

2022

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L. Dietiker, E. Barno. 2022. "Opportunities in social justice mathematics curriculum: Analyzing high school algebra lessons"

<https://hdl.handle.net/2144/48783>

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Paper Title Opportunities in Social Justice Mathematics Curriculum: Analyzing High School Algebra Lessons

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Session Title What and Whose Stories Are Told in Mathematics Education and Toward What Ends?

Session Type Paper

Presentation Date 4/22/2022

Presentation Location San Diego, California

Descriptors Curriculum, Social Justice

Methodology Qualitative

Unit SIG-Research in Mathematics Education

DOI <https://doi.org/10.3102/1888822>

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**OPPORTUNITIES IN SOCIAL JUSTICE MATHEMATICS CURRICULA:
ANALYZING HIGH SCHOOL ALGEBRA LESSONS**

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OPPORTUNITIES IN SOCIAL JUSTICE MATHEMATICS CURRICULA: ANALYZING HIGH SCHOOL ALGEBRA LESSONS

This paper describes the opportunities for students in social justice mathematics (“SJM”) curricula designed for high school algebra students. We looked for opportunities for students to make sense of intersectional identities, take political action, and experience rich and expansive mathematical activities. Across 16 lessons, a majority have a strong emphasis on middle school, early-sequence linear functions, and statistics content. Additionally, the social action available to students within the classroom setting tends to be more on understanding contexts and less on using mathematics as a catalyst for identity attunement and community change. With these results, we make recommendations for future development of SJM materials that offer a wide spectrum of opportunities, designed in collaboration with local communities.

Increasing calls to incorporate social justice themes in secondary mathematics classrooms aim to confront social inequity and systems of oppression in a disciplinary space that is traditionally viewed as apolitical (e.g., Felton, 2010). Even with this call, most high school mathematics teachers in the United States feel constrained due to content expectations of the Common Core State Standards of Mathematics (“CCSSM”) (Banilower et al., 2013). Or, when social justice themes are connected to sought-after gatekeeper mathematical topics, teachers may not feel the lessons make space for students to authentically reflect and make societal change. Enacting curricular materials that balance these tensions can offer an opportunity for students to have continued mathematical access while making space to uncover and address inequities (Gutstein, 2016).

To answer this call, lessons for social justice mathematics (“SJM”) have been design and published for educators. Although there has been an increase in SJM lessons, there is little known about their multifaceted nature. In this study, our goal is to learn more about the affordances and limitations of available SJM curricula designed for students learning high school algebra. In addition, we describe future directions for SJM curriculum authors to consider.

Thus, this paper analyzes high school algebra SJM materials to answer the questions: *In existing SJM, how is mathematical and social justice content juxtaposed and structured? And what*

opportunities exist for students to respond to injustice? Our aim is not to criticize the SJM materials currently available to educators, but instead to describe the current range of materials available for teachers in terms of both student mathematical learning and social justice action. This analysis seeks to describe the scope and qualities of opportunities available for how SJM positions students to question the status quo, understand intersectionality in relation to inequities, and reimagine the world in mathematics classrooms.

Theoretical Framework

We assume that by knowing gatekeeper knowledge, students will “have economic survival for themselves, their families, and their communities; future education and meaningful vocational or career plans; reading and writing the world; and the full actualization of their human potential” (Gutstein, 2016, p. 457). In light of this, we draw from Berry III et al. (2020) to frame *social justice learning* within curricular materials to be opportunities for students to critique and address contributions and rights of individuals and communities across for constructs: access, participation, empowerment, and human rights. Thus, *social justice mathematics* refers to designed content that aims to use “settled” (Warren et al., 2020) mathematics “to comprehend and change the world—and through the process, deepen knowledge of both this form of mathematics and their social reality” (Gutstein, 2016, p. 455). Although algebraic content within the CCSSM and its focus in this study reflects dominant, settled mathematics and mathematical teaching and learning has historically excluded the thinking, learning, and doing of marginalized communities (Gutiérrez, 2017), we focus on high school mathematics, and more specifically algebra, to locate SJM within the gatekeeping expectations constraining the curricular decisions of teachers.

Methods

Lessons were first identified by searching for “Social Justice High School Mathematics Lessons” in order to identify the sources and textbooks with SJM lessons targeted to address high school CCSSM standards. Of these, we narrowed to plans that were designed to specifically address secondary algebraic content. From our search, we included the most recent form of a given lesson if it was presented and/or adapted in multiple formats and if it was available without subscription. Additionally, we eliminated materials that did not detail a complete implementation plan for teachers to utilize (e.g. sources that included vignettes of an enacted lesson).

In total, we identified 16 lessons that met this criteria: *High School Mathematics Lessons to Explore, Understand, and Respond to Social Justice* (“Responding,” Berry III et al., 2020), *Reflecting the World: A Guide to Incorporating Equity in Mathematics Teacher Education* (“Reflecting,” Felton-Koestler et al., 2017), *Classroom Fruition* (“Fruition,” Fruin, 2019), and *Solving World Problems: Equity and Social Justice in Mathematics Education Solving* (“Solving,” Harper, 2016).

Each lesson was coded by the lead author, in collaboration with the second author, using three passes: First, using a framework adapted by Felton-Koestler et al. (2017) (see Table 1) we coded how mathematical and social justice content are juxtaposed, such as whether mathematical ideas emerge from the analysis of social phenomena or if mathematical investigation informs understanding of social phenomena. Second, we coded the nature of each lesson’s mathematical inquiry using Felton-Koestler et al.’s (2017) framework of four categories for how the mathematical ideas of the lesson are structured (see Table 2). Third, we coded each lesson for how lessons made space for students’ engagement with social injustices with a framework adapted from Berry III et. al (2020) (see Table 3).

Findings

Across the 16 SJM lessons, patterns emerged in terms of mathematics, social justice learning, and the connection between. The results described in this section are summarized in Table 4.

Mathematical and Social Justice Content Juxtaposition

The most frequent juxtaposition of mathematical and social justice content in the lessons was *Providing Insight*. Three *Providing Insight* lessons (Fruition) provide 15-minute activities where students wonder about a graph and then make predictions when it is connected to a real-life context (e.g., prices of medication, changing poverty rates in different cities). The rest (8) contain 60-minute case studies where students mathematically analyze specific scenarios to learn more about the lived experience of inequity.

In the five remaining lessons, there is one *Stepping Stone* lesson, two *Backdoor* lessons, and three *Tool* lessons. The *Native American Star Quilt* lesson is a *Stepping Stone* because it uses the quilt design as the basis to discuss various transformations of shapes to make eight-point stars. One *Backdoor* lesson, *Intersectionality and the Wage Gap* (Responding), begins by “paying” students depending on their shirt color in order to reveal insights on inequitable distribution of wealth. The second, the *US Poverty* lesson (Fruition), prompts students to make predictions about an unlabeled graph and noting the drastic differences before being told it represents income inequality. Of the *Tool* lessons, *What Is the Cost of Globalization?* (Responding) asks students to create and present a function representing the cost of making an iPhone8 to persuade sellers to adjust their production choices. The lesson *Literacy: What Matters and Why?* (Responding) focuses students’ attention on how data can be used to perpetuate deficit perspectives about groups

of peoples' literacy levels; the lesson then prompts students to present their mathematical work to community stakeholders as a call to diversify available books in local libraries. The third *Tool* lesson, *Water Bottles for Detroit* (Reflecting), prompts students to develop a mathematical method to identify the best water bottle design based on their own criteria to support those impacted by the water crisis in Detroit.

Mathematical Structure of Inquiry

Most of these lessons (9 of 16) have a *Directed* structure of inquiry, where teacher-led questions guide student thinking through a contextual task as opposed to students leading themselves through inquiry via their own questions. For instance, *Mortality and Race* (Reflecting) has students create a histogram and a box plot of mortality rates; the teacher has students discuss patterns by age revealed in each representation and reflect on potential causes.

Five of the remaining lessons have a *Proto-Modeling* structure of inquiry. Of these, the lessons usually prompt students to create a best-fit model of a certain scenario, but then offer students an opportunity to choose if the model should involve a linear, quadratic, exponential, or trigonometric function. In three of these lessons, the data being analyzed is linear.

Only two lessons were identified as *Modeling* tasks. In *What is the Cost of Globalization?* (Responding), students are required to determine applicable variables when approximating the environmental and human cost of making an iPhone8 before using a linear, quadratic, or exponential function as a model. Similarly, *Water Bottles for Detroit* (Reflecting) prompts students to use their choice of mathematical functions to justify their chosen bottle design.

Opportunities for Students to Respond to Injustice

Nearly all lessons (14 or 16, or 88%) prompted students to *Explore* an inequity and understand ways in which it is perpetuated. Four *Explore* lessons are 15-minute activities using a variety of real-world contexts (Fruition); in these, all mathematical activity occurs during the first two-thirds of a discussion, and the last third prompts students to take a stance on a social phenomenon (e.g., deciding if the cost of an EpiPen should be regulated). Four additional *Explore* lessons involve a case study of three post-graduate plans in relation to the community of the students and their potential earnings (Solving), an investigation of data about incarceration and mortality rates to discuss connections to systemic inequities (Reflecting), and an exploration of how the design of Native American Star quilts are mathematically constructed (Reflecting).

Only three lessons provide opportunities for students to both *Explore* and *Respond* to injustice (*Children at the Border*, *Climate Change in Alaska*, and *What is a Fair Living Wage?*) by writing letters to local officials, making a video to encourage others to advocate for change, or discussing related policy proposals with a politician. Three other lessons provide an opportunity for students to *Explore*, *Understand*, and *Respond* to injustice (*Culturally Relevant Income Inequality*, *Intersectionality and the Wage Gap*, and *Literacy: What Matters and Why?*). These lessons provided opportunities for students to examine their intersectional identity and to consider how to respect others in intersectional ways. The two remaining *Respond* tasks prompt students to present their mathematical thinking to community members and did not explicitly include any exploration or understanding of the given context (*Water Bottles for Detroit* and *What is the Cost of Globalization?*).

Discussion and Future Directions

Analyzing where these SJM lessons land on the spectrum of how mathematics is connected to the social justice topic, how mathematics is positioned within the lesson, and how students are presented with opportunities in relation to social justice activism reveals a wealth of certain opportunities and a limited availability of others. Overall, the social justice reflection, identity work, and justice-oriented action available to students within the classroom setting tends to be more on understanding contexts and less on using mathematics as a catalyst for identity attunement and community change. It is also clear that there are more SJM lessons that are designed to *provide insight* into an inequity through using mathematics and *direct* the mathematics introduced from either the teacher or the curricular handout. In terms of content, there was a limited range as to what algebraic topics were addressed even though all the SJM lessons were explicitly labeled in relation to high school algebra. This study shows that there is a strong emphasis on middle school, early-sequence functions and statistics content overall. So, not only were the SJM lessons presenting mathematics to understand the presented injustices in a way that is directed by the teacher, but the mathematical content tends to not address uniquely high school algebra standards as defined by the CCSSM. Therefore, our analysis reveals dual tensions present among the available curricular materials for secondary algebra teachers in regards to the available mathematical opportunities and authentic social justice engagement and action for students.

Our dimensions of analysis points to useful opportunities for designing future secondary mathematics lessons for social justice. We ask: *How can we increase opportunities to connect high school algebra content in a way that makes space for political action and encourages mathematical tools to actively address inequities in addition to understanding their complexity? How can students intentionally be given opportunities to understand themselves, others, and ways*

of thinking of intersectional identities in relation to their thinking mathematically? The lessons we analyzed begin to do this work. However, more work needs to be done. If one goal of incorporating SJM lessons into high school algebra classes is to explicitly challenge the narrative of mathematics being apolitical while providing knowledge to gatekeeper knowledge, it is critical that curriculum be designed with opportunities for authentic student reflection and engagement to challenge inequities through mathematical problem solving.

Acknowledgement

This material is based upon work supported by BLINDED FUNDER under Grant #blinded. We appreciate the many contributions of our broader research team.

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Table 1

Coding Framework to Describe the Juxtaposition of Mathematical and Social Justice Content, Adapted from Felton-Koestler et al. (2017).

Code	Conditions	Example
Stepping Stone	Real-world contexts serve as a stepping off point for thinking about particular mathematics concepts.	A lesson investigating the mathematical nature of Native American Star Quilts. Although we are looking at native making practices, the goal is to use the shapes used in the context of nets.
Providing Insight	Mathematics done provides some new insight into real-world topic under investigation. The learners should learn something new about the real-world context by engaging with mathematics.	A lesson looking at three different case studies of post-graduate paths and income, where students use mathematics to learn more about earning potential based on those educational backgrounds in their community that they didn't know before.
Backdoor	Begins as a math problem with a largely 'apolitical' context, but then revealed the math done has another real-world meaning.	Students are shown an unlabeled graph, and are asked to share noticing and wonderings within different domains. Then, it is revealed that the graph <i>actually</i> is a representation of changing poverty rates in the US.
Tool	Mathematics serves as a tool for reaching a goal (ideally for helping those in need).	Students develop an equation representing the human and environmental cost of making an iPhone, and present the equation to raise questions about capitalism and its negative impacts.

Table 2

Coding Framework for Structure of Mathematical Inquiry, Adapted from Felton-Koestler et al. (2017).

Code	Conditions	Example
Directed	<p>The mathematical questions asked about the context are primarily given.</p> <p>Usually one or more mathematical problems to complete that are intended to reveal something about the context.</p>	<p>A lesson where students are told to look at specific domains within a graphical representation in order to see the difference in rising crime rates in New York and Chicago, and connect that to a misleading headline presented in a local newspaper.</p>
Modeling	<p>Learners are making significant decisions about how to make sense of the context, ask questions, and analyze the content mathematically to answer those questions.</p>	<p>A lesson where students are asked to design an eco-friendly and cost-efficient design for a water bottle to supply to areas unable to access clean water. Students are given limited to no direction on how to approach this problem; student responses are mathematically creative and diverse.</p>
Proto-Modeling	<p>While the task can lead to discussion of different models, the number of decisions made by learners are minimal because of limited information provided and the structure of the task.</p>	<p>A lesson where students are given data about incarceration rates, and are asked to represent it in a clear way. Although students are choosing <i>how</i> to represent the data, the possibilities of representing that data are limited and are influenced by the curricular materials or teacher.</p>

Table 3

Coding Framework for Responding to Social Injustices, Adapted from Berry III et. al, (2020).

Code	Conditions	Example
Explore	Learners are presented with more information about a topic and how it creates inequitable lived experience.	A lesson where students are shown a graph of rising EpiPen prices, and students discuss why this is happening and how it impacts those who need it.
Understand	Learners will develop their lens to see the intersectionality of self, others, and lived experiences. Learners will build upon and affirm their multitudinous identities.	A lesson where students see data and how it is misrepresented to perpetuated deficit views of people of color. The lesson has students discuss why this happens, and how statements like this need to be unpacked in order to counter white supremacy narratives.
Respond	Learners have the opportunity to act or develop a public project.	A lesson where students present to local community stakeholders about the human and environmental cost of making an iPhone8 in order to enact change.

Table 4

Opportunities Presented within SJM Lessons for High School Algebra

	Positioning of Mathematics with Social Justice Content				Structure of Inquiry of Presentation to Math			Anticipated Student Response to Injustice		
	Stepping Stone	Providing Insight	Backdoor	Tool	Directed	Modeling	Proto-Modeling	Explore	Understand	Respond
EpiPen Prices		•			•			•		
Using Domain to Understand a Story		•			•			•		
Plastic in the Ocean		•			•			•		
US Poverty			•				•	•		
Post-Graduation Plans		•			•			•		
Children at the Border		•			•			•		•
Climate Change in Alaska		•					•	•		•
Culturally Relevant Income Inequality		•			•			•	•	•
Intersectionality and the Wage Gap		•	•				•	•	•	•
Literacy: What Matters and Why?		•		•			•	•	•	•
What is a Fair Living Wage?		•			•			•		•
What is the Cost of Globalization?				•		•				•
Incarceration Rates		•					•	•		
Native American Star Quilts	•				•			•		
Water Bottles for Detroit				•		•				•
Mortality and Race		•			•			•		