

“I Can Make a Difference Through Mathematics”: Mathematics Majors’ Conceptualizations of Justice in the Context of Teaching Mathematics for Social Justice

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There has been a call to emphasize how mathematics can be used to tackle social issues in ways that create a more just world. Such efforts can take the form of an explicit topic, entire course, or as a call-to-action impacting communities in various manners. This study analyzed course reflections of 15 mathematics majors enrolled in a Teaching Math for Social Justice course. We used open coding and constant comparison analysis to analyze pre-class and post-class reflections to understand the ways that students conceptualized the notion of “justice”. Eight themes emerged from the data, with notable differences between the ways students described justice before and after the course, with students’ conceptualizations demonstrating change or becoming solidified after completion of the course. These findings contribute to the larger body of research that continues to investigate how mathematics students engage with incorporating social justice contexts into mathematics teaching and learning.

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In the past 40 years, there has been a call to emphasize how mathematics can be used to tackle social issues in ways that create a more just world. Social justice pedagogy “can be used in mathematics classrooms to help students interpret and apply mathematical knowledge to answer questions that will potentially empower their lives and their communities” (Leonard et al., 2010, p. 264). Scholars like Bob Moses (2002), Rico Gutstein (2006), and Rochelle Gutiérrez (2013) are a few in a long list of scholars who have committed themselves to using mathematics to engage in and address real-world issues. Grounded in critical pedagogy (Freire, 1970/1996), which asserts that education can be used to transform and improve society, using mathematics to understand and address issues of social justice is a way to understand and “engage in political and economic realities of everyday life” (Kirylo et al., 2010, p. 332). With a recent sociopolitical turn in the mathematics education field (Gutiérrez, 2013), there has been a more focused attention towards issues of social justice. Gutstein (2006) defines reading the world as using mathematics to “understand issues of power, resource inequities, and disparate opportunities between different social groups and to understand explicit discrimination based on race, class, gender, language, and other differences” (p. 25-26), which he argues is necessary for students.

Teaching mathematics for social justice (TMfSJ) has become an explicit topic in teacher preparation programs, courses in mathematics departments, and as calls to action for college mathematics faculty. We believe that the education system is one of many institutions in the United States that has been historically oppressive, violent, racist, sexist, ableist (and more). Asking students to engage and learn about these facets in a safe space in the context of mathematics is one way that we can begin to acknowledge these oppressions in ways that we can make important shifts towards change. Gonzalez (2012) shares four components of TMfSJ: 1) access to high-level, quality mathematics instruction for all, 2) recentring the curriculum around the experiences of students from marginalized communities, 3) use of mathematics as a critical tool for understanding social life and injustices within it, and 4) using mathematics to actively advocate for social change toward a more equitable society (p. 128-129). There are multiple authors who have published materials to support the conceptualization of using real-world social

issues to engage in mathematics learning. Gutstein and Peterson's (2013) book provides context and "examples of how to weave social justice issues throughout the mathematics curriculum and how to integrate mathematics into other curricular areas" (p. 1). Berry III et al. (2020) developed a textbook that helps mathematics teacher educators support future high school teachers to understand relevant social justice standards in the classroom context while also providing ready-to-use lesson plans. Karaali & Khadjavi (2019/2021) provide examples of lessons for the college classroom, in which they point out that college mathematics instructors have "the opportunity and the responsibility to help...students develop strong analytical skills and empower them to tackle complex issues" (p. 3).

In recent years, more emphasis has been placed on preparing future mathematics teachers to incorporate social justice contexts within their mathematics lessons. This has been challenging, however, given that many students have not experienced instruction that utilizes societal issues as context for the mathematics content. Leonard and Evans (2012) found that it is difficult to change preservice teachers' beliefs and dispositions around social justice via short-term interventions (e.g., five-week module or after participating in a social justice activity), indicating that it may take more time to assist in developing a commitment to social justice. Bartell (2012) asked preservice mathematics teachers to articulate how they conceptualize the notion of TMfSJ, in which students felt they better understood their community, were more motivated to be more active citizens, and that they saw mathematics as a tool to change the world. However, it has also been challenging to find appropriate examples that connect to the content in the mathematics classroom (Leonard et al., 2010). Bartell (2013) found that preservice teachers struggled to find cohesion between the mathematics content goals of the lesson to the social justice goals, with students often focusing on mathematics content in the start of the lesson and finalizing the lesson by returning back to social justice goals, not finding ways to negotiate both at the same time.

Theoretical Framing

This study is framed by the notion of social justice pedagogy (Leonard et al., 2010), which allows students from all backgrounds to engage in meaningful mathematics grounded in relevant contexts which develops their mathematics identity. Social justice pedagogy provides the opportunity for students to develop an awareness of their world, while also developing critical mathematics literacy to accomplish goals relevant to them (Martin, 2000). Larnell and colleagues (2016) argue that it is important for a student to have agency within the mathematics classroom while also developing their mathematics identities – but that their identities are impacted by social structures. That is, a student's mathematics identity develops within the context of understanding the world around them. We believe that part of the development of mathematics identities through social justice pedagogy is that students have the need to develop a personal understanding of what justice means to them within the contexts of their own lived experiences. Parsons (2005) argues that oftentimes, the literature presents justice and caring as incompatible ethics. On the one hand, justice is seen as addressing moral problems through previously established rules (Parsons, 2005). However, from an ethic of caring, individuals approach moral dilemmas differently, considering "responsiveness to others and the nurturance of interpersonal relationships as paramount in determining action" (Parsons, 2005, p. 26). Parsons argues that "justice and caring must come together in the act of teaching; if not, systemic inequities and inequalities are preserved and perpetuated by the teacher's actions" (p. 26). Su (2020) defines primary justice (treating people with dignity and care) and rectifying justice (spotting something wrong and trying to make it right). Su argued that if primary justice was the only type of justice present, then rectifying justice would not be needed. Defining justice is a nuanced task—Gutiérrez

(2018) believes that concepts such as equity are difficult to engage in when people hold different conceptualizations of it—we argue the same is true related to the concept to justice. We believe that a student's engagement in social justice pedagogy can shape their understanding of the ethic of justice such that their definition of justice can take on a more caring perspective, and that this can impact their mathematics identity. Our study investigates how mathematics majors enrolled in a TMfSJ course: 1) conceptualize the phrase “justice” prior to and upon completion of the course and 2) change/develop their perspectives on what “justice” means to them.

Methods

This study took place at a large, public Hispanic- and Asian American Native American Pacific Islander-serving institution (HSI & AANAPISI). A total of 15 mathematics students enrolled in an upper-division mathematics course intending to engage students in using mathematics as a tool to investigate issues of social justice. Within this course, students engaged in social justice lessons and were expected to develop and implement their own lesson. Students were labeled with identifiers S1-S15. Eleven students majored in pure mathematics, three majored in applied mathematics and one majored in electrical and computer engineering with a minor in math. There were a total of nine men and six women in the course. Three students identified as Asian (one woman; two men), six identified as Latine (four women and two men), two identified as Latine and White (one woman; one man), three identified as White men, and one student identified as a Latine, Asian, & Black man. Six students spoke another language at home, including Spanish, Mandarin, Vietnamese, and Bengali. Two-thirds of students were first-generation status while 80% of students received financial aid. Two-thirds of students worked while enrolled in the course, with two of those students working a full-time job. Not all students who enrolled in the course intended to go into the field of teaching—only half of students had this as a goal, whereas others planned to work in industry.

All course assignments were collected consisting of homework, reading reflections, students' lesson plan, and a final portfolio. The data for this paper is pulled from two course assignments. Prior to the first day of class, students were asked to read Chapter 1 and 10 from Su's (2020) book *Mathematics for Human Flourishing* and to reflect on what the phrase justice means to them. At the end of the semester, students were asked to submit a final portfolio where one component asked students to reflect on their first write-up and to re-evaluate their definition of justice. Students were not obligated to change their conceptualization and were encouraged to utilize any experiences in the course in their reflection. For sake of analysis, we will call these pre-class (PreCR) and post-class reflections (PostCR). One student did not submit her PostCR and therefore will not be included in the change analysis.

The PreCRs and PostCRs were analyzed in two rounds using open coding (Merriam, 2009) and constant comparison analysis (Corbin & Strauss, 2008). First, two authors coded each assignment individually, developing and grouping themes that came from the data. All authors met to discuss these themes, developing a set of eight themes (discussed in the findings). Next, two authors analyzed the differences in the students' conceptualization of justice. We categorized these differences as 1) moderate change, 2) profound change, or 3) solidified. We defined a change in their conceptualization based on 1) whether the students explicitly stated that their definition had changed, 2) students indicated that they wanted to expand their definition, or 3) when a student did not make explicit mention, all authors discussed the students' PreCR and PostCR accounting for nuances in their writing (in which we utilized the presence of the eight themes developed from the initial coding to determine whether the change was moderate or

profound). A student's conceptualization of justice was labeled solidified if the student explicitly stated that their definition had been "solidified" from their initial writing, indicating no change.

Given the nature of TMfSJ, we recognize the importance to share the authors' positionalities. Author 1 is a cisgender, white, disabled, queer woman who is a tenured professor at a HSI in a large urban city. She is also the instructor of the TMfSJ course analyzed in this study. Author 2 identifies as a white, able bodied, neurodivergent, cisgendered woman. She is a doctoral student at a large public HSI. Author 3 is a cisgendered Hispanic Chicano male who is a masters student at the same institution as Author 1. He was enrolled as a student in the TMfSJ course analyzed in this study. Due to proximity of both Author 1 and Author 3 to the course, both authors consistently reflected on and discussed possible subjectivity during the analysis process. All data were de-identified, yet due to the small sample, full anonymity may not always be possible.

Findings

We will first discuss the students' conceptions of *justice* in their PreCR and PostCR through the themes that developed from their responses. Then we will discuss the changes we saw in students' conceptualizations from start to end of the semester. Table 2 shows the eight themes demonstrating the total counts from the PreCRs (270) and PostCRs (172) across all responses; each theme contains a set of subcodes that made up that theme. An excerpt could receive more than one subcode when it contained multiple ideas (e.g., "justice means fairness and equality" was coded as "fairness" and "equality" which both fell under the theme JFEO). Repeated mentions of the same term within a single statement/sentiment were not double-coded. It is important to note that different themes could apply to the same statement. For example, the statement, "[Justice] is actively working to give voice to individuals who do not have one or need help being heard." which would be coded under themes JP and JRV.

Table 1: Themes Related to Conceptualizations of the Word "Justice"

Justice as...	PreCR Freq (N=15)		PostCR Freq (N=14)	
Fairness, Equity, & Opportunity (JFEO)	48	(17.8%)	27	(15.7%)
Systemic/Institutional (JSI)	40	(14.8%)	26	(15.1%)
Contextualized (JC)	98	(36%)	50	(29%)
Care, Dignity, & Ethical Guidance (JCDE)	19	(7%)	8	(4.7%)
Rectification (JR)	18	(6.6%)	8	(4.7%)
Recognition & Valuation (JRV)	24	(8.8%)	15	(8.7%)
Identity, Positionality & Empowerment (JIPE)	9	(3.3%)	12	(7%)
Praxis (JP)	14	(5%)	26	(15%)

Pre- and Post-class Conceptualizations of *Justice* by Theme

Of the eight themes, we will discuss four that demonstrated most variance from PreCR to PostCR. The most frequently coded themes across both reflections were Justice as: Fairness, Equity, and Opportunity (JFEO), Systemic/Institutional (JSI), and Contextualization (JC). The first, JFEO, refers to students' associations between justice and familiar terms such as fairness, opportunity, equality, equity, access, and support. JFEO captured moments when students emphasized equal opportunities are a core component of justice. JSI reflected the ways students connected justice and injustice to broader systems, institutions, and structures. JC encompassed the ways that students drew on specific examples, metaphors, and lived experiences to define justice. Reflections in JC stressed that justice is dependent on context and is up for interpretation. We noticed significant decrease in these three themes from pre to post with one theme

demonstrating a notable increase, Justice as Praxis (JP), which represented views as justice as action through advocacy, responsibility, and efforts to redress injustice.

Justice as Fairness, Equity, and Opportunity. JFEO was coded 48 times (17.8%) in PreCR and 27 times (15.7%) in PostCR. Within the JFEO theme students most often invoked concepts of fair/fairness and opportunity. Early responses framed justice in individualistic and concrete terms, equating justice with fair and equal chances. There were cases in the PreCRs where students used the terms equity and equality interchangeably, S6, a first-gen, white man wrote “justice means to treat everyone with equitability and fairness...upholding the idea of equality”. This illustrates how students collapsed equity, equality, and fairness into a single cluster of ideas. By the end of the course, however, references to fairness and opportunity had declined, and some students began to articulate clearer distinctions between equity and equality. S10, a first-gen, Latina woman explained that “equitability isn’t the same thing as equal”. Such statements signal a progression from broad, interchangeable framings towards more precise definition of justice.

Justice as Systemic/Institutional. JSI was coded 40 times (14.8%) in the PreCR and 26 times (15.1%) in the PostCR. The PreCRs highlighted the absence of justice within systems through references to discrimination, prejudice, bias, and stereotypes. By contrast, PostCRs contained fewer references to these individual or interpersonal manifestations and instead demonstrated an increased emphasis on a larger view of social justice and systemic injustice, and the notion of “more than individual” appeared. S1, a first-generation, Asian, Bengali-speaking man reflected in their PostCR, “Justice, I now realize, is a concept that extends far beyond individual fairness.” Another student, S7, a white man, admitted that in their PreCR, “I believe I focused too heavily on what justice means for me”. Such statements capture students’ movement away from describing isolated manifestations of injustice toward recognizing the structural mechanisms that sustain injustice. In PostCRs, students began to reflect on larger, systemic oppressions that may inhibit justice. S13, a Black/Asian/Latine man shared the value of TMfSJ, indicating that “If we want to give justice to those that have been systematically oppressed by the U.S government, then teaching mathematics for social justice will be a necessary step.”

Justice as Contextualized. JC was coded 98 times (36%) in the PreCR and 50 times (29%) in PostCR. The subcode contextual most often applied in PreCRs, marking when students made up an example to ground their definition or indicated that the definition was dependent on the context of a scenario or situation. Students also frequently relied on lived experiences (moments when a student would recall a time in their life or retell a story from someone they knew) and connections to education (when a student mentioned anything related to the presence of justice/injustice within education) to make sense of justice. While JC decreased in frequency from the PreCRs to PostCRs, various subcodes shifted in density; all three subcodes above decreased by more than half. A code that increased significantly in the PostCR was *connection to math*. This was coded whenever a student mentioned mathematics or the math classroom, oftentimes referring directly to the power that mathematics has when addressing issues of social justice. S15, a white man, shared, “I can make a difference through mathematics” and S5, an Asian Vietnamese-speaking man indicated that he recognized that “the intersection of mathematics and social justice reveal[s] how math education can be a powerful tool to address and understand social justice issues.” This shift indicated that students were formulating a more attuned perspective of justice within their world as mathematicians.

Justice as Praxis. JP was coded 14 times (5%) in the PreCR and 26 times (15%) in the PostCR, illustrating a significant increase in responses related to collective action. There was an increase in the subcode *practices, advocacy and action*, which was applied any time a student

mentioned the importance of justice-oriented practices, recognized injustices, called for action, or provided examples of how they or others could engage in justice work and the subcode *responsibility of justice*, captured when moments when students described a personal or collective responsibility to act, reflecting on the roles individuals play in correcting injustices, or contributing to justice. In their PostCRs, S7 and S15 (both white men) shared this shift to action. S7 shared “You instead need to look at the greater efforts and ask yourself how you can help in such efforts”. S15 viewed his role as one who influence his community, “I will continue to challenge those around me to speak out on injustice and take the necessary actions to bring positive change to the community I serve.” Taken together, this theme showed notable growth and suggests that students’ conceptualizations of justice shifted from abstract ideas toward enactment and commitment to transformative action. The rise in responsibility language highlights a deepened sense of both personal and collective obligation.

Development of Conceptualizations of *Justice* at the End of the Course

Of the 14 students who submitted both PreCRs and PostCRs, five students showed moderate change, seven students exhibited profound change, and two students’ views were solidified.

Moderate Change. Students that demonstrated moderate change mostly indicated adjustments they would make to their original conceptualization. For example, S2, a Latina Spanish-speaking woman, initially described justice as “a staircase with many exit points” indicating that the world has little respect for justice of fairness. She chose the staircase analogy because “you can step off when you’re done or tired of fighting...where some people keep fighting till the top, some people fall off the stairs and some sit on the stairs instead of getting off”. In her PostCR, she slightly modified her analogy to indicate that “everyone is actually on their own ladder regardless of what they want to be.” S9, a Latino/White Spanish-speaking man, initially stated that, “justice is a response to make matters right as much as possible for victims of wrongdoings and for consequences to ensue for the perpetrators of the wrongdoings.” Later, he indicated that overall he still agreed with his first definition but with a slight change in what “the scope for which the word justice could be used for” indicating that initially he only saw it as used purely in legal issues, however, now he sees “that justice is not only for legal cases but for issues of social inequity beyond the lens of legality.”

Profound Change. Seven students indicated profound change in their conceptualizations of justice, indicating complete re-definition of the concept. For example, S6, initially described justice as “treating individuals equitably and fairly, regardless of their background, identity, or circumstances.” Yet, in his PostCR he indicated that he sees it as much bigger than being equitable and fair, indicating that using the word “fair” was too ambiguous. He expanded his thoughts by sharing, “Justice to me is ensuring that everything is taken at face value from person to person, circumstance to circumstance, regardless of any assumptions or pre-existing notions. However, this course hasn’t just changed my understanding of justice, it’s changed the way I approach and think of issues and broadened my mind about how people think.” S10, initially conceptualized justice as “when everyone gets a chance to experience life equally.” Later, in her PostCR, she shared that justice “means making sure everyone is given the tools they need so that everyone is at the same level or in other term everything is equitable for everyone. The reason for this is because equitability isn’t the same thing as equal because equal just means to give everyone the same number of things while equitability means to make sure everyone is at the same starting point.”

Solidified. Two students were labeled solidified. Both students utilized this word in their write-up, indicating that this course reaffirmed their initial view of justice, making it a more

stable conceptualization for them. S8, an Asian Mandarin-speaking woman, initially indicated that “justice isn’t just righting a wrong but showing the true qualities of something.” Later, she indicated that her understanding had been solidified after the 15-week course. S13, a Latino/Black/Asian man, initially described justice as “righting any wrongs that have been done upon another and stopping those wrong doings from happening again. I think I understand justice more as rectifying justice due to how much discrimination I see everyday from the news to social media.” Upon completion of the course, he shared that the course solidified his definition.

Discussion

This study sought to understand how mathematics majors enrolled in a TMfSJ course conceptualized the notion of *justice* before and after the course experience. Our analysis of students’ reflections highlights several important shifts in how students understood, described and located justice. The findings suggest that engaging undergraduates in explicit study of social justice pedagogy both broadened conceptualizations and elevated their identities as mathematicians and future educators. Our data points out that conceptualizing *justice* is a complex and challenging task, yet being able to begin defining such a nebulous word is important to rehumanize mathematics learning and its impacts in the classroom and on society (Gutiérrez, 2018). However, we did see that most students developed and expanded their conceptualizations of the phrase, which shows promise that a semester course can have impact.

We saw four notions arising from the data: 1) movement from individualized justice to collective views, 2) a shift from the view of fair/equal to more equitable stances, 3) an overall increase in viewing justice as action or a way of being, and 4) more direct connections to how students see the power of mathematics contributing to justice. In initial descriptions of justice, students often gave individual experiences as examples to demonstrate the concept. By the end of the term, students spoke in much larger perspectives, indicating that achieving justice was part of a sociopolitical movement (Gutiérrez, 2013), of which many students saw themselves as one part of a bigger process. Next, students initially discussed justice with many words that were used interchangeably, including *fair*, *equal*, and *equitable*. Students end of term reflections suggested a deeper understanding of the differences between these words, including direct acknowledgement of how they felt prior to the course they did not necessarily understand the differences between them. We noticed a large decrease in use of the word *fair* at the end of the course, with students demonstrating an awareness that there is a lot to consider when determining fairness. The theme of Justice as Praxis demonstrated a significant shift in students’ perspectives of action. Students often indicated ways to advocate and enact justice, reflecting views of rectifying justice (Su, 2020). We noticed that students began to write more about *who* is involved in the concept of justice, but also *where* and *when* justice (or injustice) takes place. Students also indicated more about *how* power and resources tie into justice. These tie into the notion of *reading the world* (Gutstein, 2006), in which students think about these types of issues related to power and identity. Finally, students reflected more on how mathematics is a powerful tool with which to use to consider justice, which is an important tenet to transitioning to TMfSJ (Gonzalez, 2012).

We note that, generally, students did not explicitly discuss issues of race or gender, often referencing injustices of oppressed or marginalized groups without naming the oppression. Milner (2003) argues that preservice teachers specifically need to be comfortable discussing issues of race within larger contexts. Due to the small sample size, we were unable to find any trends in the data related to students’ demographics (e.g., race, gender). We plan to investigate this further with future data collection.

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