Connections Pre-Service Teachers Make Between Social Justice and Mathematics

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This study explored pre-service teachers' (PSTs') initial experience connecting mathematics and social justice. This work is part of an on-going action research project on improving mathematics PSTs' experiences in their methods courses, specifically focusing on culturally responsive mathematics teaching. Research stresses the need to prepare teachers who can teach a diverse student body, are mindful of differences in student backgrounds and, are cognizant of their own biases (Mark & Id-Deen, 2020; Brown et al., 2019; Gallard, Mensah, & Pitts, 2014; Johnson & Atwater, 2014; Lemons-Smith, 2013; Leonard, 2008; Lewis, Pitt, & Collins, 2002). PSTs developed lesson plans balancing both mathematics and social justice goals. Lesson plans were analyzed to find initial connections PSTs made between mathematics and social justice.

Keywords: Pre-service teachers, mathematics for social justice, mathematics teacher education.

A focus on equity and social justice is needed in mathematics education (NCSM, 2019; AMTE, 2020; Kokka, 2020). Research stresses the need to prepare teachers who can teach a diverse student body, are mindful of differences in student backgrounds and are cognizant of their own biases (Mark & Id-Deen, 2020; Brown et al., 2019; Gallard, Mensah, & Pitts, 2014; Johnson & Atwater, 2014; Lemons-Smith, 2013; Leonard, 2008; Lewis, Pitt, & Collins, 2002). Teachers must be able to look beyond their classrooms and see their role as a teacher in a wider context. They must recognize their responsibility to prepare responsible citizens who can use mathematics to change the world (Aguirre & Zavala, 2013).

Existing frameworks can help mathematics teachers develop practices in line with this call. Examples of these frameworks include standards-based mathematics instruction (National Council of Teachers of Mathematics, 2000), complex instruction (Cohen, 1994; Cohen & Lotan, 1995; Lotan, 2006), culturally relevant pedagogy (Ladson-Billings, 1994, 1995a, 1995b), and teaching mathematics for social justice (TMSJ; Gutstein, 2003, 2006). All these frameworks build on each other and emphasize teaching for understanding (Rubel, 2017). However, even with the existence of these frameworks it is challenging to teach novice teachers about pedagogy that connects social justice, culture, and mathematics (Gutstein, 2018). Teachers need to be proficient in making connections between mathematics and community, as well as developing their students' awareness of the world (Gutstein, 2018; Freire, 1970). To prepare such teachers it is necessary to determine what skills they would need, and develop ways to cultivate these skills (Gutstein, 2018). To fill this need, the study focused on pre-service teachers' (PSTs') experience in a mathematics methods course. The guiding research question was: What initial connections do mathematics PSTs make between social justice and mathematics?

Theoretical Perspective

Teaching Mathematics for Social Justice (Bartell, 2013; Gutstein, 2006) or Critical Mathematics (Frankenstein, 1983; Gutierrez, 2002) is pedagogy that seeks to develop students' conscientização (Freire, 1970). This means helping students understand content and become academically proficient, develop an awareness of inequities around them and begin to take action (Ayers, 2009; Kokka, 2019). This kind of teaching requires teachers to set two kind of goals, mathematics pedagogical goals and social justice pedagogical goals (Gutstein, 2006).

Teachers need to be mindful of both these goals as they work together to guide their students' development of conscientização (Gutstein, 2006). Mathematics pedagogical goals include, reading the mathematical world, traditional mathematics success, and conceptual understanding of mathematics/learning how to use mathematics as a tool (Gutstein, 2006). To achieve the mathematics pedagogical goals, teachers can seek guidance from standards frameworks (e.g., national or state standards), textbooks or standardized assessments (Gutiérrez, 2002; Kokka, 2020). On the other hand, social justice pedagogical goals focus on, grasping sociopolitical situations, taking action towards change, and developing positive identities (Gutstein, 2006). These identities include both cultural and social identities and are of particular importance for students who are not part of the dominant culture (Gutstein, 2006; Kokka, 2020).

In addition to goals, teachers must develop and implement tasks that help students use mathematics to learn about their cultural context, such as, a task comparing students' own neighborhood to those with different socio-economic status (Kokka, 2019). When implemented well, such tasks allow students to see the power of mathematics to learn about local social issues (Yang, 2009). While powerful, these tasks are employed in tandem with a district/textbook curriculum, and are used only 15% to 20% of the time (Gutstein, 2006). It is challenging for teachers to develop and implement mathematics tasks that develop students' conscientização (Bartell, 2013; Gregson, 2013; Brantlinger, 2013; Rubel et al., 2016; Kokka, 2020), and as mentioned earlier, it is crucial to develop supports for them (Gutstein, 2018).

The goal of this study was to learn from mathematics PSTs' experience developing lesson plans that balanced both mathematics and social justice goals. PSTs' developed lesson plans and made videos implementing them. Their lesson plans were analyzed to find the initial connections they made between mathematics and social justice.

Research Methodology

This study employs action research (Sagor, 2000) methodology to develop supports for PSTs inside mathematics methods courses. In particular, the goal of this project is to develop PSTs' teaching philosophy and teaching practice connected to culturally responsive mathematics teaching (CRMT) and TMSJ. The study took place at a mid-sized university in the Mid-Atlantic region of the United States. Participants in the study were twenty-three PSTs enrolled in a middle school mathematics methods course during Fall 2021 and Spring 2022 semesters.

PSTs were asked to develop lesson plans guided by the CRMT lesson analysis tool (Aguirre & Zavala, 2013). The CRMT tool was developed to help PSTs contextualize the mathematics they teach and to help them see their role as teachers who prepare their students to engage in the society (Aguirre & Zavala, 2013). It includes 8 dimensions: (1) intellectual support; (2) depth of student knowledge and understanding; (3) mathematical analysis; (4) mathematical discourse; (5) communication and student engagement; (6a) academic language support for ELL; (6b) use of ESL scaffolding strategies; (7) funds of knowledge/culture/community; and (8) social justice. The PSTs were required to include both mathematics and social justice standards (Learning for Justice, 2016). Open coding (Strauss & Corbin, 1998) was used to analyze the lesson plans and learn about the connections PSTs made between mathematics and social justice.

Results

PSTs favored some social justice standards in their lesson plans over others (please see table 1). For example, standard 12 was used most frequently, *students will recognize unfairness on the individual level (e.g., biased speech) and injustice at the institutional or systemic level (e.g., discrimination)* (Learning for Justice, 2016). This standard was connected to the following

mathematics topics, evaluating and simplifying algebraic expressions, equivalent fractions, graphing linear functions and identifying the slope and y-intercept of a linear function, identifying the components of the coordinate plane, histograms, rational numbers, and solving linear equations. In general, students favored Probability and Statistics over other content strands. This was followed by Patterns Functions and Algebra, Numbers and Number Sense, Measurement and Geometry, Computation and Estimation, and Expressions and Operations.

Table 1. The most commonly used social justice standards

Standard	count	SJ Standard
12	7	Students will recognize unfairness on the individual level and injustice at the institutional or systemic level.
6	6	Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.
9	6	Students will respond to diversity by building empathy, respect, understanding and connection.
1	2	Students will develop positive social identities based on their membership in multiple groups in society.
8	2	Students will respectfully express curiosity about the history and lived experiences of others and will exchange ideas and beliefs in an open-minded way.
10	2	Students will examine diversity in social, cultural, political, and historical contexts rather than in ways that are superficial or oversimplified.

Here, I share examples to show connections that PSTs made between social justice standards and mathematics. In a 6th grade lesson, one PST connected, Measurement and Geometry to social justice standard 12. The lesson focused on identifying the coordinates of a point, and graphing ordered pairs in a coordinate plane. The PST planned to have students graph sets of ordered pairs. Each ordered pair would represent a residential unit, with the origin of the coordinate plane representing a hospital. Students would analyze the location of the housing units and their proximity to the hospital. They had prepared to ask questions such as: *Compare and contrast the consequences of living closest to the hospital and furthest from the hospital?* and *If you could move the hospital anywhere on the coordinate plane, where would you move it and why?*

The PST stated that they wanted their students to discuss, the various advantages and disadvantages of living in a specific location. Standard 12 focuses on recognizing unfairness either on a personal or a systemic level and the PST had planned for their students to investigate the map of their local area to find essential resources (i.e., hospital, police station, school) with the goal to discuss systemic injustice and raise students' awareness.

Another PST developed a 7th grade lesson plan, using social justice standard 6, *students will express comfort with people who are both similar to and different from them and engage respectfully with all people* (Learning for Justice, 2016). The PST connected this standard to solving two-step linear equations. They started the lesson with a problem frequently found in standard mathematics textbooks (please see figure 1). Following this problem, they planned to ask questions to foster discussion focusing on both mathematics and accessibility. Their questions for the mathematics discussion were, *What is the cost dependent on? How is this different for members vs. non-members? How does the membership fee affect the total cost? How*

can we represent this problem using algebraic terms? What does each part of the equation tell us? How will we know when having a membership is a better deal? These questions would foster

> *The local amusement park sells summer memberships for $50 each. Normal admission to the park costs $25; admission for members costs $15.*
>
> *a) If Darren wants to spend no more than $100 on trips to the amusement park this summer, how many visits can he make if he buys a membership with part of that money?*
> *b) How many visits can he make if he does not?*
> *c) If he increases his budget to $160, how many visits can he make as a member?*
> *d) And how many as a non-member?*
> *e) Based on what you found above, after how many trips would having a membership be a better deal? Why?*

Figure 1. A Problem about student recreational activities.

discussion about what the algebraic equations represent and the meaning of each part of the equation. In addition to the mathematics discussion question, they had prepared questions for what they called an "accessibility and implications discussion." These questions were, *Are amusement parks widely accessible? What determines who is able to go to amusement parks and who isn't? What are other forms of entertainment/recreation that are not widely accessible? Why is this? What forms of entertainment/recreation are widely accessible? How do these differ from those that are not widely accessible?* The PST explained that their goal was for their students to study and explore the accessibility of different forms of recreation. They shared that students should become aware that some students might be able to spend more time and money on recreational activities than others. Their lesson focused on awareness of similarities and differences between peers.

In the last example, a PST developed a 7th grade lesson plan using social justice standard 9, *students will respond to diversity by building empathy, respect, understanding and connection* (Learning for Justice, 2016). They connected standard 9 to histograms, stem-and-leaf plots, line plots, and circle graphs. The goal of their lesson was for students to learn, *How do histograms allow us to interpret data? How can you use intervals, tables, and graphs to organize data? Why do refugees flee their own country? What opportunities do refugees receive when they come to the United States? What age are the majority of refugees?* At the beginning of the lesson, the

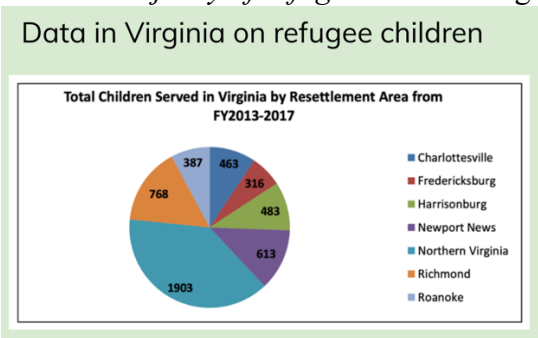

Figure 2. A graph depicting refugee data.

PST had planned to ask the students if they had any pre-existing knowledge on refugees and why refugees flee to other countries, and to have a class discussion. After the initial discussion, the PST had planned to show a video to the class on, *What does it mean to be a refugee?* (TED-Ed, 2016) followed by asking the following questions: *Why do refugees leave their home/country?*

What is the difference between migrants and refugees? What is a refugee camp? What data could be used on refugees to make a histogram? If I wanted to create a histogram on the age ranges of refugees, what would I label my x and y axis?

Following a discussion, the PST had planned to share graphs depicting state data on refugee children (please see figure 2 for one such graph). The PST had prepared the following questions for their students to answer, using data from the graphs: *Based on the histogram data what is the highest age range of refugees and what is the lowest? Why do you think so many refugees are young? How do histograms show the differences in distributions of data? List a couple of challenges that refugees could encounter at school? What are some actionable steps that you could take to help refugees in your local community? What is something new you learned today about refugees?* This lesson plan had the potential to have the students learn about mathematics as well as develop awareness. It is noteworthy that lessons such as these that focus on statistics lend themselves well to connections between mathematics and social justice.

Implications for teaching practice and future research

The process of developing lesson plans allowed the PSTs to research social justice topics that would connect to a middle school population, and they began to make connections between specific contexts and mathematics. PSTs also challenged themselves to develop questions that would lead to discussions in their classrooms. Such discussions would focus on unpacking the mathematics content and helping students become aware of the world around them. This exercise had the potential to help PSTs develop their own awareness of the world, potentially leading to their development of conscientização (Freire, 1970).

It was a challenging task for the PSTs to balance mathematics and social justice goals in a lesson. This finding is in line with existing research, as learning to balance mathematical and social justice goals is difficult and a long term pursuit (Harper, 2019; Bartell, 2013). Successfully balancing the two goals means being mindful during planning so that a focus on social justice does not take away from students' development of mathematical proficiency (Moses & Cobb, 2001; Harper, 2019). The PSTs began to experience this tension and would need further support to develop their own understanding of social justice in a mathematics classroom.

Teaching for social justice is a long journey that requires teachers to connect their teaching to contexts that are relevant to them and their students (Cochran-Smith, 1999). This process takes time, perseverance, and reflection (Darling-Hammond, 2002; Bartell, 2013). Teachers who begin this journey must understand that it is not a short-term goal (Gutiérrez, 2009), as their thinking and practice will develop and grow with practice and reflection (Bartell, 2013). As teachers develop an understanding of teaching mathematics for social justice, the changes are reflected in their teaching goals and teaching practice (Bartell, 2013). For PSTs it is particularly important to reflect on their teaching experience to develop a sense of who they are as teachers, this identity is necessary for them to employ pedagogies that connect culture, social justice, and mathematics (de Freitas, 2008, Leonard et al., 2010). Experiencing the challenge of connecting mathematics and social justice goals, allowed the PSTs to start thinking about teaching for social justice. At this early stage, most of their lessons aimed to have their students become aware of their selected context. The PSTs did not plan to have deep conversations about why the issues existed or to discuss actionable steps that can be taken to address the issues. With continued support PSTs can not only focus on awareness but also learn to discuss possible solutions so their students can take action and feel empowered. Such practice is necessary for PSTs to engage in repeatedly, for them to become experts (Nasir et al., 2008). Future research will focus on guiding PSTs to develop their identity as teachers who connect culture, mathematics, and social justice.

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