Teaching Preservice Early Childhood and Elementary School Teachers Mathematics Through a Social Justice Lens

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Abstract

We describe the objectives and some outcomes of a mathematics course for preservice elementary and early childhood education students that is focused on presenting mathematics through a social justice lens, as well as some examples of activities and content with which students engage throughout the course. Activities based on ratio and proportional reasoning are very accessible to students and yield fruitful discussions around notions of fairness and justice. We close with examples of student projects and feedback collected over several semesters.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. We often hear children say, "That isn't fair!" Many societal problems ultimately come down to a sense of *fairness*. How can mathematics help us measure fairness?

2. Reflect on your own experiences learning mathematics. What messages did you receive (explicitly or implicitly) about who "belongs" in mathematics? How might these experiences influence your approach to teaching mathematics?

3. How can presenting elementary and early childhood mathematics content through a social justice lens impact preservice teachers and their view of mathematics in the world?

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Christopher Yakes and Julie Klipfel

The idea of teaching mathematics through a social justice lens is well examined and has been trailblazed by many distinguished researchers. An entire issue of *TEEM* is devoted to these ideas, and many prominent scholars have investigated the outcome of using social justice mathematics content to engage students from elementary school through college. At Salem State University, the Department of Mathematics had the opportunity to create a course for preservice early childhood and elementary educators that presents the content of upper elementary and early middle school through a social and economic justice lens. In the view of the authors, this means that mathematics content is presented and explored as much as possible by starting with a mathematical artifact based on real-life situations—a news story, some data or a graphical representation of data, or a plausible story problem—and engaging students in thinking about the implications of the artifact. We will present some examples of such artifacts and related activities, specifically in *ratio and proportional reasoning*, which naturally allows for discussions about *fairness*. Then we share some student feedback illustrating course impact on their perspectives.

In 2019, the Salem State University Department of Childhood Education and Care created a new major for prospective early childhood and elementary education teachers, titled *Justice in Education*. As part of the major, a third mathematics content course was added to the curriculum, one that would focus on the mathematical topics in upper elementary grades and middle school. One stipulation for this new mathematics course was that the course be tied into social justice issues as much as possible. This task presented a unique opportunity, in that such a course did not yet exist at Salem State, and resources for implementing courses for preservice childhood educators do not typically focus on social justice.

The authors of this article created the course and collaborated on the first iterations of the course. When considering a theme and topics for the course, the question of how to interweave mathematics topics and social justice issues authentically is paramount. The major theme determined by the team for the course was: *to the extent possible, every mathematical topic would be introduced by exploring an issue around social justice first*. Thus, beyond simply using application problems or exercises to demonstrate the concepts and skills of the course, the concepts and skills would instead be introduced in the context of a social justice issue. As the creators of this course, Dr. Yakes and Ms. Klipfel, approached this work acknowledging both their commitments to mathematics education and social justice, as well as the importance of examining their own positions of privilege in undertaking this work.

While a mathematics PhD student at UCLA, Dr. Yakes began working with the California Mathematics Project, and he has continued working with teachers in several different capacities for the past 20 years. He has facilitated professional development workshops, provided coaching to teachers and technical assistance to schools, and after arriving at Salem State, began teaching math methods and supervising teaching candidates during their practicum. Over time, his interest in issues around equity and social justice started to enter his educational work, and the opportunity to help create this course represented a chance to fully integrate these interests. Dr. Yakes keeps at the forefront of his mind an awareness of the privilege and social capital being a highly-educated white male has afforded him. At the same time, being a first-generation college student from a working-class background, he is acutely aware of issues around wealth disparities and the divide between the working and professional classes. Dr. Yakes has made it a personal and professional goal to be an advocate and ally to students from under-represented backgrounds in mathematics and mathematics education.

With backgrounds in both mathematics and elementary education, Ms. Klipfel brings a unique perspective to mathematics education through dual roles as an elementary school teacher and adjunct professor working with preservice educators. Her experience teaching future teachers while maintaining an active role in the elementary classroom has deepened her understanding of how critical a robust teacher preparation program is for developing effective mathematics instruction. Over time, she has witnessed how building a strong mathematical culture in the classroom is essential for

successfully integrating social justice perspectives in mathematics instruction. Through her position at the intersection of elementary education and mathematics instruction, and mindful of her privileged experiences as a white, English-speaking female growing up in a Boston suburb with access to high-quality education, she has made it her mission to prepare future teachers to create inclusive, engaging mathematics classrooms where all students feel a sense of belonging.

Creating a Course Focused on Mathematics through a Social Justice Lens

The development of this new course provided an opportunity to explicitly link the teaching of mathematical concepts and skills to student consideration of social justice contexts. We feel it of utmost importance that preservice teachers see that mathematics can inform their understanding of the world. This serves the dual purposes of helping to develop their sense that mathematics is productive and useful, as well as opening their eyes to real problems around equity and social justice. Most of our preservice teachers will graduate and teach in schools where many students experience poverty, are members of oppressed and marginalized groups, and for whom English is a second language. To become advocates for and allies of their students, it is important for preservice teachers to understand the structural impediments existing for many, and mathematics can help them develop this understanding. Further, as our work and the work of others shows, teaching mathematics through a social justice lens deeply engages students and motivates them in ways that an objective, positivist curriculum often does not. As James Banks (2014), considered the father of multicultural education, writes, "Students are more likely to master skills when the teacher uses content that deals with significant human problems related to race, ethnicity, and social class within society." (p. 6)

In a series of works, Marilyn Frankenstein describes a framework through which students may develop what she terms *criticalmathematics literacy*. Frankenstein builds on the work of Freire and several others, most notably appealing to the notion of "problem posing" as a means for instructors to co-construct content with students (Frankenstein, 1983). Her work is an extension of the ideas of critical pedagogy to mathematics teaching. Specifically, she gives several examples of how university students in a statistics course can be encouraged to critically examine injustices present in society as well as in the "standard curriculum" of such a course. In the course presented here, we attempt to do the same: frequently an infographic or collection of data is presented to students, and they are asked to investigate the implications for society they perceive. Mathematical tools are introduced to comprehend the data, as well as make arguments for or against the status quo that is often present in such examples.

Gutiérrez (2019a, 2019b) describes the inherent tensions in teaching mathematics with a focus on equity. We attempt to diffuse some of these tensions by getting to know our students through mathographies and by employing open discussions of the "What do you notice, what do you wonder?" style. These serve to include a human element into the course—indeed, this is not the typical math class these students have encountered. The focus is on real issues around social justice as well as the mathematics content and building trusting relationships among students and instructor is critical. Recognizing these inherent tensions, we introduced many topics in the course with content advisories, and the discussions often became spaces for collaborative learning where instructors and students together explored sensitive concepts.

We are further inspired by the work of Jo Boaler (e.g. Boaler, 2013), in that an important theme for this population of students is the notion of *democratizing mathematics*. We take this term to loosely describe the shifting of mathematical agency to students rather than only to the instructor. We also emphasize the notion of collectivism—in the Vygotskian sense of co-constructing knowledge using social tools (like language), in contrast to American notions of an individualistic society. This is particularly important not only for the present course, but for the future classrooms of these prospective teachers, many of whom have experienced classrooms emphasizing rote memorization and skills, a glossing over of conceptual understanding, timed tests, or negative attitudes towards mathematics. Thus, while one goal is engendering a productive disposition, we try to embody the eight Standards of Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) and the NCTM Process Standards (NCTM, 2000) in implementing the course. This means providing opportunities for problem solving, for making arguments and critiquing

others' reasoning, and for class discussions about procedures and concepts. This attempt to democratize our own mathematics classroom serves to further elicit and make public the inherent tensions described by Gutiérrez (2019b).

Before moving on, we must make note that in class discussions around many of these ideas, the notion of "fairness" will arise, and this is precisely the type of discussion we should want in a course such as this: that is, when can we quantitatively decide something is "fair"? Some will want to avoid such discussions in a course designated as a mathematics content course. We feel strongly this is entirely appropriate for this group of students, especially at this period in U.S. history. It is imperative to give students the space to grapple with ideas of fairness and to equip them with the quantitative tools for decision-making as they embark on their careers. Furthermore, in this way, students are *reading and writing the world with mathematics*, as described by Gutstein (2016).

Engaging Students in Social Justice Mathematics Activities

Being the third mathematics course in a sequence for childhood educators, the content is focused on upper elementary and middle school. Many topics ultimately connect to the area of ratio and proportional reasoning, which is particularly rich for engaging students in mathematics arising from social justice scenarios. Below are three topic areas and example artifacts that presented opportunities for rich discussion among students.

Topic 1: Absolute and Relative Reasoning

In the course, we begin with the contrast between *absolute* and *relative thinking* (Lamon, 2020). Consider for example the following hypothetical situation we present to students:

> *A stockbroker and his assistant pay federal taxes on their income. The broker made $2,000,000 last year, while the assistant made $60,000. The broker paid a total of $300,000 in taxes, while his assistant paid $21,000 in taxes. Who paid more in taxes?*

An absolute reasoning view of this problem answers that the broker paid more in taxes. However, we encourage students to investigate further by allowing students to engage in discussion and by prodding for some thinking about comparing the amount of tax *relative* to the income of each person. Students begin to implement fraction reasoning and percentages, which may require some scaffolding along the way. In the end, they can all see that there is an argument that the assistant paid *more* in taxes, relative to their income. Using percentages, we see this more clearly: the broker paid 15% of his income in taxes while the assistant paid 35%. Figure 1 demonstrates two student responses to the problem, wherein students make effective use of tape diagrams to illustrate their thinking.

Perhaps this example seems farfetched. However, students can be encouraged to read about the ways the ultra-wealthy in the U.S. pay a lower effective tax rate than lower-income earners. They can learn about tax brackets, taxes on business profits, and the like, and engage in discussions about what seems reasonable to them or experiment with hypothetical situations regarding tax revenue and the use of taxpayer funds.

Many examples can be found for using similar infographics or data to introduce and explore relative and absolute thinking and related topics. First, students can consider whether sales tax is fair; while sales tax appears to be uniformly applied to all subjected purchases equally, the absolute amount of taxes paid will have an outsized effect on someone making a lower income. Students may be led to wonder why certain items are not taxable in their state. This example also allows for the opportunity to discuss progressive and regressive taxes, and to investigate the feasibility of a "flat tax" with a common fixed rate (on income, say), which on the surface appears to be the fairest way to tax people of all but may not actually be so.

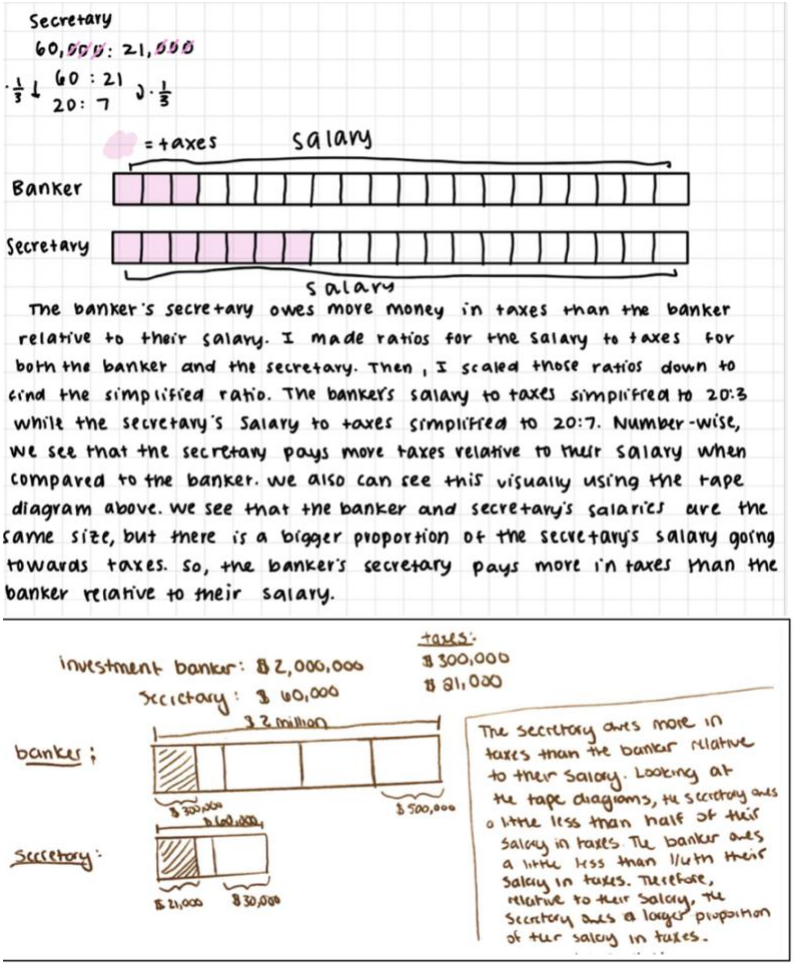
Proportional representation in government is another rich area in which to explore the basic notions of relative and absolute reasoning. The class can research the number of representatives in the U.S. House of Representatives for their state, and compare that number to another state's, relative to population. Consider the question presented below:

> *New York has a population of about 19.8 million and 27 representatives in the House of Representatives, while Massachusetts has a population of about 6.89 million and 9 representatives. Do these situations represent equivalent ratios?*

Students may find that even though the representation in the House is not exactly equivalent, it is more-or-less proportional. Students can be asked a similar question about the U.S. Senate, wherein they may be very surprised to find quite a different answer. Again, infographics and sources of data abound to help explore this idea.

Figure 1

Comparing Taxes Relative to Salaries, Where the Taxes Paid Are Commensurate, to Make an Argument



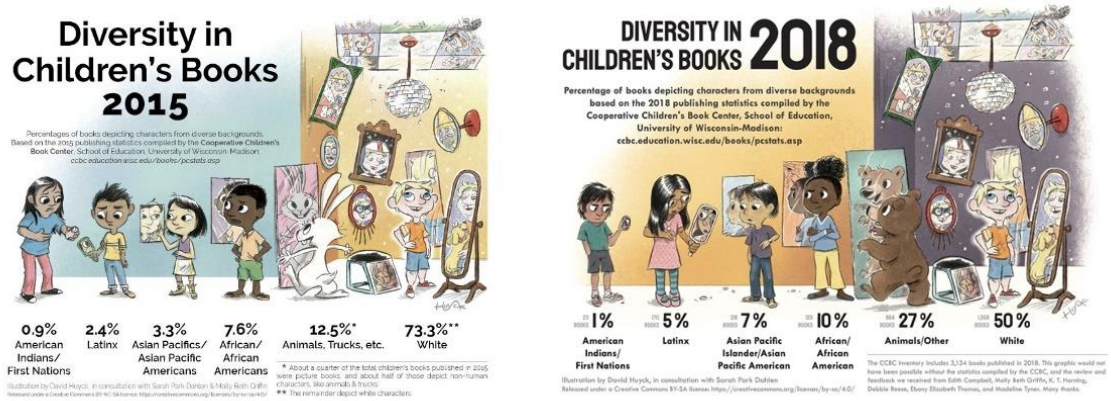
Topic 2: Working with Percentages and Percent Reasoning

In 2020, the Alabama State Legislature drew a new congressional districting map that appeared to disenfranchise Black voters. The population of Alabama is roughly 27% Black, while the new map carved up areas of Alabama that are majority Black in such a way as to create only 1 district out of 7 that is majority Black. The case eventually went to the U.S. Supreme Court. This scenario can be presented to students, who can discuss the implications of the new map and can be introduced to gerrymandering, critical for understanding current power structures in state governments around the U.S (de Vogue, 2023).

Another interesting example for preservice childhood educators includes the infographics in Figure 2, which describe the breakdown of diversity in children's book characters in two different years. Students can be asked both how the percentages changed in an absolute sense and a relative sense, using the concept of percent change to express their answers.

Figure 2

Diversity in Children's Books 2015 and 2018. (Hyuck et al., 2016, and Hyuck et al., 2019)



Topic 3: Comparing Linear and Exponential Patterns

While we do not necessarily expect our students to develop expertise in growth rates, it is worthwhile to investigate the difference between constant additive change (linear change, a middle-grades topic) and constant multiplicative change (exponential change). One of the more fruitful areas for investigating this is the basic notion of wealth inequality.

As a simple but thought-provoking example, students can be asked how long it would take someone earning the federal minimum wage to make a billion dollars. They may be surprised by the answer. They can then investigate graphs such as the one in Figure 3, which demonstrates an essentially exponential growth in someone's wealth (noting that the horizontal axis does not represent equal-size intervals).

Throughout the different overarching mathematics topics introduced in class, students were often asked to design their own problems or take their learning from class to explore a social justice topic further in the context of the mathematics learned. While working with linear functions, one student posed a problem that involved the 49:1 ratio in Massachusetts of white K-12 teachers to K-12 teachers of color. The question had several parts, which included using a table, equation, and graph. The student's work is shown in Figure 4.

Finally, while the question of how long it takes someone earning minimum wage to become a billionaire is somewhat whimsical, there are very real questions regarding patterns and growth that can be framed to make students think about economic issues in a different light. For example, the Prison Policy Initiative (https://bit.ly/4ktDbAT) reports that in 2017, incarcerated persons in Massachusetts made as little as $0.14 per hour (Sawyer, 2017). Students can determine how many hours such a person must work to be able to afford an essential item in the commissary that costs $10.

Figure 3

Approximate Net Worth of Warren Buffett Over Time (Source: https://bit.ly/3TtxS9M)

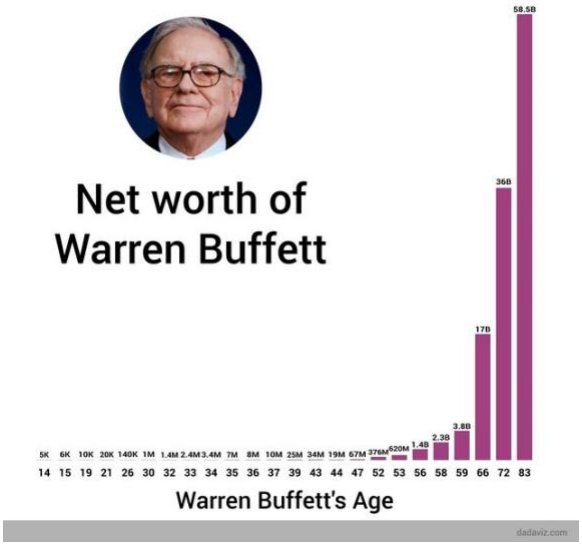
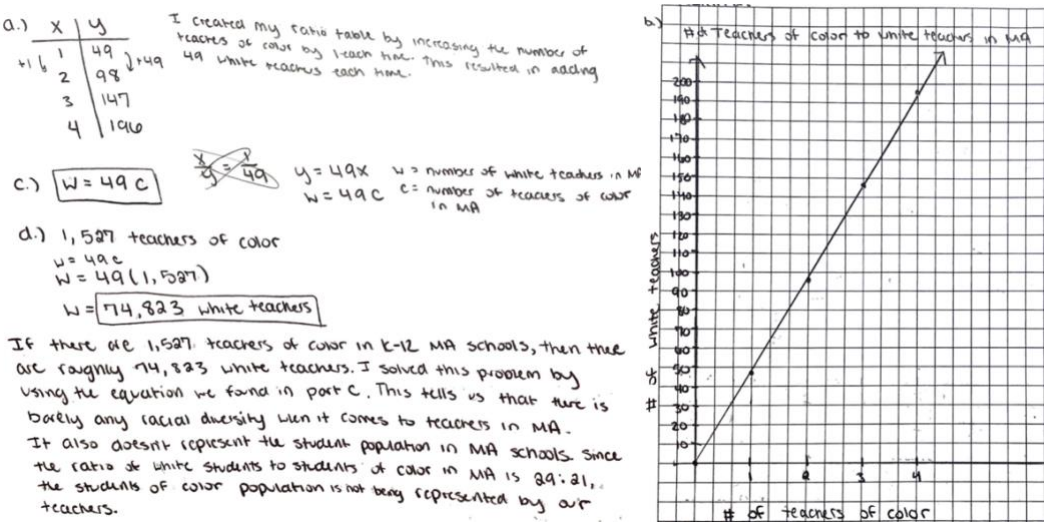


Figure 4

Student Work on the Ratio of White Teachers to Teachers of Color in MA



Impact on Students

In the first iterations of this course, both instructors implemented a final project as a culminating assessment. Students worked individually or in pairs and were required to apply some of the skills and reasoning developed throughout the semester to a social justice topic of their choosing. Many students made use of Census.gov (https://www.census.gov), a tool that was introduced during the semester to find interesting demographic data to ask questions around diversity trends.

Final Projects

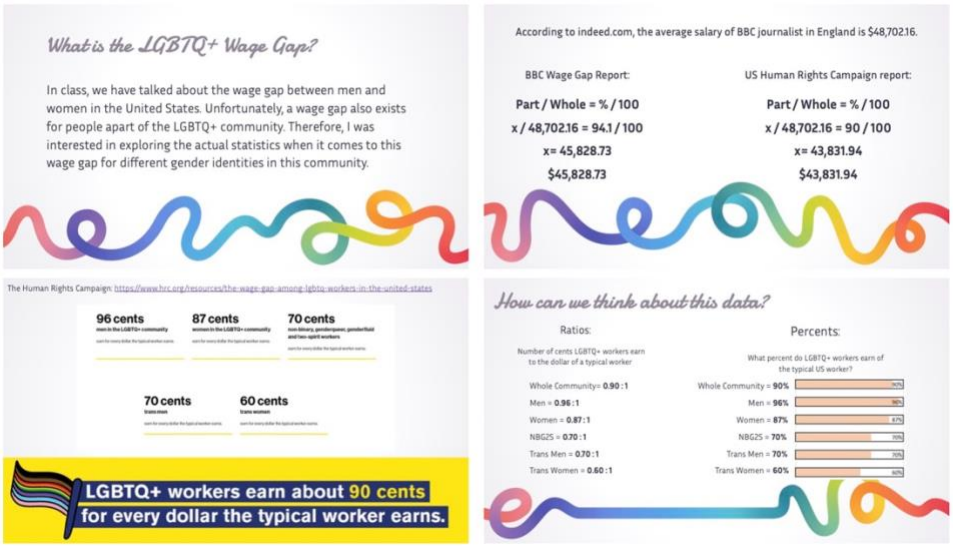
We present two examples of student final projects as evidence of the impact the course had on students, both mathematically and in their awareness of social justice issues. Most students created a slideshow to present during the final class meeting or the final exam period. Topics varied quite a bit, as students were inspired to research social justice issues they cared about and showcase the mathematics they had learned.

Project 1: LGBTQ+ Wage Gap

One student used her content learning from the course, particularly regarding ratios and percentages, to analyze the LGBTQ+ wage gap in the United States. She wrote, "Everybody knows that there are wage gaps between men and women, but some might not realize that these wage gaps extend to people in the LGBTQ+ community." As presented in her final project, she took data to then create ratios, percents and even precent bars to show the pay gaps (Figure 5).

Figure 5

Student project on the impact of LGBTQ+ wage gap



She took her mathematical investigation further to research the LGBTQ+ wage gap in other countries, again applying her learning about ratios and percentages. In her final reflection. she wrote, "I thought it was important to show the class how this issue was not just happening in the United States and that it was happening worldwide." In addition, she explored the impact this would have on LGBTQ+ teachers in the state she plans to work (Figure 6).

Figure 6

Exploring LGBTQ+ Wage Gap Impact in Massachusetts

In her final reflection, this student wrote:

> Both the Human Rights Campaign and the BBC Studios report show that this is a real issue that many people might not realize. More research needs to be done in order for people to understand the urgency. Also, based on my calculations, trans women face the most discrimination when it comes to the wage gap. When estimating the average teaching salary, I found that trans women would make roughly $34,000 less than the typical teacher...While there are anti-discrimination laws in Massachusetts, more has to be done to protect LGBTQ+ workers.

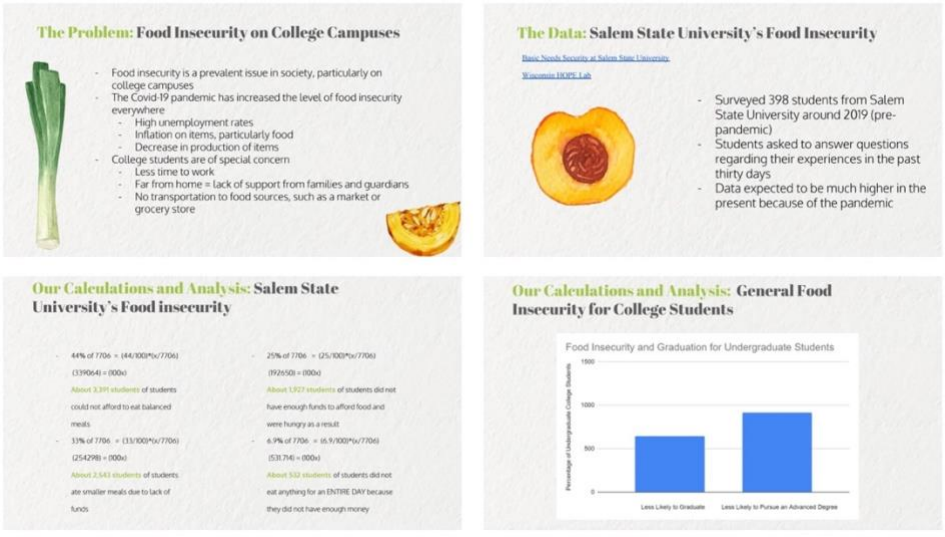
This student's final project examining LGBTQ+ wage gaps demonstrates the successful application of course concepts to meaningfully investigate social justice issues important to them while also further investigating the notion of fairness. This work exemplifies how mathematical inquiry can deepen students' understanding of societal inequities on a global scale and connect directly to students' future professions. The depth of this investigation demonstrates the power of the course's approach of introducing mathematical concepts through a social justice lens.

Project 2: Food Insecurity on College Campuses

One group of students investigated data on food insecurities on college campuses across the United States, including specifically at the college they attend. They presented their findings using knowledge of percents and ratios gained from the course (Figure 7).

Figure 7

Student Project on Campus Food Insecurity



In their final reflection, the students wrote, "This report reinforced the idea that food insecurity is a major issue at Salem State University and colleges across the United States, and that we must do something to combat it." This has shown how powerful the use of real-life mathematics can be in opening preservice teachers' eyes to social justice issues around them.

It is also important to note that the final projects allowed students to share social justice topics important to them that we might not have covered in the course. This provided another valuable learning opportunity where the instructors could experience learning moments alongside our students. For example, one final project presented mathematics related to the GSA, which many historically knew as the "Gay-Straight Alliance." Through the student-led presentation, the class learned that it has evolved to the "Gender and Sexuality Alliance." Such moments of shared learning highlight how the approach to mathematics education in this course creates spaces for continued growth and understanding for everyone involved.

Conclusion

The literature around mathematics for social justice is extensive and growing. This paper describes a context wherein future early childhood and elementary teachers develop a better awareness of social justice issues while developing an understanding of upper elementary and middle school concepts, specifically ratio and proportional reasoning. This audience is well-suited for this course that presents the mathematics as a tool for empowerment and helps students improve their disposition towards mathematics.

We feel that mathematics educators have an obligation to respond to recent political events, which include attacks on education as well as on vulnerable communities, and that now is the time for increasing preservice teachers' awareness and understanding of issues around social justice that they may already encounter in their personal lives and will likely encounter in their professional lives. Our goal in creating this course goes beyond simply increasing our students' understanding of upper elementary grades mathematics content; we seek to develop in our students the capacity for viewing social issues through a quantitative lens, with which they can understand and make informed arguments and decisions.

Our intention is that this paper inspires others to take risks in their own instruction in presenting mathematics through a social justice lens and challenging their students to expand their worldview and see themselves as empowered to make a difference in their and their future students' lives.

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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. As described in this paper, proportional reasoning—ratios, rates, percentages—is a big idea in mathematics that can be applied to many real-world situations. Discuss with a colleague some other ways that proportional reasoning can help us describe *fairness*.

2. What are some other big ideas in mathematics that have their own wide-ranging applications to social justice topics?

3. Find a recent article that presents data and uses percentages (or ratios or rates) to discuss a real-world scenario. Think about how to present the data in a way that causes your students to think about the social-justice implications of the data.

4. Team up with a colleague from a different discipline (e.g., social studies or science) and co-plan a unit in which students must use mathematics to describe the world around us.