care. Since elementary PSTs overwhelmingly choose teaching as a career because they care about children (DeLong, 1987; Reif & Warring, 2001), I expected PSTs to make connections between Tunnel and teaching, but this was evident only in about 12% of the reflections.

One scene explicitly addressed the disparity in graduation rates between different races and ethnicities, and while many reflections identify this scene as mathematical, only one PST connected it with her/his future career, noting that it "offered a jumping off point for me in particular because it really made me look towards my future and the future of those who I will be teaching." Some reflections show awareness of the relationship that exists between problems in society and problems that children face, like the one noting that "when I teach, all of these [social justice issues] are things that I am going to see and experience," and motivation to make a difference, but none discussed systemic roots of inequitable educational outcomes, instead only describing their future individual efforts to help all children.

More PSTs were moved by issues that resonated with them personally: women were affected by scenes that involved sexual violence; parents commented on scenes that dealt with victimizing children; and almost all seemed impacted by local scenes, such as human trafficking in our state and the strained relationship between our campus and the local community. This is not surprising, but serves as a reminder that, if we want PSTs to be open to the social justice contexts we expose them to, we should begin with topics personally relevant to them. We should also not assume that PSTs will pay attention to education contexts just because they are offered, nor that they will be able, on their own, to go beyond feeling compassion for youth who do not graduate and instead begin to understand the systemic forces that marginalize them in schools and result in inequitable outcomes (Willey & Drake, 2013).

Mathematics: Omnipresent, but Is It Deep?

The simpler mathematics in the Tunnel is easily seen, usually in the form of numbers or percentages. The underlying mathematics, which includes methods of counting people or measuring impacts, is not as obvious, especially for those PSTs who have an uncomfortable relationship with mathematics, and limited prior experiences with it.

What mathematics is there? The vast majority of PSTs see mathematics in the Tunnel, expressing the belief that numbers help convey the seriousness of the issue being highlighted. One PST wrote:

"Originally, I consciously questioned how math could take part and really make an impact in this type of event. Believe it or not, I felt that one of the strongest aspects of the whole event was the statistics provided to help support at the different scenes. Statistics are obviously a part of math and helped the viewers of this event really see and compare the tragedy of what was happening."

Reactions like this one are uncommon. There have been only five dissenting voices, almost all lamenting that no mathematics was seen in the Tunnel other than statistics and percentages, which raises the question of which topics PSTs consider legitimate mathematics if some are willing to dismiss ones most frequently encountered in our daily lives.

At the other extreme are PSTs who only see mathematics in statistics and percentages, which are overwhelmingly the most commonly mentioned topics. The reflections especially refer to numbers, lauding their impact on the understanding of a particular issue. While important in conveying information, numbers are not the only mathematical concepts present in the Tunnel. Take for example a scene that asked participants to find a wheelchair-accessible route between two parts of campus that could be traveled in a certain amount of time. Only three PSTs identified this scene as containing mathematical information, possibly because it featured non-numerical mathematical content.

Other topics that were successfully identified by PSTs as mathematical were life-expectancy, pre-existing conditions for health insurance, taxes, "budgeting with WIC," or "showing oppressed families unable to pay for their loved one's medical expenses." Though rates and ratios are occasionally mentioned, only two PSTs explicitly noted the role of proportional reasoning in understanding large numbers. One in particular noted "the power of comparing a more abstract concept to something more familiar to a general audience," in response to a scene that scaled down the numbers related to sexual assault in the military to the size of our university's student body. The PST found this "really impressive because it immediately made the numbers real and tangible and was incredibly effective." However, comments like this one are rare, and the PSTs' descriptions of mathematics are often vague, repeating the numbers seen and heard, but seldom asking about how they were obtained, or commenting on their meaning. The following comment is an exception:

"The … scenes also offered data on rates that a particular issue or injustice effected [sic] people but … they rarely went into depth about where this data was found or if it was exclusive to a particular group of people."

Ideally, such comments should be more common. Content courses need to provide multiple opportunities for PSTs to develop a broad understanding of mathematics, one that goes beyond numbers and counting. For example, all PSTs, not just one or two should learn to appreciate the use of proportional reasoning to understand large numbers. Similarly, considering how data are obtained and understanding the limitations of almost any type of survey or census, is essential to reading the world with mathematics, and PSTs need more experience with this practice.

What mathematics was missing? Just as they praised numerical information for helping better understand certain issues, PSTs also critiqued scenes that were devoid of numbers. This was especially evident in a scene that presented opinions the local youth and university students hold of each other. Because the scene only featured words, PSTs found it hard to form an opinion about the issue. One wrote,

It would have been easier to understand the peers I share classes with if there was a number or percent of students on campus surveyed … because I'm assuming a large number when there might have only been a small amount (changes perception).

Along similar lines, another PST called for a campus survey, because "if people were surveyed on their views, the ability to see actual percents to go along with the phrases presented, this scene would have stood out more."

While calls for more numbers and data are prevalent in the reflections, few concrete mathematical questions are asked. Some questions are unrealistic, like wanting to know how many people use certain derogatory words, or how many people in the world are oppressed daily. More successful questions highlight comparisons. For example, when discussing pricing of health care, a PST wanted to know "how much it could actually cost in comparison to how much an average low income family makes with x amount of kids." This topic raised more interesting questions, such as "about how many families in the United States have to live without health care or how much families have to pay for the most simple health situations when they don't have proper health care." Finally, one PST who found the mathematics in the Tunnel lacking proposed the following comparisons:

"[C]ompare how these numbers have changed (in any area) to show that either things are getting worse; which would make a bigger impact on those learning, or that they are getting better; which would show that people are becoming educated and doing something to change the situation."

The PSTs' positive reactions to the use of numbers as a tool for shedding light on social justice issues are promising; but to become mathematically literate citizens fluent at reading the world, they need mathematical tools in addition to openness.

Recommendations

It would be unreasonable to expect that PSTs will be successful in identifying complex mathematics, posing relevant mathematical questions, and noticing the sociopolitical complexities in the Tunnel scenes (or another context) entirely on their own. Instead, instructors need to take concrete steps to help PSTs begin to develop these competencies.

First, PSTs, like K-12 students, respond better to a curriculum that is personally or culturally relevant to them (Gay, 2000; Ladson-Billings, 1995). Therefore, their initial contact with social justice mathematics should be through contexts that are familiar and relevant, and preferably not too

uncomfortable. For my students, sustainability is a much easier initial topic than sweatshops or homelessness. I also require PSTs to pose mathematical questions about issues that are of concern to them, which helps them see that they already possess social justice concerns, even though they may be different from mine. Once PSTs are comfortable with the idea of social justice in a mathematics course, more complex topics can be introduced. It is especially important for PSTs to understand issues related to education, and in particular we can present them with data sets, questions, and assignments that can help them question the current rhetoric around standardized testing, "achievement gap," "failing schools," and others. For example, PISA results, graduation rates, or suspension rates, when segregated by race, ethnicity, and socioeconomic status, all provide a powerful starting point for a conversation about the inequities in the U.S. educational system.

PSTs should be provided with multiple opportunities to read the world with mathematics, to stretch their understanding of mathematics beyond the obvious uses of numbers, and encompass the messy mathematics that helps better understand oppression in particular and the world in general. Through the Common Core Standard for Mathematical Practice of modeling (CCSSI, 2010), introducing these messy contexts in content courses is easier now than it has been in the past. Also, because PSTs will not ask these questions themselves, it is important not only to use real-world data, but also to consider how they are obtained.

Finally, a stronger focus on problem posing is needed. Because I typically require PSTs to pose problems only once or twice in a semester, they are unable to ask the deep and meaningful questions I hoped for in the Tunnel assignment. In the future, I intend to make problem posing a larger component of the course, and in particular to scaffold the assignments for PSTs to be able to progress from straightforward to important and complex questions about their world. The instructor should explicitly model this process at the beginning of the semester, providing multiple opportunities, ample feedback, and, as already suggested, relevant contexts, to help PSTs grow in this process. The end-result should be, in the words of one PST, "being able to teach in a way that not only explains algorithms but explains and looks for solutions to social justice issues."

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Appendix: Tunnel of Oppression assignment

1. Attend the event. Allow yourself at least 45 minutes (most people take 50 minutes to an hour) to walk through it. If possible, go to a debriefing session available when you finish walking through the tunnel. Be warned that some of the scenes may make you uncomfortable. If you believe you will not be able to handle the emotional stress of going through the tunnel, please speak to me beforehand.

2. Write a ½-1 page reflection on the event. Describe what you saw and your reaction to the scenes. In addition, respond to the following questions:
   - How, if at all, did mathematics come up in the scenes?
   - How, if at all, did mathematics come up in the debriefing session (if applicable)?
   - Were there any situations in which mathematics was absent but would have been beneficial for understanding the issue?

3. Do some additional research about one or more of the scenes. Do some fact checking and data collection on the content of the scene(s). Then write a 1-2 page report to the Tunnel organizers. Your report should contain the following components:
   - At least three mathematical facts that were not in the Tunnel, from at least two different outside sources (site sources);
   - At least one application of addition/subtraction/multiplication/division;
   - At least one fraction;
   - At least one use of percents;
   - At least one ratio or proportion;
   - At least one mathematical argument combining the numbers you found, as in the examples given at the end of the document;
   - An explanation to the organizers about how more mathematics could have strengthened their argument, with concrete examples of mathematics that could have been used.

4. Feedback on reports and an opportunity to revise. In particular, feedback will be given on making arguments mathematical based your research.

5. Revised reports due.

I would like to share your reports with the students who created the Tunnel scenes, as well as with the Tunnel organizers. If there is interest, we can organize a session during which you can present your findings and conclusions to them. In the past years, the Tunnel organizers have taken into consideration feedback given by students, and in particular have included more mathematical data in the scenes as a consequence.

This assignment is somewhat open-ended, and there is no one right way to do it. One of my primary objectives is to show you how mathematics can strengthen ethical and philosophical arguments, and to teach you to "mathematize" the world around you. The main thing to keep in mind is that the assignment needs to be as mathematical as possible, while also keeping in mind the issues addressed in the Tunnel.

Below are excerpts from some successful reports from previous years:

"Let us take a look at one statistic and expand on it, that the more than half a billion bottles of water are purchased in the United States every year can circle the globe more than five times. If the average height of a water bottle is 9 inches, or approximately 0.75 feet, and the circumference of the globe is 24,900 miles, then the approximate 600,000,000 bottles times 0.75 feet is 450,000,000 feet or, divided by 5280 feet in a mile, 85,227.27 miles, is the distance of the bottles purchased in the US. Divide 85,227.27 miles by the circumference of the earth and you get the bottles circling the earth 3.42 times. Now, this does not match up to the originally stated amount of five times, but perhaps they were calculating with a different bottle height and more exact number of bottles, as I have to work with generalizations and approximations."

"Out of the 57.7 million [people living with depression[1]], only 4 million will receive any treatment for their anxiety, and only 400,000 receive the proper treatment for their illness. Using math to find the percentage that is only 6.9% of the

total who will receive any treatment at all and only .07% of people who will receive the correct treatment for their particular illness. By using those percentages we can figure out that 93.1% of the 57.7 million go without any treatment at all and 99.93% go without the proper treatment. This leaves many untreated individuals vulnerable and even suicidal."

"According to the tunnel, Americans consume an average of 23 pounds of pizza each year, which is about 46 slices. I think I definitely exceed that amount. With the Unites States population currently at 313,286,647, an average of 7,205,592,881 pounds of pizza is consumed each year. This got me thinking. With all of the pizza being consumed, where are all of the pizza boxes going. Although the pizza boxes are recyclable, you can't recycle the parts of the box that have been soiled by the food. That is at least half of the box. So, most people just end up throwing the whole box away. According to the company Good News Reuse, enough pizza boxes are thrown away each year to circle the earth 26 times (goodnewsreuse.com)."

"I was most upset by the statistics concerning the trafficking of children. The fact that the *mean* age of girls coerced into the sex industry is 13, according to law-enforcement leaders is extremely disturbing (Seattle Times). This means that while there are girls both older and younger in the industry, 13 is the average age. The total estimated amount of children in the sex trade each year in the United States is 300,000. That's roughly 100 times the amount of students enrolled at PLU. If the aforementioned number of people estimated to be trafficked into the U.S. per year is 17,500, this is only 5.83% of the annual amount of child prostitutes in the United States. Furthermore, there are 39 total counties in Washington, and trafficking has taken place in at least 18 of them. This means that the *probability* of living in a Washington county where trafficking occurs is 46.15% - almost half. It is my personal belief that if this particular scene had utilized more mathematical applications, it would have been even more effective. In my own research, I found a variety of discrepancies in statistics - for example, some sources said there are 100,000 children in the U.S. sex trade annually, while others said 300,000. This shows the crucial importance of fact checking (these statistics are all estimates because it is impossible to acquire exact numbers)."

[1]http://www.anxietycentre.com/anxiety-statistics-information.shtml

Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. What are the benefits of learning and teaching mathematics through contexts related to oppression? What are the disadvantages?
2. How could K-5, 6-8, 9-12 students learn mathematics through contexts related to oppression?
3. What teaching approaches can help facilitate students' and preservice teachers' ability to uncover more complex mathematics in the real world?
4. What teaching approaches can help facilitate students' and preservice teachers' ability to gain a deeper understanding of social justice contexts?
5. What teaching approaches can help facilitate both uncovering complex mathematics and deeper understanding of social justice issues?
6. How can mathematics instruction for preservice teachers be responsive to their experiences and interests, while also addressing issues that will be relevant to them as teachers?