The Influence of an Experiential Learning Social Justice Class on Undergraduate Students' Beliefs About Mathematics and Mathematics Teaching

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In this study, we explore the influence of an experiential learning social justice math class on undergraduate students' beliefs about mathematics and mathematics teaching. Twenty-three undergraduate students participated in this ten-week long class. Students reflected on their learning by responding to weekly journal prompts and designed a learning product for the high schools. Students' journal entries and project design will be analyzed to answer three research questions. How does the class influence students' beliefs about mathematics? How does the class influence students' perceptions about who does mathematics? How does the class influence students' understandings of how to teach math equitably? Preliminary results suggest the following: Students' views of mathematics expanded from a focus on application and problem solving to include intrinsic values of mathematics such as beauty and exploration. Students' perception of mathematicians became more inclusive. Students' understanding of equitable teaching varied.

Keywords: Experiential Learning, Social Justice, Reflection, Beliefs

Introduction

For over two decades, there has been a call for undergraduate mathematics to become a "gateway not a gatekeeper" (Douglas, 2017; Bryk & Treisman, 2010; Cooper, 1996). Mathematics educators have been identifying equitable teaching methods (Ching & Roberts, 2022; Martin, 2019; Hand, 2012) and focusing on the teaching of mathematics for social justice (Branson & George, 2022; Su, 2020; Gutiérrez, R. 2018; Leonard et al., 2010). As equitable teaching practices are gradually being established, promoted, and practiced in undergraduate mathematics (Leyva et al., 2022), there is an opportunity for mathematics departments to go deeper. In particular, the authors designed an experiential learning class to delve directly into issues of mathematics education and social justice.

In this study, we consider three research questions about the impact of this class on the undergraduate students who participated.

1. How does the experiential learning social justice class influence undergraduate students' beliefs about mathematics?
2. How does the experiential learning social justice class influence undergraduate students' perceptions about who does mathematics?
3. How does the experiential learning social justice class influence undergraduate students' understandings of how to teach math equitably?

Literature Review

In this review, we first present literature related to beliefs about mathematics, beliefs about who does mathematics, and equitable math teaching. These correspond to three themes common to research on equitable mathematics teaching: positioning of mathematical power, psychological approaches to teaching, as well as specific pedagogical approaches (Yolcu, 2019).

We then highlight literature related to the role of experiential learning courses in deepening undergraduates' understanding of social justice issues.

Beliefs about mathematics

Ernest (1989) and Muhtarom (2019) highlight three philosophies of mathematics which are prevalent in the teaching of mathematics: beliefs: instrumentalist, Platonist, and problem solving or constructivist. At the lowest level, instrumentalist belief is that mathematics is a "useful, but unrelated collection of facts, rules, and skills" (Ernest, 1989, p.8). The Platonist view is that mathematics is an unchanging product of interconnected structures and truth which is invented, but not created. The problem solving or constructivist view is that mathematics is a dynamic field open to revision and connected to other disciplines.

The shift of mathematics away from being a "gatekeeper" to a "gateway" into STEM fields represents a shift from a deficit orientation to asset orientation (DiGregorio & Hagman, 2021; McGee et al., 2021). This language shift also represents a change in thinking about mathematical power. Rather than demonstrating power in achievement to reduce the education gap, there is a movement to "rehumanize" mathematics in ways that empower all students to benefit from and contribute to mathematics (Gutiérrez, 2018; Ching & Roberts, 2022). A narrow view of mathematics limits the diversity of people who do mathematics. In *Mathematics for Human Flourishing*, Francis Su (2020) argues that mathematics meets the intrinsic human desire to build virtues: virtues such as exploration, play, truth, beauty, justice, struggle, and power.

Beliefs about who can do mathematics

Representation is important for students to identify as someone who can do mathematics (Oyserman & Lewis, 2017; Boaler & Greeno, 2000). Productive learning mindsets are also key to helping students identify as someone who can do math (Casad et al., 2018). Having a mindset of relevance is related to the idea that mathematics is relevant to the individual learning it (Romero, 2019). A mindset of belonging is about learning mathematics within a welcoming community (Romero, 2015). Growth mindset is the idea that intelligence can be developed through effort rather than being an innate ability; in a classroom this means mistakes are opportunities to grow and asking questions deepens understanding (Latterell & Wilson, 2022; Sun, 2018; Dweck, 2014; Boaler, 2013).

Equitable Math Teaching

Equitable math teaching is student centered. Equitable teaching methods includes active learning (Burke et al., 2020), flexible structures (Levya et al., 2022) and grading systems (Fernandez, 2021), and a focus on high expectations (Jamar & Pitts, 2005) cultural relevance (Bartell et al., 2017), and student engagement in which problem solving is key (Samson, 2015; Hake et al, 2003; Suh & Fulginiti, 2011). Along with teaching in ways that promote social justice, equitable practice also involves math that teaches social justice (Gutstein & Peterson, 2005). As we search for ways to teach math in ways that promote social justice, we consider five basic questions: *Who*, *What*, *Where*, *Why* and *How* we teach (Branson & George, 2022).

Experiential Learning and Social Justice

Experiential learning and reflection are critical components of deepening understanding of social justice. Experiential learning provides a tangible way for students to grapple with the abstract concepts of social justice (Pugh, 2014). Online service experiences have also been

shown to contribute to students' understanding of social justice (Ahmad & Gul, 2021). Group discussions and individual reflections help students synthesize and analyze the issues within the context of their teaching experience (Jacob, 2006). It is also thought that reflection is a key piece of developing effective tutoring strategies (Johns & Burks, 2022).

Context

The authors designed an upper division undergraduate math class, *Mathematics Education and Social Justice* which examines issues of social justice surrounding mathematics education in U.S. public schools. Topics included problem solving, pedagogy, power, meaning, struggle, and freedom. Class time was split between student-led discussions of the readings and small group problem solving tasks. The immersive experience involved tutoring precalculus onsite at local high schools whose student body was an underrepresented population; due to the pandemic, seven of the twenty-three undergraduates tutored online through Zoom. The experiential learning social justice component cultivated social justice, civic life, civic perspective, and civic engagement. The tutoring component helped the undergraduate students grow in their ability to understand student thinking and developed ways to strengthen high school students' understanding of precalculus content. Three overarching themes were presented.

- What is math?
- Who does math?
- How can we teach math more equitably?

Mathematics Education and Social Justice was first taught in the ten-week long spring quarter of 2022 at a mid-sized private university on the west coast. The twenty-three students enrolled in the class included math, computer science, engineering, finance and economics majors. Weekly readings included chapters from Mathematics for Human Flourishing (Su, 2020) supplemented by readings about pedagogy and equity in mathematics. Students responded to weekly journal prompts to reflect on their tutoring experiences within the context of the readings and discussion. For their final project, the undergraduate students designed a learning product which could be used by teachers in the local high schools where they tutored.

Methods

We will use the constant comparative process to analyze the journal entries (Yin, 2009). First, the authors will identify incidents, or idea threads, which demonstrate any of the three main ideas: "What is math?", "Who does math?" and "How can we teach math more equitably?" To reach an agreement on the incident, we will identify incidents together for two randomly selected transcripts and then do so independently for the remaining entries. We will then meet to assess agreement on the incidents. Note that a single incident may contain two main ideas. For example, the idea thread from Student 4, Journal 1 in Table 1 addresses both the ideas: "What is math" and "Who does math." This thread illustrates the belief that math is useful for the student's major; it also indicates the belief that some people have a natural talent for math and that effort can help a student succeed in school mathematics.

Once the idea threads for the week one journal entries are identified, we will develop a code book using inductive and deductive processes. In the idea thread from Student 4, Journal 1, the a priori code applied to "What is math" will be instrumentalist, because this student sees math as being useful to their major. We will also develop emergent codes if the "What is math" idea threads when one of the three a priori codes do not apply. For example, the idea thread from Student 3, Journal 1 in Table 1 indicates that the student thought of math as memorization.

Table 1. Sample codes

Parent Code	Sub Code	Example
What is math	Instrumental	Once I got to high school, I started putting a little more effort into math, mostly because I knew my grades were going to matter for applying to colleges. The real switch, however, came about halfway through high school when I started looking at what major I wanted to pursue. From that point on, I realized the importance of math for my life and aspirations. (Student 4, Journal 1)
Who does math	Innate gift Effort for grades	
What is math	Memorization	I felt like multiplication tables were too hard. I had a difficult time focusing in order to memorize them and it took a lot of effort from my parents and myself in order to work through that difficulty. (Student 3, Journal 1)

We will follow a similar process to address the second research question. A priori codes will be based on the beliefs that mathematics intelligence is an innate gift or achieved through effort. In the incident above from Student 4, Journal 1, the a priori code applied will be an innate gift because they are "naturally good" at math. Emergent codes will be developed as different views of mathematicians arise in the idea threads. That same incident will have an emergent code describing "effort for grades" as that is different from effort for growing math intelligence.

We will follow a similar protocol for the third research question. A priori codes for teaching math will be developed around Su's (2020) ideas to teach math for human flourishing through exploration, problem solving, and play. After coding journal entries, we will develop a rubric to analyze the final project in terms of those same equitable math teaching practices.

Upon completion of the codebook, we will divide remaining journal entries between the authors to identify and re-code the idea threads. We will then engage in a two-step process to assess reliability. First 100% of each author's journals will be given to the other author to ensure all idea threads in the journals were captured and identified accurately. We will then calculate the percent agreement between the authors. The second process of reliability assessment will be seeking agreement on codes that were applied to each idea thread. Again, 100% of each coder's journals will be exchanged and the percent agreement calculated.

To address the first research question, we will examine general trends across the beliefs about mathematics. To address the second research question, we will examine patterns across beliefs about who does math. To address the third research question, we will connect student's understanding of equitable teaching with different student characteristics, such as college major.

Preliminary Results

While the full data analysis has yet to be completed, these are some preliminary findings related to each of the three research questions.

How does the experiential learning social justice (ELSJ) class influence undergraduate students' beliefs about mathematics? Rather than change students' beliefs about mathematics, the ELSJ learning experiences expanded students' beliefs about mathematics. At the beginning of the quarter, most of the undergraduate students described mathematics as memorized facts,

procedures, or a tool; in contrast, the four mathematics majors tended to see math as problem solving and logical thinking. By the end of the quarter, most students moved from seeing mathematics as a set of rules to a set of ideas and a way of thinking. In addition to seeing math as a toolkit, students became aware of the intrinsic value of mathematics and see mathematics as a way of "understanding the world." Most students moved forward along the continuum from an instrumentalist to a problem-solving view of mathematics.

How does the experiential learning social justice class influence undergraduate students' perceptions about who does mathematics? Students' experiences throughout the quarter also expanded their perception about who does mathematics. Undergraduate students, who saw themselves as innately good at math, grew to recognize that through persistence and effort, anyone can develop math skills. Students saw that invisible labels through 'grouping' could encourage or discourage that persistence and effort. Students began to see that all students have the potential to be mathematicians. In their last journal entry, one business major enthusiastically noted that anyone could be a mathematician, "even me!"

How does the experiential learning social justice class influence undergraduate students' understandings of how to teach math equitably? Students' journal entries gave evidence to their thoughts about teaching math equitably, such as high expectation, relationships, motivation and engagement, and such; the final projects revealed the depth of their understanding. Some groups were able to identify ways to provide higher order thinking and problem solving; this aligned with equitable teaching. Some other groups focused more on basic concepts and rote learning, which tend to perpetuate inequities.

Implications and Future Research

The reflections in this course influenced students' thinking about what is math, who does math, and how to teach math equitably. In person tutoring gave undergraduate students a chance to get to know underrepresented high school students, to build a joint learning community with them, and to experiment with what types of teaching strategies helped the students learn.

These undergraduate students scratched the surface of learning what equitable math education looks like. We need to continue to study equitable teaching practices at all levels: elementary through graduate school. At the undergraduate level, we can cultivate an open mindset about mathematics, an awareness of the disparities that exist, and highlight equitable practices such as building learning communities among students from different backgrounds.

The mathematics learning center is a natural place to cultivate that awareness (Reinholz et al., 2020). Tutors have a unique opportunity to develop a relationship with their students, to understand their students' thinking, to encourage a growth mindset, to engage students and build on their individual mathematical strengths. Raising tutor awareness of social justice issues and having tutors try out different teaching methods is one way to build a diverse learning community. Creating a sense of belonging in the math learning center is a critical first step. From there we can explore other teaching methods to promote equitable math teaching and make a difference in the mathematical future of the students who come.

Questions for Audience

1. Two key components of the class are the immersion experience and the reflection piece. What questions do you have about either of these?
2. What questions do you have about the specific reflection prompts?
3. How do these preliminary results impact what you will do in your own classes?

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