EMOTIONS IN SOCIAL JUSTICE MATHEMATICS: COLLEGE PRECALCULUS STUDENTS' EXPERIENCE

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This study investigates the interrelationship between emotion and learning in a college precalculus lesson that examined lead poisoning in participants' local community. Through a thematic analysis of students' responses to lead poisoning lessons, the study reveals a range of emotional responses, including empathy, concern, and heightened awareness of social issues. The findings underscore the critical role of emotions in deepening student engagement and commitment to social change, emphasizing the importance of incorporating social justice themes into the precalculus curriculum to foster a more engaged and empathetic student body.

Keywords: Affect, Emotion, Beliefs, and Attitudes, Precalculus, Social Justice, Undergraduate Education

The call to change mathematics instruction in high school and college classrooms has been ongoing (see Bartell, 2013; Gutierrez, 2002; Gutstein, 2003, 2006; Guzmán & Craig, 2019) with arguments from mathematics education researchers for a need to change mathematics instruction from conventional procedural practice to focus more on understanding the world and social issues (Gonzalez, 2009; Wright, 2016). Recent research in the field suggests that students are increasingly engaged in mathematics lessons contextualizing issues of injustices in society (Gutstein & Peterson, 2013; Voss & Rickards, 2016). We imagine the future of mathematics education to lean toward contextualizing students' local environments to make mathematics more relatable to students. In addition to the theoretical arguments and empirical claims in favor of teaching mathematics by contextualizing social injustices, students experience various emotions when they learn about societal inequities (Kokka 2019; 2020). The empirical evidence from Kokka's research necessitates the inclusion of emotions in students' mathematical learning. Our study aims to explore the variable of emotions in students' mathematical learning. Our study is set to explore and inform the mathematics education field about emotions students experience in situ of social justice mathematics lessons.

Mathematics education research has for a long time been focused on reasoning (Roth & Walshaw, 2019), knowledge, and other cognitive factors, with little attention to emotions (Schukajlow et al., 2017), the exception being mathematics anxiety (Zan et al., 2006). A few decades ago, however, there was a shift in focus toward incorporating "affect" into this research. Specific definitions and perceptions of affect vary. McLeod (1992) viewed affect as being connected to cognition and performance. Lewis (2013) perceived affect as a student's attitude toward or enjoyment of mathematics. These slightly earlier perceptions of affect regard students' relationships to mathematics, with less emphasis on other factors that may influence students' emotions in the mathematics classroom. In recent years, mathematics education researchers have also more directly incorporated emotion into their study of affect. For example, students bring

emotions with them into the classroom (Kokka, 2019; Valoyes-Chavez & Darragh, 2022). Students experience emotions in a mathematics classroom when learning about injustices (Kokka, 2019, 2022; Valoyes-Chavez & Darragh, 2022). Therefore, it is important to consider students' emotions as a factor that affects their learning in mathematics classrooms. Our study is guided by the research question: *How did learning about a local social justice issue affect students' expression of emotions in a college precalculus classroom?*

Theoretical Framework

We leveraged a combination of two theoretical frameworks for this study: affective pedagogical goals (APG) for social justice mathematics (SJM) by Kokka (2022) and historically responsive literacy (HRL) by Muhammad (2020; 2023). The APG aims to support instructors' preparation of SJM lessons by anticipating students' emotions related to injustices. The idea is to provide a space for students to express their emotions about mathematics and the oppressive systems they interact with; this, in turn, may help students process their emotions to understand and use mathematics to address inequities., For this study, we focused on the affective pedagogical goal (Kokka, 2022) of supporting students' expression of emotions related to the local social injustice issue and ongoing efforts to address the issue. Kokka named this goal "identifying and processing emotions to take action." We consider this the first step in helping students process their emotions to act in SJM lessons.

Muhammad (2020; 2023) defined the historically responsive literacy (HRL) framework as a literacy model with five learning pursuits: identity, skill, intellect, criticality, and joy. Muhammad (2020) defined identity as learning about yourself, and the people around you. Skill refers to the concepts and procedures as outlined in school standards. Intellect is the ability to apply skills to understand social interactions. Criticality is the ability to understand injustices in society and use knowledge to challenge the status quo. Finally, Muhammad (2023) defines joy as experiencing happiness, related to celebration, wellness, and justice. We broadened Muhammad's (2023) framing of joy to include other emotions as students engage in a SJM lesson. For this study, we conceptualize meaningful mathematics learning based on the integration of the five learning pursuits of Muhammad's HRL framework, and Kokka's APG.

Methods

Research Context

The participants were forty-three first-year precalculus students enrolled at a predominantly white university in the Northeastern United States. Students completed a SJM lesson designed from an HRL and SJM framework, that mathematized the lead poisoning issue in Metroville, the city where participants attended university. It was created on Desmos, an online tool for creating and teaching lessons. After the lesson, instructors downloaded and saved the anonymized student responses in a shared OneDrive folder accessible only to the research team.

The SJM lesson had three components: pre-lesson survey, Desmos lesson, and post-lesson reflections and surveys. This paper focuses on analyses of students' responses to the Desmos lesson. The Desmos lesson introduced the students to the lead poisoning issue through a video, showed how lead decay can be modeled using exponential functions, asked students to solve exponential decay problems, and informed students about the ongoing efforts to address lead poisoning in Metroville. We asked students to express and explain their emotions at two instances in the lesson: first after learning about the lead poisoning issue, and second after

learning about the ongoing efforts. Students were asked to "Name up to three emotions, if any, you experienced after watching the video and writing about lead poisoning in your hometown. Explain what made you feel these emotions." Our analyses focused on students' responses to the two questions that asked students to name emotional responses related to injustices and action.

Thematic Analysis

We employed Braun and Clarke's (2006) six-phase thematic analysis approach to analyze students' responses to "Explain what made you feel these emotions" questions from the Desmos lesson. We reviewed students' responses and the research question, wrote notes/memos about initial impressions, and shared them during weekly research meetings. In the second phase, we coded the data and reconciled coding weekly, using a data-driven approach. The third phase involved developing themes by identifying patterns and grouping similar codes. We created a coding frame document to ensure intercoder reliability, including themes, code definitions, and example data segments. In the fourth phase, we checked theme coherence across the dataset. The fifth phase involved aligning the coded responses of the students with themes to address the research question. In the final phase, we selected compelling data excerpts to support our results and developed solid arguments based on these examples.

Results

Our analyses informed us that students expressed emotions because of lack of awareness about lead poisoning, empathy for children/tenants, knowledge about lead poisoning, and views on existing efforts to address lead poisoning. There were other themes in addition to the four mentioned, but in this paper, we focus on these four themes (see Table 1). Students expressed emotions because of a lack of awareness or experience with lead poisoning, and empathy for families living in lead-poisoned houses. Students also expressed emotions based on their knowledge of the lead poisoning issue, willingness to play a role in helping affected families, and their views on the current efforts to address lead poisoning.

Table 1: Theme Findings and Examples

Theme Name and Definition	Associated Emotions	Examples
Theme 1: Lack of awareness about lead poisoning Students express a lack of awareness about the lead poisoning issue by self or people in general.	Shock, Concern, Sad, Annoyance, Curiosity, Disbelief, No emotion, Disturbed	• *"It is frustrating that people don't put in a effort to help others and fix this issue."* • *"never thought about lead poisoning being a problem"*
Theme 2: Empathy for children/tenants Students express empathy for children, tenants, or families who have lead poisoning or have to live in homes with lead poisoning issues.	Sad, Compassions, Pity, Guilty, Concerned, Anger, Bad, Sympathy	• *"I feel concerned for the welfare of the children still subjected to live in those areas."* • *"It is sad that young children are exposed to major health risks due to their living conditions"*
Theme 3: Knowledge about lead poisoning and/or determination to help Students share their knowledge about lead poisoning and a desire to help solve the cause of lead poisoning issues.	Guilty, Motivated, Shocked, Upset, Disturbed, Sadness	• *"I would say that I feel disturbed about the severity of issue and the potential consequences of lead poisoning"* • *"I feel the emotion of sadness desire to help these people."*
Theme 4: Views on existing solutions efforts to mitigate lead poisoning Students express their views on the current efforts/solutions to solve the problem of lead poisoning.	Optimistic, Happy, Promising, Hopeful, Confidence, Enlightened, Knowledgeable, Grateful, Relieved, Excited, Motivated	• *"I'm happy to see that the problem of lead poisoning is being addressed in the community"* • *"It feels good to know that issue is being addressed and that there is things that are beginning to get done in order to combat the problem."*

Theme 1: Lack of Awareness about Lead Poisoning

The first theme captures students' emotions about a lack of awareness regarding lead poisoning. One student expressed their shock at learning about lead poisoning by stating, "I was unaware that lead poisoning was still a thing and lead poisoning itself is a very dangerous thing to still have around. I can't believe that lead poisoning is still a thing, especially in this day in age." We interpreted this student's response as evidence of shock and lack of awareness about lead poisoning. Some students expressed surprise at how easily one can get lead poisoning.

Theme 2: Empathy for Children/Tenants

The second theme explores the emotions that arise from empathy for the people dealing with lead poisoning. After learning about the lead poisoning issue and how it affects people who live in homes with lead, students expressed empathy for the tenants, families, and children who had to choose between having a roof over their heads or being safe from lead poisoning. Learning that people living so close to them are dealing with these issues brought on a wide range of emotions in the students, such as sadness, compassion, pity, guilt, concern, anger, and sympathy. Notably, students were concerned that children were subject to lead poisoning in their home.

Theme 3: Knowledge about Lead Poisoning and/or Determination to Help

The third theme explores students' knowledge about lead poisoning and their determination to help. This theme includes student responses where they share their knowledge about lead poisoning and a desire to help solve the cause of lead poisoning issues. Furthermore, this theme also includes student responses expressing awareness about lead poisoning health risks and the population that is more vulnerable to being impacted. The theme also includes answers expressing students' willingness to help solve or raise awareness about this issue. As students learned about lead poisoning in Metroville, they demonstrated an understanding of the issue and a willingness to help the cause.

Theme 4: Views on Existing Solutions to Mitigate Lead Poisoning

The theme centers on students' positive emotions when learning about efforts to combat lead poisoning. Characterized by optimism and hope, students feel happy and relieved to know that governments and organizations are actively addressing the issue through specific initiatives, fostering confidence in future solutions. It reassures them that change is possible and that there are viable solutions to the challenges they are studying. Students know that their learning has an impact on the real world, which fosters a sense of self-empowerment, encourages them to take a forward-looking perspective, and allows them to look to the future where their newfound mathematical skills and social awareness contribute to social progress and justice.

Discussion

In summary, this study emphasizes the critical role of emotion in social justice mathematics. By addressing social justice issues, mathematics educators could deepen students' understanding of mathematical concepts and develop empathy, critical thinking, and social responsibility. We argue that a careful study of students' emotional responses to SJM lessons is needed to understand and support their learning. Further research could explore how instructors can attend to students' emotions to support their learning. Making mathematics relatable to students by contextualizing their social environments is the future of mathematics education.

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